Universidade de Brasília
Faculdade de Ciências da Saúde
Departamento de Nutrição
Programa de Pós-Graduação em Nutrição Humana

INGREDIENTES E COMPOSIÇÃO NUTRICIONAL DE SUBSTITUTOS VEGANOS DE CARNE, LEITE E OVOS E SEUS DERIVADOS COMERCIALIZADOS NO BRASIL

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Tese apresentada ao Programa de Pós-Graduação em Nutrição Humana do Departamento de Nutrição da Universidade de Brasília como requisito parcial à obtenção do título de Doutor em Nutrição Humana.

Área de concentração: Alimentos, dietética e Bioquímica aplicada à Nutrição.

Orientadora: Profa. Dra. Renata Puppin Zandonadi

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RESUMO

Introdução: Carnes, leites e ovos e seus derivados são amplamente utilizados na alimentação da população mundial. Por outro lado, cresce de forma próspera o número de pessoas adeptas à alimentação isenta de alimentos de origem animal (padrão alimentar vegano) e o mercado de alimentos direcionado para esta população. Contudo, em relação ao aspecto nutricional, estima-se haver diferença entre produtos veganos e seus respectivos equivalentes animais. Até então, não há estudo realizado no Brasil acerca da composição nutricional e ingredientes empregados nos produtos veganos comercializados no Brasil comparados aos seus substitutos equivalentes. **Objetivo**: Analisar a composição nutricional e os principais ingredientes dos análogos veganos de carnes, leite e ovos e seus derivados comercializados no Brasil. **Métodos:** Este estudo conduzido em duas etapas: (i) revisão integrativa com busca sistemática (protocolo PRISMA) acerca da qualidade nutricional de substitutos veganos de carne nas bases de dados Pubmed, EMBASE, Scopus, Science Direct, Web of Science e literatura cinzenta (google scholar e o google patentes); e (ii) estudo experimental que visou mapear e determinar a composição nutricional de análogos veganos de carne bovina, suína e caprina, aves, pescados, bebidas vegetais, iogurtes, queijos, maionese e ovos.O estudo experimental foi realizado em três etapas: (i) levantamento de amostras dos produtos veganos análogos a carnes, leite e ovos e seus derivados comercializados no Brasil; (ii) coleta e classificação de dados; (iii) análise estatística dos resultados. **Resultados:** Na revisão integrativa, foram incluídos 11 estudos e verificou-sebaixo valor energético e altas quantidades de carboidratos e fibras dietéticas nos produtos veganos comparados aos equivalentes de origem animal. Os valores de proteína variaram de acordo com as categorias analisadas, com maior quantidade nos substitutos de carne bovina. Os substitutos de carne apresentaram valores gorduras totais e saturadas similares às suas versões de origem animal. Soja, ervilha e trigo foram as principais fontes proteicas empregadas nos substitutos de carnes, e óleos vegetais como fontes de gordura. Metilcelulose, gomas e flavorizantes foram os aditivos alimentares mais empregados. Os valores de ferro, zinco e vitamina B12 não foram quantificados para a maioria dos estudos, dado que são nutrientes de declaração opcional nas legislações dos países produtores dos estudos. No estudo experimental acerca dos substitutos para carnes foram incluídas 125 amostras. De forma similar ao encontrado na revisão, os principais ingredientes utilizados foram soja, glúten e proteína de ervilha. Os substitutos de carne apresentaram valores similares de energia (kcal) e de proteína quando comparados aos seus equivalentes de origem animal. Poucas diferenças em relação ao teor de sódio dos substitutos veganos e seus equivalentes de origem animal foram encontradas. Os substitutos veganos de carne apresentaram maior concentração de carboidratos e fibras dietéticas que seus equivalentes de origem animal e mínimas diferenças em relação aos teores de gordura total e saturada. No que diz respeito aos substitutos de leite e seus derivados e ovos, 152 amostras foram analisadas e não foram encontradas diferenças em relação aos teores de gorduras total e saturada em comparação aos produtos de origem animal. Valores superiores de carboidratos e fibras dietéticas foram encontrados nos análogos veganos de todas as amostras em comparação aos produtos de origem animal. As versões veganas de bebidas vegetais e queijos apresentaram menos proteína em comparação aos seus equivalentes de origem animal. Castanhas de caju, arroz, coco e soja foram os principais ingredientes empregados nas versões veganas de leite e seus derivados, enquanto emulsões de óleo, amido e proteínas vegetais foram predominantes nos substitutos de ovos. **Conclusão:** Os substitutos veganos de carne apresentaram menores valores energéticos e maiores valores de carboidratos e fibras dietéticas em relação aos seus equivalentes de origem animal. Poucas diferenças em relação aos teores proteicos e de gorduras totais e saturadas foram encontrados. De forma geral, os substitutos de carne apresentaram altas concentrações de sódio, destacando a necessidade da elaboração de versões com menor teor de sódio. Soja, trigo, ervilhas e diferentes hidrocoloides foram os ingredientes mais implementados. Os laticínios veganos apresentaram menores teores de proteína e cálcio que seus equivalentes de origem animal. Arroz, coco e diferentes oleaginosas foram os principais ingredientes nesta categoria de produtos. Destaca-se por fim a carência de substitutos para ovos in natura e a necessidade de avaliação global dos produtos veganos disponíveis no mercado.

ABSTRACT

Introduction: Meats, dairy, eggs and their derivatives are widely used by the world population. On the other hand, the number of people adept of vegan diets and the food market aimed at this population is growing prosperously. However, regarding its nutritional aspect, it is estimated that there is a difference between vegan products and their respective animal equivalents. At the time, no studies have been carried out in Brazil on the nutritional composition and ingredients present in vegan products marketed in Brazil, while also comparing to their animal-based equivalents. **Objective:** To analyze the nutritional composition and the main ingredients of vegan analogues of meat, dairy and eggs marketed in Brazil. **Methods:** This study was conducted in two stages: (i) integrative review with a systematic search (PRISMA protocol) about the nutritional quality of vegan meat substitutes in five databases Pubmed, EMBASE, Scopus, Science Direct, Web of Science and gray literature (google scholar and google patents); and (ii) experimental study that aimed to map and determine the nutritional composition of vegan analogues of beef, pork, poultry, fish, vegetable beverages, yogurts, cheeses, mayonnaise and eggs. The experimental study was carried out in three stages: (i) mapping of samples of vegan products similar to meat, dairy and eggs commercialized in Brazil; (ii) collection and classification of data; (iii) statistical analysis. **Results:** In the integrative review, 11 studies were included. The results show low energy value and high amounts of carbohydrates and dietary fibers in vegan products compared to their equivalents of animal origin. The protein values varied according to the analyzed categories, higher in bovine meat substitutes. The meat substitutes present total and saturated fat values similar to their versions of animal origin. Soy, wheat were the main protein sources used as meat substitutes, and vegetable oils as sources of fat. Methylcellulose and flavorings were the most used food additives. The values of iron, zinc and vitamin B12 were not quantified for most of the studies, since they are optionally declared nutrients in the laws of the studies countries. An experimental study on two substitutes for meats included 125 samples. Similar to found in the review, the main ingredients used were soy, gluten and pea protein. The meat substitutes presented similar values of energy (kcal) and protein when compared to their equivalents of animal origin. Few differences in relation to the sodium content of the vegan substitutes and their equivalents were found. The vegan meat substitutes present a higher concentration of carbohydrates and dietary fibers than their animal origin equivalents and minimal differences in total and saturated fat. Regarding dairy and egg substitutes, 152 samples were analyzed and no differences were found on total and saturated fat values compared to products of animal origin. Higher values of carbohydrates and dietary fibers were found in the vegan analogues of all the samples than in the products of animal origin. The vegan versions of beverages and cheeses presented less protein than their equivalents of animal origin. Cashew nuts, rice, coconut and soy were the main ingredients included in the vegan dairy products, while oil emulsions, starches and vegetable proteins were predominant in egg substitutes. **Conclusion:** Vegan meat substitutes present lower energy values and higher values of carbohydrates and dietary fibers in relation to their equivalents of animal origin. Few differences in relation to protein values and total and saturated fat were found. In general, meat substitutes present high concentrations of sodium, highlighting the need for the preparation of versions with reduced levels or sodium. Soy, wheat, beans and different hydrocolloids were the most implemented ingredients. Vegan dairy products presented lower protein and calcium content than their equivalents of animal origin. Rice, coconut and different oilseeds were the main ingredients in this category of products. Finally, the study showed the lack of substitutes for fresh eggs and the need for a global assessment of vegan products available on the market.

LISTA DE SIGLAS E ABREVIATURAS

DCNT - Doenças Crônicas Não-Transmissíveis

SVB – Sociedade Vegetariana Brasileira

IVU – International Vegetarian Union

SUMÁRIO

ESTRUTURA DA TESE

O presente trabalho está apresentado em três capítulos: O capítulo 1 é composto de introdução, referencial teórico, objetivos e material e métodos. No segundo capítulo, são explorados os resultados da pesquisa e suas respectivas discussões. Estas informações estão dispostas em três artigos: O primeiro, intitulado "*Nutritional profile of plant-based meat commercialized woldwide: An integrative review with a systematic approach,* aceito para publicação na revista *Foods (*FI: 5.75); o segundo, intitulado: "*Are vegan alternatives to meat products healthy? A study on nutrients and main ingredients of products commercialized in Brazil",* publicado na revista *Frontiers in Public* Health, (FI 6.461); e o terceiro, denominado "*Vegan milk and egg alternatives commercialized in Brazil: A study of the nutritional composition and main ingredients",* publicado na mesma revista. Por fim, o terceiro capítulo dispõe das considerações finais as referências bibliográficas.

CAPÍTULO 1

1. Introdução

Desde os tempos antigos, alimentos de origem animal como carne, leite e ovos são componentes presentes na dieta humana em várias refeições dadas as suas características nutricionais, principalmente relacionadas a proteínas de alto valor biológico, ferro, cálcio, vitamina B12, além de características sensoriais e aspectos culturais (GEIKER et al., 2021; HENCHION et al., 2014; ILAK et al., 2021). O consumo mundial de carne é estimado em 35 kg *per capita* por ano, enquanto o consumo de leite e ovos, corresponde à 30-50 kg *per capita* e 161 ovos *per capita,* respectivamente (STATISTA, 2022). É importante destacar que, devido ao crescimento exponencial da população mundial, a demanda por produtos de origem animal irá superar a capacidade de produção mundial em 2050 (TONHEIM et al., 2022).

Por outro lado, destaca-se uma parcela crescente da população preocupada com os efeitos do consumo de produtos de origem animal, principalmente no que concerne aos seus efeitos na saúde e impacto em alterações climáticas e ambientais (FOOD AND AGRICULTURE ORGANIZATION, 2011; MCCARTHY, 2019; TONHEIM et al., 2022). No que diz respeito aos efeitos na saúde, verifica-se que dietas baseadas principalmente em produtos de origem animal estão relacionadas com aumento nas prevalências de doenças crônicas não transmissíveis (DCNT), além de requererem o uso ostensivo de recursos ambientais não renováveis, como terra e água potável. Nesse sentido, verifica-se o aumento da adesão a dietas baseadas em plantas (*plant-based diets)* de forma mundial (CURTAIN; GRAFENAUER, 2019).

O termo "dieta baseada em plantas" corresponde tanto a padrões alimentares vegetarianos, veganos (BARNARD et al., 2019; KAHLEOVA et al., 2018, 2019), ou também em padrões alimentares baseados em sua maioria (não necessariamente exclusivamente) em alimentos de origem vegetal (BARNARD et al., 2019; LYNCH; JOHNSTON; WHARTON, 2018). Atualmente, não existem dados acerca da prevalência mundial de adeptos a um padrão alimentar baseado em plantas, contudo, o padrão alimentar vegetariano adquire crescente atenção, especialmente no continente asiático, onde 19% da população se declara como vegetariano (STATISTA, 2016). O padrão alimentar vegetariano também é comum na África e no Oriente Médio, com 16% de adeptos, seguidos de 8% nas Américas do Sul e Central e 6% na América do Norte (STATISTA, 2016). No continente Europeu, apenas 5% da população se declara como vegetariana (STATISTA, 2016). No Brasil, entre 2012 e 2018, o número de adeptos a um padrão alimentar vegetariano cresceu de 8 para 14%, além disso cresceu também um interesse por parte da população em produtos de origem vegetal tal como o interesse da indústria em monetizar a partir deste movimento (IBOPE, 2018). O comportamento do consumidor em relação a produtos baseados em plantas também é um determinante no crescimento deste movimento, visto que por muitas vezes são considerados mais saudáveis e associados ao bem-estar emocional e social de quem os compra (MIGUEL; COELHO; BAIRRADA, 2020a).

É essencial destacar que a aceitação de alimentos está associada a fatores econômicos, culturais, sociais, dado o papel da alimentação na sociedade humana como um tudo. Influenciam também características inerentes aos alimentos como a qualidade nutricional, sensorial e tecnológica. Desta forma, a transição para adoção de um padrão alimentar diferenciado como baseado em plantas, vegetarianos ou veganos também está associada a estes fatores (ONWEZEN et al., 2021; SHORT; KINCHLA; NOLDEN, 2021). Dada a necessidade do consumidor por alimentos que respeitem a escolha do padrão alimentar, mas sem deixar de se atentar aos aspectos culturais, de hábitos alimentares e visando a aceitação de alimentos, a indústria alimentícia tende a produzir alternativas baseadas em plantas similares aos seus equivalentes de origem animal, priorizando principalmente aspectos sensoriais (sabor, textura, aparência e método de cocção) (SHORT; KINCHLA; NOLDEN, 2021; TZIVA et al., 2019). Com este objetivo, diversos ingredientes baseados em leguminosas, cereais, oleaginosas, fungos além de aditivos alimentares como antioxidantes e espessantes são empregados (ONWEZEN et al., 2021).

Contudo, estudos sugerem que as alternativas à base de vegetais consideradas veganas comparadas aos produtos de origem animal não apresentam características nutricionais similares aos seus equivalentes de origem animal (ALESSANDRINI et al., 2021; BOUKID; CASTELLARI, 2021; CHALUPA-KREBZDAK; LONG; BOHRER, 2018a; COLLARD; MCCORMICK, 2021a; CURTAIN; GRAFENAUER, 2019; FRUCTUOSO et al., 2021; MARISEVA; BEITANE, 2020; TONHEIM et al., 2022; VANGA; RAGHAVAN, 2018). No que diz respeito aos substitutos de carne, estudos demonstraram valores reduzidos de proteínas e concentrações elevadas de sódio, de gorduras, de calorias, de fibras e de carboidratos totais quando comparados aos seus equivalentes de origem animal (CURTAIN; GRAFENAUER, 2019; SAMARD; RYU, 2019; TONHEIM et al., 2022). No contexto de substitutos de laticínios (leites, iogurtes e queijos), são relatadas baixas concentrações de proteína e cálcio quando comparados aos produtos de origem animal (CHALUPA-KREBZDAK; LONG; BOHRER, 2018b; COLLARD; MCCORMICK, 2021b; FRUCTUOSO et al., 2021; VANGA; RAGHAVAN, 2018). Até o momento, há estudos acerca da composição nutricional de substitutos de carne comercializados e disponíveis para a população em diversos países como Estados Unidos, Reino Unido, União Europeia, Noruega, Latívia, Suécia e Austrália (ALESSANDRINI et al., 2021; BOUKID; CASTELLARI, 2021; BRYNGELSSON et al., 2022a; CURTAIN; GRAFENAUER, 2019; MARISEVA; BEITANE, 2020; TONHEIM et al., 2022; ZHANG; HUGHES; GRAFENAUER, 2020), ao passo que diversos estudos relacionados a substitutos de leite foram executados em países como os Estados Unidos, Noruega, Lativia, Nova Zelândia, Austrália Reino Unido e Suécia (CHALUPA-KREBZDAK; LONG; BOHRER, 2018b; COLLARD; MCCORMICK, 2021b; PAUL et al., 2020; SILVA; SILVA; RIBEIRO, 2020a, 2020b; VANGA; RAGHAVAN, 2018; ZHANG; HUGHES; GRAFENAUER, 2020) e nenhum sobre a composição de substitutos de ovos *in natura*.

Com a expansão e o crescimento do consumo de alimentos substitutos baseados em plantas como alternativas aos de origem animal, seus potenciais efeitos na saúde relacionados ao seu consumo devem ser estudados para melhor formulação de políticas públicas relacionadas à qualidade nutricional destes produtos. É fundamental ter conhecimento acerca da composição nutricional destes produtos para fomentar melhores escolhas por parte da população que adota um padrão alimentar diferenciado. Apesar de terem sido conduzidos estudos sobre estes produtos em outros países, não há informação acerca das alternativas comercializadas no Brasil, evidenciando assim uma lacuna de conhecimento dentro deste eixo temático.

A hipótese central deste estudo é de que as alternativas veganas comercializadas no Brasil não se assemelham nutricionalmente aos seus equivalentes de origem animal. A hipótese secundária é de que os substitutos para carne apresentam mais carboidratos e sódio e menos ferro e proteína que seus equivalentes, ao passo de que os substitutos de leite e ovos apresentam menores concentrações de proteína e energia, além de menores quantidades de cálcio nos substitutos para leites e ferro nos substitutos para ovos.

2. Referencial Teórico

2.1 Histórico do Vegetarianismo, consolidação como movimento e prevalência mundial

Na fase ancestral humana, durante seu desenvolvimento e evolução, a literatura demonstra que a dieta era quase que exclusivamente vegetariana, com exceção ao consumo de eventuais artrópodes e larvas (SPENCER, 1996). Ao analisar a anatomia humana nesse período, verifica-se a presença de características que distanciam os seres humanos de animais mamíferos carnívoros (ANDREWS; JOHNSON, 2020). No que diz respeito à dentição, mamíferos carnívoros apresentam dentição adaptada para o dilaceramento de tecido muscular e vísceras (caninos afiados e diversas fileiras de dentes), diferentemente dos seres humanos que apresentavam dentes mais achatados e arcadas dentárias mais largas, de forma correspondente a espécies da época. Ademais, ao se analisar o trato gastrointestinal de mamíferos carnívoros, verifica-se um intestino mais curto, com objetivo de eliminação mais rápida de toxinas oriundas de tecidos musculares de animais em putrefação, enquanto o trato gastrointestinal humano apresenta vários metros de alças intestinais compactadas na cavidade abdominal, permitindo maior tempo de digestão e a ação de micro-organismos fermentadores, presentes no intestino grosso (ANDREWS, JOHNSON, 2020; SPENCER, 1996).

Contudo, com o passar do tempo, na fase de desenvolvimento *Homo erectus,* um dos mecanismos de evolução humana envolveu o desenvolvimento de mecanismos de caça, tanto de mamíferos terrestres, quanto de animais aquáticos, introduzindo assim a carne de animais na alimentação humana (SPENCER, 1996).

Com o desenvolvimento da agricultura, no período paleolítico da evolução humana há cerca de 13 mil anos, espécies vegetais foram introduzidas na alimentação humana, de forma concomitante à carne, agora além de oriunda de práticas de caça, também resultante da domesticação de animais. Entretanto, apesar de diversos relatos históricos do consumo de carne da época, correntes teóricas especulam que parte da população era adepta ao vegetarianismo, não de forma consciente como parte de um movimento, mas devido à disponibilidade sazonal de alimentos e condições climáticas (SPENCER, 1996).

Na era antiga, por volta de 4000 a.C com sequência na era moderna (476 d.C) da história humana, um potencial motivador para a prática e disseminação do vegetarianismo foi a religião. No antigo Egito, preconizava-se que a carne de animais não fosse consumida devido à crença de que esta prática estava associada à reencarnação, um dos principais mitos religiosos da época (BEIG, 2008). Na civilização indiana na mesma época, o hinduísmo, (principal prática religiosa até os dias atuais), apresenta em seus princípios básicos o *ahimsa*, princípio da não-violência, que engloba aspectos relacionados ao abate de animais. além do reconhecimento da vaca como um animal sagrado, não apto para abate com fins de alimentação (ALSDORF, 2010).

Na antiga Grécia, por cerca de 400 a 300 a.C, filósofos como Platão, Diógenes, Plutarco e Pitágoras demonstraram entusiasmo pela alimentação sem carne, ao propagar a crença de que o ato de abater um animal para alimentação teria influência no pensamento, mente e espírito, tornando-os impuros. O filósofo Pitágoras teve excepcional destaque neste movimento, visto que o vegetarianismo foi denominado na época de dieta pitagórica, nomenclatura esta que permaneceu presente até meados do século XIX na Europa e em regiões banhadas pelo mar mediterrâneo (SOUZA; DUARTE; CONCEIÇÃO, 2017). Na mesma região, propagou-se também o pensamento de que animais são seres senescentes, dotados de pensamento, emoções e vontade próprias, sendo seu abate assim uma prática brutal e desnecessária (SOUZA; DUARTE; CONCEIÇÃO, 2017).

Grandes pensadores cristãos propagaram a ideia de que os seres humanos, dotados do espírito santo, eram livres para consumir a carne de animais e os animais eram considerados seres "sem alma" e presentes na terra com o único fim de servirem a seres humanos (NUNES, 2010). Com base na teoria evolucionista, criou-se também a crença de que seres humanos são a fase final de evolução das espécies, portanto acabam por encabeçar a cadeia alimentar, gozando do direito de se alimentar de espécies consideradas como "inferiores" e/ou não evoluídas (NUNES, 2010).

A partir do século XX, foi fundada a primeira União Internacional Vegetariana (IVU) em 1908, união esta que permanece ativa até os dias atuais. Em 1960, um movimento pautado em melhoria pela saúde e preservação ambiental, baseado em evidências científicas da época, contribuiu para o crescimento do vegetarianismo como um movimento consolidado, observando-se assim o crescimento e expansão do movimento até os dias atuais (SOUZA; DUARTE; CONCEIÇÃO, 2017).

Atualmente, em nível mundial, verifica-se expressiva prevalência do vegetarianismo, ainda com resquícios de hábitos da antiguidade humana, conforme descrito na Figura 1.

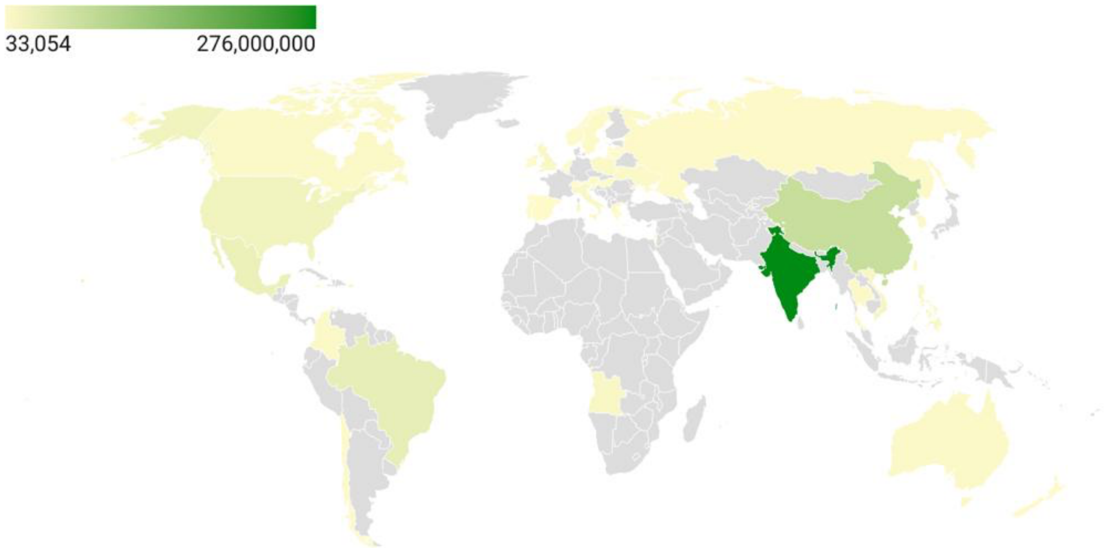

Figura 1 - Distribuição do número de adeptos do vegetarianismo por diferentes países. Fonte: Produzido pelo autor baseado em STATISTA, 2020.

Em nível continental, visto que as duas correntes religiosas mais comuns do continente, o budismo na região da China e o hinduísmo na região da Índia, mantém-se como preponderantes até os tempos atuais (FISCHER, 2016), apresentando a prevalência nesse continente de 19% da sua população (STATISTA, 2016). Ao estratificar os dados, verifica-se que, apenas na Índia, o total de vegetarianos corresponde a cerca de 24% (n=276,000,000) da população (STATISTA, 2021). Na China, o quantitativo numérico da população adepta ao vegetarianismo corresponde à cerca de 50 milhões de pessoas, aproximadamente 5% de sua população (STATISTA, 2021). Entretanto, apesar de apresentar uma população densa e um mercado culturalmente diverso, no Japão, apenas 9% (n=11,160,00) de sua população é adepta ao vegetarianismo (STATISTA, 2021).

No continente africano, a prevalência de adoção do vegetarianismo equivale a 16% de sua população (STATISTA, 2016), com destaque para os países Gana, Quênia e Nigéria, com a maior concentração de adeptos, entretanto, sem dados numéricos concretos devido à falta de pesquisas na região (STATISTA, 2016).

No continente europeu, estima-se a prevalência de 5% da população total se declarando como vegetariana (STATISTA, 2016). Entretanto, considerando-se apenas o Reino Unido, mais de 3 milhões de pessoas, (4% da população), declaram-se como adeptas ao vegetarianismo (STATISTA, 2016). Na França, 5,2% de sua população (n= 3.400.000) declara-se como vegetariana. Já na Itália, esta proporção cresce para 8,9%, percentual que corresponde a 5.340.000 pessoas (STATISTA, 2021). Em Portugal, o percentual encontra-se entre os mais baixos do continente europeu, com apenas 1% da população declarando-se como vegetariana (n=120,000).

A América do Norte, consiste do Canadá e dos Estados Unidos e México. Dados conjuntos entre os Estados Unidos e o Canadá apontam cerca de 6% de suas populações se declarando como vegetariana (STATISTA, 2016). No Canadá, 7,1% da população (cerca de 2,3 milhões de pessoas) se autodeclara como vegetariana (STATISTA, 2021). Nos Estados Unidos, 8 milhões de adultos (cerca de 9% da população total) são adeptos ao vegetarianismo, sendo que destes aproximadamente 3,7 milhões de indivíduos são também veganos (STATISTA, 2021).

No México, em uma última pesquisa feita em 2016, foram encontrados dados relatando que 19% (n= 23,750,000) da população do país se identifica como vegetariana (STATISTA, 2016). Já na América do Sul, o Brasil se destaca com uma grande concentração de adeptos ao movimento, com cerca de 14% da população se declarando como vegetariana, número este que representava o quantitativo de aproximadamente de 30 milhões de pessoas à época do levantamento (IBOPE, 2018). Na Argentina, esse percentual corresponde a 12% da população (n= 5,400,000), e no Chile, em 6% da população (1,500,000 pessoas) (STATISTA, 2021).

2.2 Aspectos gerais, classificação e benefícios associados aos diferentes tipos de padrões alimentares vegetarianos

Por definição, o padrão alimentar vegetariano é caracterizado pela exclusão de alimentos de origem animal da alimentação (SLYWITCH, 2012). Contudo, diversas subclassificações estratificam os diferentes tipos de alimentação vegetariana possíveis de serem praticadas, conforme descrito na Figura 2.

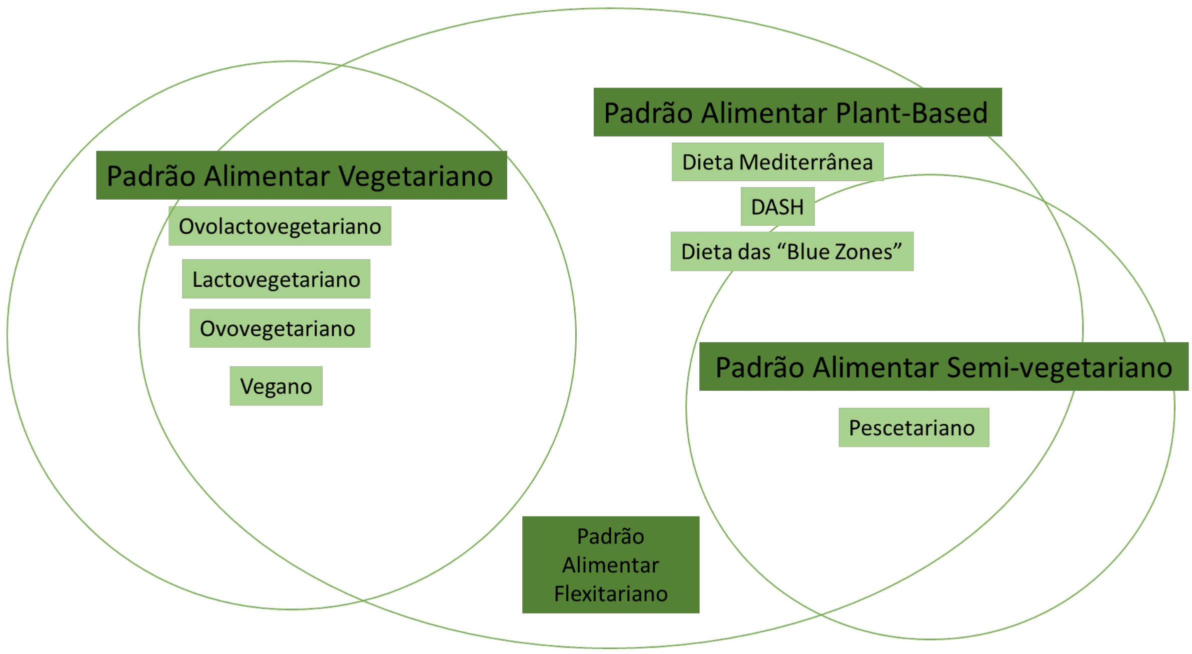

Figura 2 - Subclassificações de tipos de alimentação vegetariana, adaptadas de CLARYS et al., (2014) e HARGREAVES et al., (2023).

Dentro do padrão alimentar vegetariano, destacam-se os padrões ovolactovegetariano, lactovegetariano e vegano (CLARYS et.al, 2014; HARGREAVES et al., 2023). Dentro do padrão alimentar plant-based, tem-se a dieta mediterrânea, a dieta DASH e a dieta das "Blue Zones". Já no padrão semi-vegetariano, destaca-se o pescetariano. Existe ainda, o padrão alimentar flexitariano. As características gerais dos diversos padrões alimentares e seus efeitos na saúde são descritos a seguir:

Padrão alimentar flexitariano

Com a crescente preocupação acerca do uso sustentável de recursos e o impacto da produção de carne no planeta, o flexitarianismo surge como uma alternativa menos restrita ao vegetarianismo, visto que não compreende a exclusão total destes produtos em todos os dias (CURTAIN; GRAFENAUER, 2019). A alimentação flexitariana surge como uma alternativa moderna oriunda de um movimento de redução do consumo de produtos de origem animal, pautada principalmente em questões relacionadas à sustentabilidade, contudo, incluindo também adeptos com motivações relacionadas à saúde e ao bem-estar animal (DERBYSHIRE, 2017). O padrão alimentar flexitariano é adotado por indivíduos que optam por não consumir produtos de origem animal de uma a quatro vezes por semana (CURTAIN; GRAFENAUER, 2019). Quanto às características deste movimento, existem divergências tanto em relação à literatura, tanto quanto no que diz respeito à legitimidade dessa prática (DERBYSHIRE, 2017). Na literatura científica, é possível encontrar publicações que se referem à alimentação flexitariana como alimentação semi-vegetariana, segundo os resultados apontados pela revisão conduzida por *Derbyshire* em 2017 (DERBYSHIRE, 2017). Contudo, é importante destacar que existem também controvérsias relacionadas à legitimidade deste alimento como parte do movimento de alimentação vegetariana, visto que um dos princípios centrais do vegetarianismo se relaciona com não apoiar a violência animal, principalmente quando esta é motivada pela alimentação (CURTAIN; GRAFENAUER, 2019; RAPHAELY; MARINOVA, 2013).

Porém, pelo consumo reduzido de alimentos de origem animal, identificam-se também benefícios decorrentes da adoção deste padrão alimentar, que se assemelha àqueles obtidos pela adoção de alimentação vegetariana ou vegana, como melhor controle de peso, prevenção de doenças cardiovasculares, melhor rendimento em esportes, qualidade de vida, bem-estar social, e principalmente, ganhos do ponto de vista ecológico (CLARYS et al., 2014; DERBYSHIRE, 2017; FORESTELL, 2018; RAPHAELY; MARINOVA, 2013).

É importante destacar que o impacto ambiental do consumo de alimentos de origem animal configura como um dos principais problemas a serem tratados na agenda de desenvolvimento sustentável da Organização das Nações Unidas (ONU) (ROMA, 2019). A exclusão de produtos de origem animal por apenas um dia resulta em diversos impactos positivos, como a diminuição da emissão de 14kg de monóxido de carbono e 3400 litros de água potável (SLYWITCH, 2012). Assim, este movimento consolida-se como vertente válida dentro de padrões alimentares com interesse em substitutos para produtos de origem animal.

Padrão alimentar pescetariano

O padrão alimentar pescetariano consiste na exclusão de carnes bovinas, suínas, caprinas, aves entre outros, entretanto, com a manutenção do consumo de pescados (CLARYS et al., 2014). No que diz respeito aos benefícios deste padrão alimentar, benefícios similares relacionados à manutenção de peso e prevenção de DCNT, comuns aos padrões alimentares ovolactovegetariano, ovovegetariano, lactovegetariano e vegano estão presentes, principalmente no contexto de benefícios à saúde (ESTRUCH; SACANELLA; ROS, 2021; GEHRING et al., 2021; RABÈS et al., 2020). No que tange à sustentabilidade deste tipo de alimentação, é de conhecimento que a produção de carne bovina e de aves está relacionada com maiores emissões de gases poluentes nocivos à atmosfera em comparação com a pesca ou cultivo de pescados em cativeiro. Assim, a adoção a uma alimentação baseada em vegetais, isenta de carne bovina, suína e de aves, porém com a inclusão apenas de pescados parece ser mais sustentável (RABÈS et al., 2020).

Um estudo recente evidenciou que uma alimentação pescetariana com consumo reduzido de alimentos industrializados pode ser benéfica em relação a aspectos relacionados à saúde, visto que o consumo de vegetais costuma ser maior nos praticantes deste estilo de alimentação (GEHRING et al., 2021). Entretanto, é importante destacar que qualquer padrão alimentar cujo consumo de alimentos industrializados seja reduzido, são verificados benefícios à saúde (GEHRING et al., 2021). Um outro estudo evidenciou também potenciais benefícios resultantes deste mesmo estilo de alimentação, pautado na hipótese de um maior consumo de proteínas de alta qualidade, ácidos graxos do tipo ômega 3, zinco, selênio, cálcio, vitaminas do complexo B e vitamina D, reduzindo assim desfechos negativos relacionados à saúde (ESTRUCH; SACANELLA; ROS, 2021).

Padrão alimentar plant-based

A terminologia *plant-based* (à base de plantas) é utilizada amplamente tanto em publicações científicas, quanto em discursos populares e como descrição de produtos comerciais (BARNARD et al., 2019; LYNCH; JOHNSTON; WHARTON, 2018). É importante destacar que não existe consenso quanto ao uso desta nomenclatura. Em algumas publicações, o termo é utilizado para descrever tanto dietas vegetarianas quanto dietas veganas (BARNARD et al., 2019) aplicado a dietas onívoras, mas baseadas em abundância de vegetais (NAJJAR; FERESIN, 2019; NAJJAR; MOORE; MONTGOMERY, 2018).

Nesse sentido, diversos estilos de alimentação onívora são também denominados como alimentação *plant-based* por serem majoritariamente compostos por vegetais, a dar-se por exemplo a dieta mediterrânea, a dieta *DASH (Dietary Approaches to Stop Hypertension)*, e a denominada *Blue Zones Diet* (APPEL, 2008; HINDERLITER et al., 2010; WILLETT, 2006).

Contudo, apesar das divergências acerca da aplicação desta nomenclatura em estilos de alimentação¸ são múltiplas as publicações que evidenciam os benefícios na saúde associados a este. Tanto no contexto de alimentação *plant-based* dentro do vegetarianismo quanto em vertentes onívoras, a principal hipótese dos benefícios dessa alimentação relaciona-se com a predominância de alimentos de origem vegetal, como cereais integrais, leguminosas, hortaliças, frutas e oleaginosas, em detrimento de proteínas e gorduras de origem animal (FEHÉR et al., 2020; KAHLEOVA; LEVIN; BARNARD, 2017).

Atualmente, verifica-se que em populações ocidentais há a ocorrência de um padrão alimentar baseado em alimentos industrializados, ricos em gordura saturada e com quantidades reduzidas de hortaliças de forma geral, sendo que esta tendência apresenta crescente aumento ao longo dos anos (CRIMARCO et al., 2021; MOUBARAC et al., 2017). Dessa forma, comorbidades associadas com este estilo de alimentação apresentam prevalências também com tendência crescente, constituindo assim problemáticas de saúde pública em nível internacional (CRIMARCO et al., 2021).

A alimentação *plant-based* resgata as recomendações primárias da ciência da nutrição, que preconizam que a alimentação saudável deve consistir num hábito alimentar baseado no equilíbrio e presença de todos os grupos alimentares, de forma harmônica e equilibrada (LOUZADA et al., 2015; MONTEIRO et al., 2021). Hábito este que teve sua prática reduzida a partir do século XX, cujo movimento de crescimento industrial destacou a demanda por alimentos de rápido preparo, longa vida de prateleira e preparo com tempo reduzido (LOUZADA et al., 2015; MONTEIRO et al., 2021).

Com a chegada do século XXI, notou-se uma mudança no padrão epidemiológico de comorbidades com mortalidade acentuada, onde antes estas estavam associadas com doenças infectocontagiosas, agora as maiores taxas de morbimortalidade encontram-se concentradas associadas às DCNT (SARTORELLI; FRANCO, 2003). Nesse sentido, evidenciou-se a necessidade de mudanças nos padrões alimentar da população mundial, visto que este é o principal eixo influenciador no curso dessas doenças (SARTORELLI; FRANCO, 2003).

A partir de análises, notou-se que a prevalência de DCNTs tinham taxas diminuídas em populações localizadas nas regiões banhadas pelo mar Mediterrâneo, onde além de menores prevalências de DCNT, verificava-se também maiores valores de expectativa de vida e melhor qualidade de vida em populações analisadas (WILLETT, 2006). Dado que a alimentação é primordial na prevenção e tratamento de DCNT, análises realizadas em países nessa região demonstraram um padrão alimentar diferente do praticado a nível mundial, sendo denominado na época como padrão de alimentação mediterrâneo (WILLETT, 2006). Nesse sentido, a alimentação baseada em alimentos industrializados, carne bovina e farináceos de alto índice glicêmico dava espaço para hortaliças variadas, gorduras poli e monoinsaturadas advindas de pescados, oleaginosas e óleos vegetais tal como preparações baseadas em diversos cereais integrais (WILLETT, 2006).

Assim, a partir do final do século XX e início do século XXI, o padrão alimentar mediterrâneo passou a fazer parte das recomendações de sociedades internacionais de cardiologia e endocrinologia, tal como de associações internacionais de nutrição (ALTOMARE et al., 2013).

De forma concomitante, evidências científicas apontam também benefícios acerca da qualidade de vida daqueles adeptos a alimentação vegetariana. Assim, estudos começaram a sugerir a aliança destes padrões alimentares, reduzindo o consumo de produtos de origem animal (ALTOMARE et al., 2013; AMINE et al., 2003; WILLETT, 2006).

É importante destacar que, apesar de baseada em alimentos de origem vegetal, nem toda alimentação vegetariana é necessariamente *plant-based* (SILVA; SILVA; RIBEIRO, 2020b). Com o advento da indústria alimentícia, produtos industrializados ricos em gordura saturada, sódio e aditivos alimentares também são produzidos somente com ingredientes de origem vegetal, adequando-se assim para adeptos ao padrão alimentar vegetariano por não conter componentes de origem animal (SCHIANO et al., 2020).

Nesse sentido, quando baseada nesse tipo de produto, a alimentação vegetariana pode não estar associada com desfechos positivos relacionados à saúde, como no caso de alimentações vegetarianas e veganas *plant-based*, contudo, dado ao fato de que o crescimento da disponibilidade destes produtos é recente, estudos futuros relacionando o consumo dos alimentos vegetarianos não saudáveis com quadros de saúde daqueles que os consomem são necessários.

Padrões alimentares ovolactovegetariano, lactovegetariano e ovovegetariano

O termo Vegetariano, inclui três subclassifcações, demostradas a seguir. O adepto ao padrão alimentar ovolactovegetarian descreve-se como aquele indivíduo que, apesar de excluir todos os tipos de carnes, mantém em seu hábito alimentar o consumo de ovos e laticínios, sendo popularmente interpretado com a nomenclatura simples de “vegetariana” (CLARYS et al., 2014). O termo padrão alimentar lactovegetariano é utilizado para descrever aqueles que apesar de manter o consumo de laticínios, opta por excluir produtos cárneos e os ovos e seus derivados (CLARYS et al., 2014). Dentro das possíveis vertentes de padrão alimentar dentro do vegetarianismo, o ovolactovegetarianaodestaca-se com a maior quantidade de adeptos em nível mundial com prevalências entre 1 a 29%, visto que se trata do padrão alimentar menos restritivo em comparação com os outros possíveis (CLARYS et al., 2014; LE et al., 2018).

Padrões alimentares alternativos como o vegetariano em suas diversas categorias podem ser interpretados como restritivos, visto que a disponibilidade de produtos que simulem as características sensoriais de alimentos comumente de origem animal, como substitutos para carnes, laticínios e ovos, tanto para aquisição, quanto para consumo imediato pode ser limitada (CHINEA MONTESDEOCA et al., 2021).

Diferentemente de restrições alimentares decorrentes da necessidade de tratamento de uma condição fisiológica específica (ex.: doença celíaca, fenilcetonúria, alergias alimentares, etc.), a adesão a um padrão alimentar vegetariano ocorre de forma voluntária para a maioria de seus adeptos, com poucas exceções relacionadas à disponibilidade de alimentos (ASHER; PETERS, 2021). São diversas as motivações para a adoção de um padrão alimentar vegetariano, dentre os quais se destacam os motivos de saúde, religião, proteção aos animais e ao meio ambiente.

Em relação aos aspectos de saúde, mesmo consistindo em um padrão alimentar que exclui alguns grupos de alimentos, são identificadas melhoras na qualidade de vida e na composição corporal dos indivíduos, bem como a prevenção de DCNT quando comparados aos indivíduos que adotam um padrão alimentar onívoro (HARGREAVES; NAKANO; ZANDONADI, 2020; NAJJAR; FERESIN, 2019; SHRIDHAR et al., 2014).

Em relação à qualidade de vida, um levantamento feito com uso de um questionário validado, com alpha de Cronbach de 0.708 composto de 26 questões subdivididas em quatro domínios (saúde física, bem-estar psicológico, relações sociais e meio ambiente) demonstrou bons resultados para todos os domínios em uma amostra 4375 vegetarianos brasileiros (HARGREAVES; NAKANO; ZANDONADI, 2020). Ainda, pessoas adeptas a um padrão alimentar vegano apresentaram melhores resultados em comparação aos indivíduos que apresentavam outro padrão alimentar vegetariano, com exceção do quarto domínio (meio ambiente), onde indivíduos com alimentação semi-vegetariana não apresentaram diferenças. Adicionalmente, um tempo maior de adoção do padrão alimentar vegetariano influenciou positivamente a qualidade de vida dos indivíduos avaliados (HARGREAVES; NAKANO; ZANDONADI, 2020).

Em relação ao aspecto de composição corporal, um estudo transversal coletado a partir de questionários validados com alpha de Cronbach superior a 0.7(SPENCER et al., 2003) feito com 37875 participantes de todos os tipos de padrões alimentares, de ambos os sexos foram analisados, e os menores índices de massa corporal (IMC) foram encontrados em vegetarianos e veganos (22.49kg/m² em homens e 21.98kg/m² em mulheres, classificando ambos os grupos como eutróficos), com diferenças significativas (Tukey a 95% de confiança) quando comparados ao grupo de onívoros. O estudo, com dados autorelatados e realização de regressão linear, mostrou que a composição da dieta foi um dos fatores mais importantes para este resultado, ao passo de que dietas vegetarianas forneceram menores valores energéticos e maiores quantidades de fibra, em comparação ao padrão alimentar adotado pelos indivíduos onívoros presentes no estudo, colaborando para a composição de massa corporal destes indivíduos (SPENCER et al., 2003).

Em adeptos de dietas onívoras, a alimentação com maior valor energético e de proteínas e gorduras saturadas, e o baixo consumo de fibras dietéticas em comparação aos grupos de vegetarianos e veganos pode contribuir para aumento do IMC. Um estudo mostrou que o tempo de adoção da alimentação vegetariana não influenciou a composição corporal de vegetarianos, onde tanto vegetarianos há mais tempo (homens e mulheres) quanto naqueles que se tornaram adeptos somente após os 20 anos de idade, boas composições corporais foram encontradas, de forma concordante com o outro estudo supracitado (ROSELL; APPLEBY; KEY, 2005; SPENCER et al., 2003).

Ainda, outro estudo realizado na Austrália comparou a composição corporal de mulheres adeptas a uma alimentação vegetariana com outras não adeptas, apresentando intervalos a 95% de confiança de 22.2 (21.7–22.7) e 23.0 (22.7–23.3) kg/m² para IMC em vegetarianas, enquanto não vegetarianas apresentaram intervalos de composição corporal superiores, com 23.7 (23.6–23.8) kg/m² (BAINES; POWERS; BROWN, 2007).

Estes resultados caminham de forma convergente com a prevenção de DCNT. Um estudo conduzido na Índia em 2014 (SHRIDHAR et al., 2014) analisou a associação da alimentação vegetariana com a incidência de doenças cardiovasculares. Em uma amostra de 6555 pessoas adeptas a padrões de alimentação onívoros e vegetarianos, analisou-se fatores como a dieta, uso de tabaco, consumo de álcool, frequência de atividade física, pressão arterial, glicemia de jejum e medidas antropométricas.

Além disso, dados referentes ao lipidograma dos voluntários também foram analisados. Por fim, concluiu-se que vegetarianos (n = 2148) apresentaram redução relacionada aos valores de colesterol (principalmente LDL), triglicerídeos totais e pressão sistólica, demonstrando que a adoção a esse padrão alimentar tem fator protetivo quanto à incidência de doenças cardiovasculares (SHRIDHAR et al., 2014).

O mesmo resultado em relação ao lipidograma foi verificado quando analisados parâmetros *in vivo* com coleta de sangue em 88 participantes de esportes de *endurance* adeptos a um padrão alimentar vegetariano em comparação com atletas de dieta onívora, com redução significativa em marcadores relacionados à ocorrência de doenças de origem cardiovascular naqueles adeptos a uma alimentação vegetariana (BARNARD et al., 2019).

O padrão alimentar vegetariano também surge como alternativa terapêutica em indivíduos acometidos com obesidade. De forma geral, o padrão alimentar vegetariano, quando baseada em hortaliças, frutas, cereais integrais e leguminosas, apresenta valores reduzidos de calorias e gordura saturada, contribuindo para menores índices de massa corporal, com consequente prevenção da obesidade (SABATÉ; BLIX, 2001). Ademais, o padrão alimentar baseado em hortaliças de forma geral apresenta compostos fitoquímicos benéficos à prevenção de algumas doenças crônicas como diabetes, hipertensão, aterosclerose e obesidade (SABATÉ; BLIX, 2001).

Em uma análise realizada em um grupo de adeptos a diferentes tipos de alimentação vegetariana na Índia, menores IMCs foram encontrados em semi-vegetarianos como pescetarianos (20.3kg/m²), veganos (20.3 kg/m²), com os maiores valores encontrados em ovolactovegetarianos (21 kg/m²) e lactovegetarianos (21.2kg/m²), além de ter sido evidenciado também redução no risco de diabetes mellitus tipo 2 nesses mesmos grupos (AGRAWAL et al., 2014). É importante ressaltar que, mesmo com resultados apontando para menores massas corporais em indivíduos com determinados padrões alimentares vegetarianos, em nenhum dos grupos foi verificada a presença de algum IMC que classificado como obesidade.

Em crianças, o mesmo padrão em relação à composição corporal de adeptos a alimentação vegetariana também foi evidenciado, com menores IMCs em crianças vegetarianas, caracterizando a alimentação vegetariana como uma estratégia na prevenção da obesidade infantil (SABATÉ; WIEN, 2010).

No que tange à prevenção de Diabetes mellitus tipo 2, uma revisão sistemática com meta-análise analisou 477 estudos e os resultados apontaram associação da alimentação vegetariana com redução significativa de hemoglobina glicada (HbA1c) (-0.39 pontos percentuais, em um intervalo de confiança de 95% ($I^2 = 3.0$; -0.62 a 0.15), contudo, sem diferença em relação à glicemia de jejum analisada, apontando assim para a alimentação vegetariana como eficaz na prevenção do curso desta doença (YOKOYAMA et al., 2014).

2.3 Padrão alimentar vegano: Características, motivações, desafios e impactos na saúde.

O indivíduo adepto ao padrão alimentar vegano, também chamado vegetariano estrito, é aquele que exclui da alimentação todo e qualquer alimento de origem animal (CLARYS et al., 2014). Entretanto, existem divergências acerca da terminologia "vegano" e em que contexto ela pode ser aplicada.

Em algumas correntes de pensamento, a denominação "vegano" compreende não apenas escolhas relacionadas à alimentação, mas deve ser interpretada como um estilo de vida, onde escolhas referentes a todo e qualquer tipo de produto utilizado de forma cotidiana, devem ser isentas de produtos de origem animal ou de participação de animais na cadeia de produção (CLARYS et al., 2014; SLYWITCH, 2012). Sendo assim, no presente estudo, considera-se como vegano o padrão alimentar vegano (ou também chamado vegetariano estrito), e não o estilo de vida vegano. Contudo, existem discordâncias acerca desta nomenclatura, dado que a credo popular, esta denominação não necessariamente pode ser utilizada por aqueles cujas escolhas estendam-se a todo estilo de vida (DE SOUZA, 2022; SLYWITCH, 2012).

As motivações para a adoção deste padrão alimentar assemelham-se com os outros estilos dentro da alimentação vegetariana, com destaque para a bem-estar animal, bem-estar social e benefícios à saúde (CLARYS et al., 2014). De fato, como verificado nos diversos tipos de alimentação vegetariana, são evidentes múltiplos benefícios à saúde, mais especificamente, relacionados à manutenção do peso, melhoria de parâmetros relacionados com a ocorrência de doenças cardiovasculares, rendimento em esportes e prevenção e manutenção de diabetes mellitus tipo 2 (HARGREAVES; NAKANO; ZANDONADI, 2020; NAJJAR; FERESIN, 2019; SHRIDHAR et al., 2014).

Entretanto, com a retirada de laticínios, ovos e carnes verificam-se possíveis obstáculos no que diz respeito à escolha de alimentos em relação ao acesso, e à qualidade nutricional, sensorial e tecnológica de alimentos veganos. No padrão alimentar ocidental de alimentação, nutrientes essenciais à manutenção da vida humana como proteínas, ferro, zinco, vitaminas D e B12, cálcio, iodo e ômega 3 comumente são fornecidos por alimentos de origem animal, constituindo desafio no planejamento da alimentação vegana (MARIOTTI; GARDNER, 2019).

No que diz respeito à proteína de dietas veganas, é necessária atenção não apenas em relação à quantidade, mas também à qualidade destas visto que, ao passo de que uma porção de carne comumente fornece uma quantidade adequada de aminoácidos essenciais (aqueles não possíveis de serem sintetizados de forma endógena pelo corpo humano), uma única porção de proteína vegetal oriunda de leguminosa por exemplo, não apresenta quantidades satisfatórias de aminoácidos para compor um aminograma completo (MARIOTTI; GARDNER, 2019).

Entretanto, destaca-se que apesar de uma única porção de uma única leguminosa não fornecer todos os aminoácidos para compor um aminograma completo, diferentes fontes vegetais destes aminoácidos podem ser combinadas a fim de obtenção de parâmetros satisfatórios, como por exemplo, em um mesmo dia, uma ou mais fontes proteicas vegetais oriundas de cereais e leguminosas fazendo parte do hábito alimentar de um adepto ao padrão alimentar vegano (MARIOTTI; GARDNER, 2019).

2.4 Produtos veganos e sua influência no comportamento, atitudes e intenções de consumidores.

De forma concomitante ao crescimento da adoção do padrão alimentar vegano, cresce também o mercado direcionado para essa parcela da população. Contudo, tratando-se de um movimento cujas motivações para a adoção variam e nem sempre são convergentes entre os diversos grupos, diversas percepções são evidenciadas acerca destes produtos.

Um estudo (MIGUEL; COELHO; BAIRRADA, 2020b) analisou através de uma escala Likert as atitudespreponderantes em comunidades veganas e o impacto destas motivações na escolha da compra de produtos veganos, em dois grupos, um com 224 portugueses e outro com 356 brasileiros. Os resultados mostraram que dentre as possíveis motivações (pessoais: saúde e influência social; e morais: motivações ambientais e bem-estar animal), a classe de motivações morais (relacionadas cm a percepção dos próprios consumidores em relação aos produtos que estes consomem e o valor que agrega na percepção dos consumidores por outras pessoas) prevaleceu em ambos os grupos, sendo estas as principais norteadoras do consumo de produtos veganos. (MIGUEL; COELHO; BAIRRADA, 2020b).

Outro estudo (MALIK; JINDAL, 2022) realizado na Índia analisou as motivações para compra de produtos veganos de 214 voluntários encontrados através de grupos no *Facebook* ®. De forma semelhante, mostrou que motivações morais relacionadas com sustentabilidade e bem-estar animal prevaleceram em detrimento de motivações pessoais, com destaque que produtos com alegações relacionadas as estas motivações, exerceram impacto mensurado pela escala Likert empregada (MALIK; JINDAL, 2022). De forma convergente com ambos os estudos supracitados, um outro estudo conduzido na Itália (MARTINELLI; DE CANIO, 2021) também destacou as mesmas motivações para o consumo de produtos veganos, adicionando a informação de que o consumo destes contribuiu para a sensação de bem-estar social daqueles que os consomem (MARTINELLI; DE CANIO, 2021).

Na Alemanha, preceitos morais também demonstraram influenciar de forma mais significativa o consumo destes produtos, contudo, a preocupação com o meio ambiente pareceu não influenciar positivamente nem negativamente a população deste estudo (MARCUS; KLINK-LEHMANN; HARTMANN, 2022).

A religiosidade também influenciou de forma significativa a intenção de compra de produtos veganos. Sendo uma das principais motivações para a adesão a uma alimentação vegana, um estudo conduzido na Itália com 1218 participantes e outro no mesmo país com 898 consumidores demonstraram que além das motivações já citadas, a religião, não descrita pelo estudo, se constituía como um fator influenciador importante (MARTINELLI; DE CANIO, 2021; RAGGIOTTO; MASON; MORETTI, 2018)

No que diz respeito à rotulagem de produtos veganos, estudos (ASCHEMANN-WITZEL et al., 2021; NOGUEROL et al., 2021) demonstram que as alegações feitas pelos fabricantes nos rótulos destes produtos influenciam de forma importante a intenção de compra por parte da população vegana. Um estudo analisou as intenções de compra de 495 voluntários dinamarqueses frente a diferentes alegações de produtos veganos *plant-based* (ASCHEMANN-WITZEL et al., 2021).

O estudo verificou que estes consumidores, de padrões alimentares que incluíam o onívoro, flexitariano, vegetariano e vegano estavam mais atraídos para produtos com alegações de serem ricos em proteína, ao passo que quando especificada a fonte proteica (se era de soja, ervilha ou trigo), a intenção de compra apresentava aparente aumento, com destaque para os produtos à base de ervilhas (ASCHEMANN-WITZEL et al., 2021). O estudo verificou também que os melhores resultados foram encontrados naqueles produtos cuja fonte proteica principal era oriunda de batata (ASCHEMANN-WITZEL et al., 2021).

Ainda, tratando-se de produtos veganos, ao se estratificar a percepção de um mesmo produto a partir dos pontos de vista de indivíduos adeptos a diferentes padrões alimentares, como o onívoro, vegano, vegetariano e flexitariano, verificou-se diferença na intenção de compra e percepção acerca da qualidade de produtos veganos. Um estudo (NOGUEROL et al.,2021) realizado por escala Likert e posterior teste estatístico de Fisher a nível de significância de 5%, analisou a percepção relacionada a esses produtos em onívoros, veganos, vegetarianos e flexitarianos habitantes da Espanha.

Como principais resultados, notou-se que onívoros em sua maioria não tinham opinião formada sobre intenção de compra deste tipo de produto, enquanto vegetarianos, veganos e flexitarianos tinham a sustentabilidade, o bem-estar animal e a preocupação com a saúde como principais motivações para a compra destes (NOGUEROL et al., 2021). Além disso, no grupo de vegetarianos e veganos, observou-se significativa rejeição a análogos veganos de carne, provavelmente pelo fato de que adeptos a esse padrão alimentar comumente apresentam dentre suas motivações a rejeição de carnes de forma geral. Além disso, nesse mesmo grupo, não foi verificada inclinação de preferência para produtos classificados como *clean label* ("Rótulos limpos", com mínimo uso de aditivos alimentares), como evidenciado no grupo dos flexitarianos (NOGUEROL et al., 2021).

Alguns estudos, também realizados através de escala Likert analisaram também a intenção de compra de produtos veganos por parte da população que ainda mantém o consumo de carne, classificando-se como onívoros (DEMARTINI et al., 2022; STREMMEL et al.,2022). Na Alemanha, foi analisada a intenção de compra de almôndegas veganas e, dentre os principais achados do estudo, verificou-se que no grupo exposto às almôndegas sem a embalagem, ou seja, sem a alegação de ser um produto vegano, apenas a informação de que possíveis benefícios à saúde demonstraram efeito positivo quanto a percepção destas, contudo, no grupo exposto à embalagem das almôndegas a alegação "Vegan", efeitos negativos na percepção foram encontrados (DEMARTINI et al., 2022).

Um efeito similar foi evidenciado em outro estudo, onde produtos que naturalmente não continham nenhum ingrediente de origem animal (como massas, pães e biscoitos) foram dispostos em dois grupos, um sem alegação do produto ser vegano na embalagem e outro com esta a mesma alegação (STREMMEL et al., 2022). Por fim, verificou-se que os produtos quando acrescidos da alegação de serem veganos, acabavam por influenciar negativamente a intenção de compra destes, enquanto o mesmo produto, com os mesmos ingredientes e composição, sem a alegação especial, não exercia influência positiva nem negativa (STREMMEL et al., 2022).

2.4.1 Substitutos para produtos à base de carnes

Apesar de o padrão alimentar vegano ter em seus princípios à exclusão de cárneos em sua totalidade (CLARYS et al., 2014), é notória a demanda por produtos que simulem aqueles de origem animal, visto que, apesar de parte dos adeptos a um padrão vegano rejeite produtos similares à carne, uma outra parcela demanda substitutos equivalentes, principalmente do ponto de vista sensorial, mas nem sempre conseguem adequação em vegano aos aspectos nutricionais (ASHER; PETERS, 2021).

O consumo destes produtos vegano similares aos produtos cárneos já atinge uma parcela importante do mercado, com valor mundial estimado de 1 bilhão de dólares no ano de 2022 e projeção constante de crescimento (THE GOOD FOOD INSTITUTE, 2020). Dois pontos de destaque no que concerne à formulação de substitutos para produtos à base de carne (carne, aves, peixe e porco) relacionam-se com sua composição nutricional e os ingredientes empregados nestes produtos.

No que diz respeito à composição nutricional e aos ingredientes de análogos veganos de carne, alguns estudos realizados em outros países (Suécia, Noruega, Reino Unido, incluindo Inglaterra, Escócia, País de Gales e Irlanda, e Estados Unidos) trazem informações referentes ao mercado internacional destes produtos. Na Suécia, um estudo analisou 142 amostras de análogos veganos de carne, em relação às recomendações de nutrientes do país. De forma geral, os análogos veganos demonstraram ser opções mais saudáveis que seus equivalentes de origem animal em relação a alguns aspectos, apresentando maiores concentrações de fibra dietética (15%/100g em produtos veganos vs. 0%/100g em carnes) e menores concentrações de gordura saturada nos análogos veganos (4%/100g vs. 15%/100g em carnes).

Não foram evidenciadas diferenças significativas no que diz respeito ao quantitativo proteico, com valores médios de cerca de 16g/100g nos dois grupos de produtos analisados. Contudo, quantidades expressivas de sal foram encontradas em ambos os grupos, com cerca de 2.5g/100g em média tanto nos produtos veganos análogos de carne (hamburgueres, salsichas, filés, almôndegas, *schnitzel* e *nuggets*) quanto nos de origem animal (BRYNGELSSON et al., 2022b). Na Noruega, 102 análogos de carne veganos foram também analisados e resultados similares ao estudo realizado na Suécia foram encontrados, com os análogos apresentando maior concentração de fibra dietética (3,5-5g/100g em média) e menor teor de gorduras saturadas (de 1 a 9% a menos do que os análogos de origem animal).

No que diz respeito aos teores proteicos, diferenças significativas foram encontradas, com os análogos veganos apresentando cerca de 8,3 a 16,3g/100g em média e as versões tradicionais, 11,3-17,7/100g em média ($p < 0.001$). Não foram encontradas diferenças significativas nas quantidades de sal dos produtos em ambas as categorias, com valores médios de 0 a 1g/100g em média (TONHEIM et al., 2022).

No Reino Unido, 207 produtos análogos de carne foram analisados a partir de 14 fornecedores locais e foram extraídos dados acerca da composição nutricional destes (valor energético, gorduras totais e saturadas, proteína, fibra e sal por 100g de preparação). Em comparação com a carne, os análogos veganos apresentaram menores valores energéticos, de gorduras totais e saturadas e maiores concentrações de fibra, de forma similar aos outros estudos realizados supracitados analisados a partir da análise de rótulos nutricionais. Também não foram encontradas diferenças significativas em relação ao teor proteico das amostras analisadas, com valores entre 10 e 17g/100g em média.

Destacam-se como limitações a ausência dos conteúdos de ferro, visto que esse nutriente não tem sua declaração como mandatória na legislação do país. Um ponto de destaque é a legislação do Reino Unido, que atualmente adota a rotulagem frontal para aqueles produtos que possam ser considerados contendo valores excessivos de gorduras totais, gorduras saturadas ou sal. Cerca de 20% dos análogos veganos apresentavam divergências no contexto dessa legislação, com destaque para o conteúdo de sal, onde ¾ das amostras continham valores excessivos, com presença de advertências no rótulo frontal(ALESSANDRINI et al., 2021).

Em um estudo conduzido nos Estados Unidos, foram encontradas menores concentrações de energia, gorduras (totais, saturadas e trans e colesterol) e proteínas, enquanto maiores concentrações de sódio e fibras. Ademais, além da composição nutricional foram catalogados também os principais ingredientes de análogos veganos de hambúrguer (COLE et al., 2021). Dentre os produtos incluídos, a soja foi o ingrediente predominante (53,6% das amostras), seguido de ervilhas, trigo e proteína vegetal texturizada (de soja ou ervilha).

Apesar de o estudo não trazer os percentuais específicos de todas as categorias dos produtos, salientou-se que a proteína de ervilha se destacava como primeiro ingrediente em 3,6% das amostras (COLE et al., 2021). Já num estudo de natureza similar realizado na Austrália (CURTAIN; GRAFENAUER, 2019), os ingredientes de 137 produtos foram listados e classificados de acordo com seu grupo principal de nutrientes-fonte. Verificou-se a presença de proteína de soja e ervilha, grãos de soja, proteína vegetal hidrolisada, mico proteínas e amêndoas como fontes proteicas.

Como fontes de gordura, tanto total quanto saturada, óleos vegetais predominaram nesse grupo, contando com a presença também de “manteiga” de coco e de amendoim. Quanto aos ingredientes fonte de carboidratos, tubérculos ricos em amido foram os mais utilizados, tais como seus amidos isolados e farinhas. As leguminosas foram as principais fontes de fibra dietética (CURTAIN; GRAFENAUER, 2019).

2.4.2 Substitutos para laticínios

Os substitutos para leite de origem animal (vaca, cabra e búfala) já são amplamente utilizados dentro de diversos contextos alimentares. Além de pessoas adeptas à alimentação vegana, indivíduos acometidos por alergias ou intolerâncias alimentares já representam cerca de 2% da população mundial no caso de alergias e 65% no caso da intolerância à lactose proveniente do leite (FLOM; SICHERER, 2019; TOBEY, 1930).

No que se refere aos substitutos para leite de vaca, comumente estes são fabricados a partir de extratos hidrossolúveis de cereais, pseudocereais, leguminosas e oleaginosas (FRUCTUOSO et al., 2021) e suas respectivas composições nutricionais variam de acordo com a principal matriz utilizada. Dentro do âmbito dos substitutos para o leite de vaca, a literatura concentra-se em dois grandes eixos, o primeiro consistindo em bebidas vegetais desenvolvidas por pesquisadores e o segundo, em análises de produtos comerciais disponíveis para a população.

No que tange aos substitutos desenvolvidos por pesquisadores, diversas matrizes foram usadas, com origem nos diferentes grupos de alimentos. No grupo de cereais, estudos foram desenvolvidos a partir de arroz, centeio, cevada e aveia

(KARIMIDASTJERD; KILIC-AKYILMAZ, 2021; RAVINDRAN; RADHAISRI, 2020). Já no grupo das leguminosas, bebidas foram fabricadas majoritariamente à base de grãos de soja, contudo, grão de bico e castanhas baru (típicas do cerrado brasileiro) também estiveram presentes (DAMASCENO; BOTELHO; DE ALENCAR, 2020; FRUCTUOSO et al., 2021; MURARO; GIAMPIETRO; GALLI, 2002). Na categoria das oleaginosas, ingredientes comuns em substitutos veganos para leite, a castanha de caju é o ingrediente mais utilizado, seguido de amêndoas e castanhas do Pará (também chamadas de *Brazil nuts)* (FAISAL MANZOOR, 2017; RASZAP SKORBIANSKY; SAAVOSS; STEWART, 2022).

Do ponto de vista nutricional, é importante destacar que, no caso de bebidas vegetais desenvolvidas por pesquisadores, um objetivo comum entre os estudos é o desenvolvimento de alternativas saudáveis para substituição ao leite de vaca (DAMASCENO; BOTELHO; DE ALENCAR, 2020). Sendo assim, a maioria destes estudos utilizou concentrações ou combinações de ingredientes a fim de obter produtos cuja composição nutricional fosse comparável aos principais nutrientes fornecidos pelo leite de vaca, como proteína e cálcio (DAMASCENO; BOTELHO; DE ALENCAR, 2020; FAISAL MANZOOR, 2017; KARIMIDASTJERD; KILIC-AKYILMAZ, 2021; RAVINDRAN; RADHAISRI, 2020). Entretanto, na ótica dos produtos comercializados, é comum que sejam priorizados aspectos sensoriais em detrimento dos nutricionais (JESKE; ZANNINI; ARENDT, 2017).

Em uma revisão narrativa realizada por *Chalupa-Krebzdak e colaboradores* em 2018, 17 marcas comerciais de alternativas vegetais para o leite de vaca foram analisadas e, dentre as mais diversas matrizes (soja, amêndoas, castanhas do Brasil e caju), os resultados apontaram, de forma geral, para menor concentração proteica (0,1 a 0,5%) e de minerais comumente encontrados no leite de vaca (cuja concentração proteica pode chegar em até 10%), como o cálcio (entre 280 a 500mg em média, contra 750mg por porção de 100mg do leite de vaca) e o magnésio (entre 10 a 180mg em média, contra 250mg do leite de vaca) (CHALUPA-KREBZDAK; LONG; BOHRER, 2018a).

Nos Estados Unidos, em 2021, o estudo analisou e comparou os substitutos para leite de vaca disponíveis a partir dos rótulos nutricionais destes, utilizando uma abordam quantitativa de valores nutricionais para compra no país, contudo, sem utilizar o leite de vaca como comparativo nutricional. Como principais resultados, o estudo trouxe que as bebidas vegetais feitas à base de amêndoas e aveia apresentavam menos da metade do quantitativo proteico ofertado por outras bebidas fabricadas à base de soja, contudo, as bebidas de amêndoas apresentavam os maiores teores de cálcio dentre todas as bebidas analisadas, devido a presença de suplementos fortificantes (COLLARD; MCCORMICK, 2021a).

Outros nutrientes de interesse como a vitamina B12 e o folato apresentaram-se em quantidades reduzidas nas bebidas de amêndoas, enquanto bebidas fortificadas à base de soja apresentavam o dobro dessas quantidades em comparação a todas as outras bebidas analisadas. De forma geral, as bebidas vegetais apresentavam menor teor de gordura e consequente menor valor energético em comparação ao leite de vaca comercializado no país (COLLARD; MCCORMICK, 2021a).

Outro estudo foi conduzido nos Estados Unidos, com foco na cidade de Buffalo em Nova York (SINGHAL; BAKER; BAKER, 2017). A partir de uma análise de bebidas vegetais comercializadas na cidade, constatou-se que as marcas presentes na cidade correspondiam à 68% de todas as bebidas vegetais disponíveis no país como um todo e como resultado, constatou-se que os principais ingredientes utilizados na produção dessas bebidas eram a soja, amêndoas, castanhas de caju, avelãs, sementes de cânhamo, e aveia (SINGHAL; BAKER; BAKER, 2017).

Contudo, com exceção das bebidas à base de soja e semente de cânhamo, todas as bebidas comercializadas apresentavam teores reduzidos de proteína em comparação ao leite de vaca, de forma similar ao constatado por outro estudo no mesmo país (COLLARD; MCCORMICK, 2021a; SINGHAL; BAKER; BAKER, 2017). A fortificação dessas bebidas com nutrientes presentes no leite de vaca, destacando-se o cálcio e a vitamina D, estava presente na maioria destas bebidas. Porém, o estudo destaca que não foram realizadas análises quanto à biodisponibilidade dessas vitaminas em bebidas vegetais (SINGHAL; BAKER; BAKER, 2017).

Na Noruega, um estudo feito com o mesmo objetivo constatou resultados similares aos estudos supracitados, com as bebidas vegetais apresentando menores concentrações energéticas (entre 30 e 54kcal/100g, em comparação a 41-50kcal/100g do leite de vaca) e de proteína (0.4 a 1.7g/100g nas bebidas vegetais em comparação a 3.3 a 3.5g/100g no leite de vaca) (TONHEIM et al., 2022).

Além de estudos acerca da composição centesimal de bebidas vegetais, outros nutrientes de interesse também foram avaliados como o perfil de ácidos graxos e análise de digestão proteica *in vitro* de amostras comerciais de bebidas vegetais comercializadas ao mesmo tempo na Europa e América do Norte (MARTÍNEZ-PADILLA et al., 2020). De forma geral, as bebidas vegetais analisadas possuíam um perfil de ácidos graxos ricos em ácidos de perfis ômega 6 e 9 (entre 45 e 60% do quantitativo total de lipídios), com destaque para a bebida baseada em sementes de cânhamo, cuja composição apresentou o maior valor de ômegas 3 e 6, e a proporção mais ideal destes ácidos graxos. No que se refere à digestibilidade proteica, as bebidas de aveia e amêndoas apresentaram digestibilidade comparável ao leite de vaca, com a bebida de soja apresentando menor digestibilidade, sugerindo assim uma qualidade nutricional inferior apesar de seu maior quantitativo proteico (MARTÍNEZ-PADILLA et al., 2020).

Além das bebidas vegetais, outros produtos lácteos também possuem alternativas *plant-based* de interesse da população, como no caso dos iogurtes e dos queijos. Um estudo realizado na Noruega analisou 47 alternativas vegetais para iogurtes e, de forma geral, a maioria deles baseada em combinações de soja, castanhas de caju e coco, apresentou concentrações proteicas inferiores aos seus equivalentes de origem animal (TONHEIM et al., 2022).

Nos Estados Unidos, 249 amostras comerciais foram analisadas e o coco sobressaiu como a principal matriz para a produção destas (n = 79). Em seguida, foram utilizadas amêndoas (n = 20), aveia (n = 20), leguminosas (n = 16) e combinação de dois ou mais tipos de ingredientes (n = 52) (CRAIG; BROTHERS, 2021). Quanto à composição nutricional das amostras analisadas, cerca de 1/3 das amostras apresentavam mais de 5g de proteína por porção, quantidade essa similar a oferecida pelo iogurte feito à base do leite de vaca.

Ainda, apenas 45% das amostras veganas apresentavam valores de cálcio correspondentes a 10% do valor diário preconizado pelas recomendações de consumo diário (CRAIG; BROTHERS, 2021). Além disso, cerca de metade dos iogurtes analisados apresentava altos teores de açúcares (entre 5 e 10g de açúcar por porção, quase 50% da recomendação diária) consistindo em uma problemática (CRAIG; BROTHERS, 2021).

Na Europa, um estudo conduzido em 2021 analisou 182 amostras de iogurtes vegetais, e constatou que estas amostras continham maiores valores energéticos (100kcal/100g em média), gordura total (10g/100g em média) e carboidratos (15g/100g em média) que seus equivalentes baseados em laticínios, demonstrando ainda que não havia diferença entre o quantitativo de gordura saturada, açúcar e sal (BOUKID et al., 2021).

No que diz respeito às alternativas veganas comerciais para queijo, comumente formulações à base de oleaginosas (com destaque para a castanha de caju) ou de amidos de mandioca e/ou batata são empregadas (BOUKID et al., 2021). De forma geral, os estudos apontam que as alternativas veganas para queijos apresentam divergências nutricionais em relação a suas equivalentes de origem animal, com destaque para menores quantidades de proteínas, gorduras e cálcio (BOUKID et al., 2021; TONHEIM et al., 2022).

Ademais, dadas as matrizes alimentares utilizadas na formulação destes produtos, regularmente queijos veganos possuem perfil rico em carboidratos (11g/100g em média), gorduras totais e saturadas (entre 20 e 35g/100g em média) e valores de sódio entre 15 e 300mg/100g e aromatizantes visando melhoria da qualidade sensorial destes (BOUKID et al., 2021; TONHEIM et al., 2022).

2.4.3 Substitutos para ovos

No contexto de substitutos para ovos de galinha, atualmente verifica-se a disponibilidade e foco da indústria em desenvolver soluções relacionadas não aos ovos *in natura*, mas sim aos ovos dentro de preparações, como no caso de emulsões e produtos de panificação (BRENNAN et al., 2022).

Priomordialmente, sugeriu-se o uso de hidrocoloides oriundos da mucilagem de sementes como a Chia (*Salvia hispânica*) e a Linhaça (*Linum usitatissimum*), visto que potencialmente estas poderiam agir como agentes melhoradores de textura em bolos e produtos de confeitaria de forma geral (MENGA et al., 2017). Contudo, apesar de verificada sua aplicabilidade ótima nos pontos de vista microbiológico, sensorial e nutricional, os géis oriundos dessas sementes não oferecem melhoras significativas na textura das preparações nas quais estiveram presentes (GALLO et al., 2018). Ademais, estes também não são comercializados como produtos substitutos de ovos (MENGA et al., 2017).

Sendo assim, no caso dos produtos em confeitaria, destaca-se uma outra opção, a utilização da água de cozimento de leguminosas como o grão de bico (*Cicer aretinum*) e a ervilha (*Pisum sativum*), que popularmente denomina-se como aquafaba (MUSTAFA et al., 2018a). De forma similar ao que ocorre na clara de ovo, a água de cozimento dessas leguminosas é rica em proteínas (entre 1 e 18%) solubilizadas que se desnaturam e aprisionam bolhas de ar quando submetidas à intensa agitação mecânica, como ocorre em batedeiras domésticas, formando uma espuma de estabilidade entre 89 e 93% (BUHL; CHRISTENSEN; HAMMERSHØJ, 2019).

Esta espuma por sua vez, tem sua aplicação destacada em produtos de confeitaria, pois o ar aprisionado nessa estrutura proteica formada pela agitação constante confere características sensoriais interessantes para os produtos nos quais ela é adicionada, como crescimento, coloração e melhor estrutura (MUSTAFA et al., 2018b). Contudo, uma das problemáticas do uso da aquafaba tem relação com a falta de padrão e consistência nas características da formação de espuma. Em outro estudo conduzido em 2018, verificou-se variações significativas na espuma produzida oriundas de diferentes latas de grão de bico e inclusive, entre diferentes latas de diferentes lotes de fabricação, porém do mesmo fabricante (MUSTAFA et al., 2018b).

Ademais, outros estudos demonstraram possíveis variáveis positivas de interferência na estabilidade e volume da espuma, como o diferente cultivar de grão de bico, presença e uso da água de remolho dos grãos (*soaking)*, pH mais ácido, uso de cloreto de sódio e de aditivos com propriedades emulsificantes (BUHL; CHRISTENSEN; HAMMERSHØJ, 2019; HE et al., 2019; LAFARGA et al., 2019; MUSTAFA et al., 2018a, 2018b).

Além disso, espumas formadas a partir de opções enlatadas de grão de bico cozido parecem oferecer melhor volume e estabilidade, provavelmente por maior tempo de contato do grão com o líquido de cocção resultando em melhor solubilidade das proteínas e a presença de cloreto de sódio que funciona como estabilizante dessa espuma (RAIKOS; HAYES; NI, 2020).

A aquafaba também é utilizada como substituto de ovos em preparações baseada em emulsões de água e óleo, como maioneses. No estudo realizado em 2019, desenvolveu-se uma alternativa vegetal para a maionese, e a estabilidade da aquafaba como ingrediente principal foi investigada (RAIKOS; HAYES; NI, 2020).

De forma geral, evidenciou-se que a aquafaba pode ser utilizada de forma bem-sucedida nessa preparação, ademais, verificou-se que proporção de aquafaba e óleo (15%/80%) obteve os melhores resultados em relação à estabilidade, coesividade e aderência da espuma, com resultados inferiores quando modificada essa proporção (RAIKOS; HAYES; NI, 2020).

Dentro do contexto de produtos veganos, além do uso da aquafaba, destaca-se também o uso de proteínas a base de leguminosas como substitutos para ovos. A principal hipótese é de que o quantitativo proteico dessas leguminosas forneceria o percentual perdido com a retirada dos ovos, resultando em melhoras tanto do ponto de vista tecnológico quanto nutricional (SÖDERBERG, 2013).

Entretanto, devido às diferenças no que tange a funcionalidade tecnológica das claras e gema de ovos de galinha, que respondem pela coloração, textura, durabilidade e coesividade de produtos, as proteínas vegetais à base de leguminosas apresentam funcionalidade limitada quando empregadas com o mesmo propósito, visto que essas não oferecem as mesmas características proporcionadas pelo uso dos ovos de galinha (SÖDERBERG, 2013). De forma geral, destaca-se a escassez de estudos realizados acerca da composição nutricional e ingredientes utilizados nos produtos veganos comercializados no Brasil, evidenciando-se assim uma lacuna de conhecimento acerca do tema.

3. Objetivos

3.1 Objetivo Geral

Avaliar a composição nutricional e os principais ingredientes dos análogos veganos de carne, leite e ovos comercializados no Brasil

3.2 Objetivos Específicos

Revisar de forma sistemática a composição nutricional de produtos veganos comerciais que simulam alimentos de origem animal

Comparar a composição nutricional dos análogos veganos com seus equivalentes de origem animal

Analisar os ingredientes utilizados em formulações veganas comercializadas no Brasil

4. Materiais e Métodos

4.1 Caracterização do estudo

Este estudo foi realizado em duas etapas principais, a primeira consistindo em uma revisão integrativa com busca sistemática acerca da composição nutricional e ingredientes de produtos veganos comerciais que simulam alimentos de origem animal e, a segunda etapa caracterizada por um estudo quantitativo experimental transversal comparativo realizado em três etapas: (i) mapeamento de amostras; (ii) coleta e classificação de dados; (iii) análise estatística.

4.2 Revisão Integrativa

4.2.1 Revisão Integrativa

A revisão integrativa abordou uma busca de literatura sistemática feita de acordo com o preconizado pelos guias *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (*PRISMA)* (MOHER et al., 2009) e *Guidance of European Food Safety Authority* (DEEKS et al., 2010). Como não se trata de uma revisão sistemática acerca de desfechos na saúde em seres humanos e/ou ensaios clínicos, não será necessário o registro da revisão na plataforma PROSPERO.

4.2.2 Critérios de inclusão

Foram incluídos apenas estudos experimentais relacionados à determinação quantitativa de nutrientes e ingredientes de substitutos de carne comerciais que simulam produtos de origem animal. Foram considerados estudos com análises para substitutos de carne (incluindo frango, peixe e porco)

4.2.3 Critérios de exclusão

Excluiram-se da revisão estudos categorizados como: 1) revisões, cartas, resumos de conferências, relatos de casos, comunicações breves e livros; 2) estudos que não analisaram quantitativamente os nutrientes ou ingredientes presentes em substitutos de carne que buscam simular produtos de origem animal; 3) estudos que desenvolveram os produtos especificamente para a publicação sem análise de produtos comercializados.

4.2.4 Fontes de informação

Foram desenvolvidas estratégias detalhadas de busca individual para cada uma das seguintes bases de dados: *PubMed, EMBASE, Scopus, Science Direct e Web of Science*. A Pesquisa de literatura cinzenta fi realizada com o *Google Scholar* ®. Além disso, buscaram-se registros de patentes por meio das seis bases de dados mencionadas e da ferramenta de patentes do Google incluída no Google Scholar.

As listas de referências de artigos selecionados para leitura de texto completo foram examinadas manualmente para possíveis estudos relevantes que pudessem ter sido perdidos durante a busca eletrônica em bancos de dados.

4.2.5 Estratégia de busca

Nesta etapa, foram empregadas palavras-chave utilizadas de forma combinada ou isolada em todas as bases de dados em língua inglesa, sendo feitas as adaptações de forma necessárias em cada base. As palavras-chave foram as seguintes: “produto”, “veganos”, “substitutos”, “carne”, “frango”, “porco”, “plant”, “based”, “alternativas”, “comercializados”, “comerciais”, “vendidos”. Os softwares *Endnote Web* ® e *Rayyan Web* ® foram utilizados para o gerenciamento das referências bibliográficas.

4.2.6 Seleção dos estudos

A seleção dos estudos foi feita em dois momentos. No primeiro momento, dois revisores (1R e 2R) analisaram de forma independente os títulos e resumos de todas as referências identificadas e disponíveis nos bancos de dados analisados.

Artigos que não atenderam aos critérios de inclusão serão descartados. Em seguida, após feitas as decisões por parte do primeiro (1R) e segundo (2R) revisores, um terceiro revisor (3R) analisou as possíveis discordâncias e determinou a possível inclusão ou exclusão dos artigos. Na fase 2, os mesmos revisores (1R e 2R) aplicaram os critérios de elegibilidade aos textos completos dos artigos selecionados. Em casos de discordância, o terceiro revisor (3R) foi consultado para resolução de discordâncias.

Ademais, dois experts (E) no assunto esteve disponível para resoluções de divergências não possíveis de serem tratadas pelo terceiro revisor (3R) e para inclusão de textos completos os quais achar pertinente. A decisão final dos artigos componentes da amostra foi feita com base nos textos completos.

4.2.7 Processo de coleta dos dados presentes nos artigos

Foram coletados os seguintes dados dos trabalhos incluídos: autores e ano da publicação, país do estudo, objetivo do estudo, delineamento do estudo, fonte de informações da composição nutricional (rótulo ou análise laboratorial de composição química), composição nutricional dos produtos, principais ingredientes utilizados nos produtos estudados e conclusões do estudo.

Os dados coletados foram sintetizados em tabelas utilizando o software *Microsoft Excel* ® (Estados Unidos, 2022). Os dados coletados a partir dos estudos foram categorizados a partir do proposto para substituição de cada produto. Criou-se as categorias: Hambúrgueres, almôndegas, carne moída, pedaços, cortes de frango, nuggets de frango, cortes frios, salsichas, frutos do mar, cortes bovinos, outros, *schnitizel* e variados.

4.2.8 Análise Estatística

A composição nutricional dos substitutos de carne coletados dos estudos incluídos foi categorizada em gramas (g) para carboidratos, proteínas, fibras dietéticas, gorduras totais e gorduras saturadas. Ferro e zinco foram coletados em miligramas (mg) e vitamina B12 em microgramas (mcg). Nos estudos onde a energia foi descrita em quilojoules (Kj), seus respectivos valores foram convertidos para quilocalorias (Kcal), utilizando o fator de conversão de 4.184 (1Kcal = 4.184Kj). Nos produtos em que apenas o seu teor de sal (g) estava disponível, o seu valor foi convertido para sódio (mg), considerando cada grama de sal correspondente a 400mg de sódio.

Foram calculados os valores de mediana, máximo e mínimo da composição nutricional dos substitutos da carne. Nesta etapa foi utilizado o software Microsoft Excel ® (Estados Unidos, 2022). Uma matriz de gráfico de dispersão foi gerada com base nos valores nutricionais coletados para cada categoria de produto. Para visualização gráfica, uma nuvem de palavras foi gerada com base nas frequências dos ingredientes implementados nas amostras incluídas, visto que frequências mais altas são representadas com palavras mais proeminentes (WORDCLOUDS, 2020)

4.3 Estudo Experimental

4.3.1 Levantamento de amostras

Os critérios de inclusão das amostras de substitutos de carne, leite e derivados e ovos no estudo foram: (i) a presença do selo “Produto Vegano”, oferecido pela Sociedade Vegetariana Brasileira (SVB®) para classificação de produtos veganos; (ii) produtos comercializados em redes de hiper e supermercados presentes nas cinco regiões brasileiras e/ou lojas de alimentos com abrangência nacional e regional.

Os critérios de exclusão foram alimentos frescos ou outros produtos veganos cujo objetivo não seja simular qualquer contraparte de origem animal. Este estudo não incluiu produtos veganos e animais rotulados com as alegações nutricionais “baixo teor de gordura” e “baixo teor de sal”, pois estes poderiam influenciar os resultados. O e-commerce foi consultado por meio de plataformas de busca (Google®), revendedores brasileiros de produtos veganos online e nas redes sociais (Instagram®, Facebook® e Twitter®), por meio de hashtags e buscas nominais para alcançar a cobertura nacional de análogos veganos vendidos no mercado brasileiro. A investigação foi realizada de 1º de fevereiro de 2021 a 1º de dezembro de 2021.

A busca foi realizada em 3 fases: um pesquisador procurou os produtos veganos na primeira fase. Em seguida, um segundo pesquisador repetiu o processo de busca e analisou a necessidade de incluir mais produtos. Como resultado, dois acadêmicos independentes verificaram novamente a precisão dos dados extraídos. Por fim, um terceiro pesquisador coordenador analisou criticamente os dados, determinando a amostra final com base nos critérios de inclusão.

Em seguida, os produtos análogos foram classificados em quatorze categorias de acordo com o produto-alvo: Hambúrgueres; Carne moída; Almôndegas; Frango Empanado; Hambúrgueres de Frango; Peito de Frango; Peixe enlatado; Bolo de peixe; Salsichas; Presuntos; Bebidas; Iogurtes; Queijos; Ovos e Maioneses.

Além disso, para fins de comparação, três amostras de três diferentes produtos de origem animal mais vendidos no Brasil para cada contraparte de produtos de origem vegetal também foram incluídas no estudo.

4.3.2 Coleta de dados

A coleta de dados seguiu estudos anteriores sobre versões modificadas de produtos comercializados (ALESSANDRINI et al., 2021; BOUKID et al., 2021; BRYNGELSSON et al., 2022a; COLE et al., 2021; CRAIG; BROTHERS, 2021; FRESÁN; RIPPIN, 2021; TONHEIM et al., 2022) que objetivaram analisar as quantidades de nutrientes e ingredientes implementados a partir de rótulos nutricionais. Os dados qualitativos e quantitativos relatados sobre os produtos foram registrados, incluindo nome da empresa, nome da marca, nome descritivo, lista de ingredientes, informações de nutrientes e tamanho da porção.

As informações sobre os ingredientes e valores nutricionais foram coletadas nos rótulos dos alimentos. Eles permitem que os consumidores escolham alimentos saudáveis e adequados de acordo com seu padrão alimentar pelo perfil nutricional e lista de ingredientes.

De acordo com a legislação brasileira, é obrigatório descrever o tamanho da porção (g), e em relação à porção, o valor energético (kcal), carboidratos (g), açúcares adicionados (g), proteínas (g), gorduras (g), gorduras saturadas (g), fibra alimentar (g) e sódio (mg) (BRASIL, 2003). Quando disponíveis, nutrientes de declaração facultativa, como o cálcio e vitamina B12 também foram coletados (BRASIL, 2003). Para fins de padronização e comparação, todos os valores foram convertidos para a porção de 100 g. Para evitar a dupla inclusão de produtos, se mais de um produto tivesse a mesma composição, eles foram considerados apenas uma vez.

4.3.3 Análise Estatística

Dados referentes ao valor energético (kcal) das amostras incluídas, carboidratos (g), açúcares adicionados (g), proteínas (g), gorduras (g), gorduras saturadas (g), fibra alimentar (g) e sódio (mg) foram calculados em suas respectivas médias ± desvios padrão (DP). A comparação entre os valores nutricionais dos substitutos de carne, leite, ovos e seus respectivos produtos à base de proteína animal foi realizada com teste não paramétrico de Mann-Whitney com nível de confiança de 95% ($p<0,05$). Hipóteses bicaudais foram consideradas no teste. O *Microsoft Excel*® (EUA, 2021) e o *SPSS® versão 22.0* (IBM SPSS Statistics, Versão 22.0, IBM corp., Chicago, IL USA, 2020) foram usados para realizar os testes.

Para visualização gráfica, foi gerada uma nuvem de palavras com os ingredientes implementados de análogos de refeições veganas, visto que frequências mais altas são representadas com palavras mais proeminentes na nuvem (Wordclouds ®, 2022)

No que diz respeito a geração da nuvem de palavras, as fontes proteicas foram agrupadas de acordo com sua matriz principal; por exemplo, proteína de soja texturizada, proteína de soja isolada e soja foram todos agrupados como “soja”. Os principais ingredientes utilizados nos produtos incluídos também foram incluídos na nuvem de palavras.

Além disso, as informações sobre os ingredientes foram representadas por porcentagens em um mapa de calor onde a cor indica a presença do ingrediente de acordo com as categorias estipuladas. O software *GraphPad Prism* ® (San Diego, CA, EUA, 2022) foi usado para gerar os mapas de calor.

CAPÍTULO 2

Nesse capítulo são explorados os resultados da pesquisa e suas respectivas discussões, dispostas na apresentação dos três artigos resultantes da tese.

ARTIGO 1: "*Nutritional profile of plant-based meat commercialized woldwide: An integrative review with a systematic approach"* (ROMÃO et al., 2023)

Nutritional profile of plant-based meat commercialized worldwide: An integrative review with a systematic approach

Given the high demand for resources for meat production and the increase in the number of adepts of meatless diets, the demand for plant-based meat substitutes also grows. In this prosperously growing market, there is a lack of knowledge about the nutritional value of these meat substitutes and their ingredients. This study aimed to review the nutritional composition and ingredients of meat substitutes commercialized worldwide. An integrative review was performed with a systematic literature search in PubMed, EMBASE, Scopus, Science Direct, Web of Science, and 11 studies were selected to compose the sample of this review. Data on meat substitutes' nutritional composition and ingredients from different categories were collected and analyzed. The results showed that meat substitutes commonly present lower energy values and higher amounts of carbohydrates and dietary fiber. Protein values varied according to the meat substitute category, with some showing a higher concentration than others, more specifically, in substitutes for bovine meat. Higher values were found in the Pieces category and lower in Seafood substitutes. Unlike animal meat, vegan meat has a proportion of carbohydrates higher than protein in most samples, except for the chicken substitutes. Meat substitutes presented similar total and saturated fat content compared to their animal-based counterparts. Higher amounts of fat were found in the "Various" category, and lower in "Pieces". Ingredients such as soy, pea, and wheat were the primary protein sources in meat substitutes, and vegetable oils were their primary fat source. Methylcellulose, various gums, and flavorings were the most used food additives. In general, meat substitutes presented high concentrations of sodium, possibly collaborating with an excessive sodium intake, highlighting the need for developing sodium-reduced or sodium-free alternatives. Most of the included samples did not describe the concentration of iron, zinc and vitamin B12. Further studies are needed to develop meat substitutes with better nutritional composition, fulfilling the need for equivalent substitutes for animal-based meat.

Keywords: plant-based; meat substitutes

Introduction

The demand for plant-based meat substitutes is growing worldwide for several reasons, such as welfare, sustainability, and health benefits (Hargreaves, Nakano, and Zandonadi 2020; Raphaely and Marinova 2013). Meat is a food that is ostensibly present in the eating habits of western populations, being responsible for providing several key-nutrients such as proteins, fats, minerals such as iron and zinc, and vitamins A, and B12 (Demartini et al. 2022). Its world consumption is about 25 kg per capita per year (McCarthy 2019); however, concerning its production, it can harm the local environment and world sustainability.

Meat production demands the concomitant use of a series of resources, such as land, water, and energy, and this model has already proven to be economically unfeasible since between 75 to90% of the energy and resources invested in cattle is lost in the animal's body maintenance and manure production (Djekic 2015). In addition, it is estimated that the production of 200g of beef involves the expenditure of 792 liters of drinking water, 4kg of grains for feeding, the deforestation of 6.6m², and the emission of 50kg of CO_2 into the atmosphere (Milford and Kildal 2019).

Also, the number of adherents to diets that remove all or part of meat or meat products grows prosperously (Estruch, Sacanella, and Ros 2021). In the world, although there is no global data on followers of meat-free diets, data on vegetarianism show significant numbers in Asia (19% of the population), Africa (16%), South and Central America (8%) and North America (6%) (Statista 2016). Moreover, given the influence of food on the social interactions of human beings, the search for plant-based meat substitutes also increases (Asher and Peters 2021; Demartini et al. 2022) .Therefore, This population needs products that replace meat and its technological and nutritional aspects.

Typically, plant-based meat substitutes consist of products based on a mix of legumes and cereals, using different technologies, depending on the final product characteristics, added (or not) by food additives to improve flavor, texture, and appearance (Onwezen et al. 2021).

However, several questions are raised about the nutritional quality of these products. Given the objective of complete meat replacement, these plant-based products must have similar nutritional quality in composition and amount of nutrients (Elzerman et al. 2021). In addition, potential health problems related to the additives used to mimic the sensory characteristics of meats are commonly observed in studies. (Demartini et al. 2022; Tyndall et al. 2022). Also, a possible heterogeneity in the nutritional composition of these meat substitutes is expected because of different matrices combinations, making it difficult for consumers to choose the best choice from a nutritional point of view.

In this sense, the objective of this review is to compile and analyze different plant-based meat substitutes (including substitutes for chicken, seafood, and pork) mapped by studies carried out around the world and, from that, provide better information to consumers to facilitate the understanding of the market.

Methods

An integrative literature review was performed with a systematic approach for best scientific rigor. The search phase for this integrative review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Checklist (Moher et al. 2009).

Inclusion and Exclusion Criteria

Only experimental studies related to the quantitative determination of nutrients and ingredients of commercial vegan meat substitutes that mimetic products of animal origin were included. Studies with analysis of meat substitutes (including chicken, fish, and pork) were included. Studies categorized as: Reviews, letters, conference abstracts, case reports, brief communications, and books were excluded from the review, were also excluded studies that did not quantitatively analyze the nutrients or ingredients in vegan products that seek to mimic products of animal origin.

Information Sources

Adapted and individual search strategies were developed for six databases: PubMed, EMBASE, Scopus, Science Direct, Web of Science, and gray literature (Scholar Google ®). Patents were searched using the Google Patent® tool. The last search was performed on September 1st, 2022. In addition, reference lists of included articles were examined for possible studies not retrieved before.

Search Strategy

At this stage, combined or isolated keywords were used in all the databases in English, and the necessary adaptations were made in each database. The keywords were the following: “product”, “vegan”, “substitutes”, “meat”, “beef”, “chicken”, “pork”, “plant”, “based”, “commercialized”, “commercial”, “sold”. Endnote Web ® and Rayyan Web ® software were used to manage bibliographic references.

Study Selection

The selection of studies was performed in two stages. At first, two reviewers (B.R. and M.L.T.) independently analyzed the titles and abstracts of all references identified and available in the analyzed databases. Articles that did not meet the inclusion criteria were discarded. Then, after decisions were made by the first (B.R.) and second (M.L.T.) reviewers, a third reviewer (D.C.M) analyzed possible disagreements and determined the potential inclusion or exclusion of the articles. In phase 2, the same reviewers (B.R. and M.L.T.) applied the eligibility criteria to the full texts of the selected articles. In cases of disagreement, the third reviewer (D.C.M) was consulted to resolve disagreements. In addition, two experts (R.B.A.B. and R.P.Z.) on the subject were available to resolve disagreements that could not be dealt with by the third reviewer (D.C.M) and for the inclusion of full texts deemed relevant. The final decision on the articles comprising the sample was made based on the full texts. The flow diagram of the literature search and selection criteria is shown in figure 1.

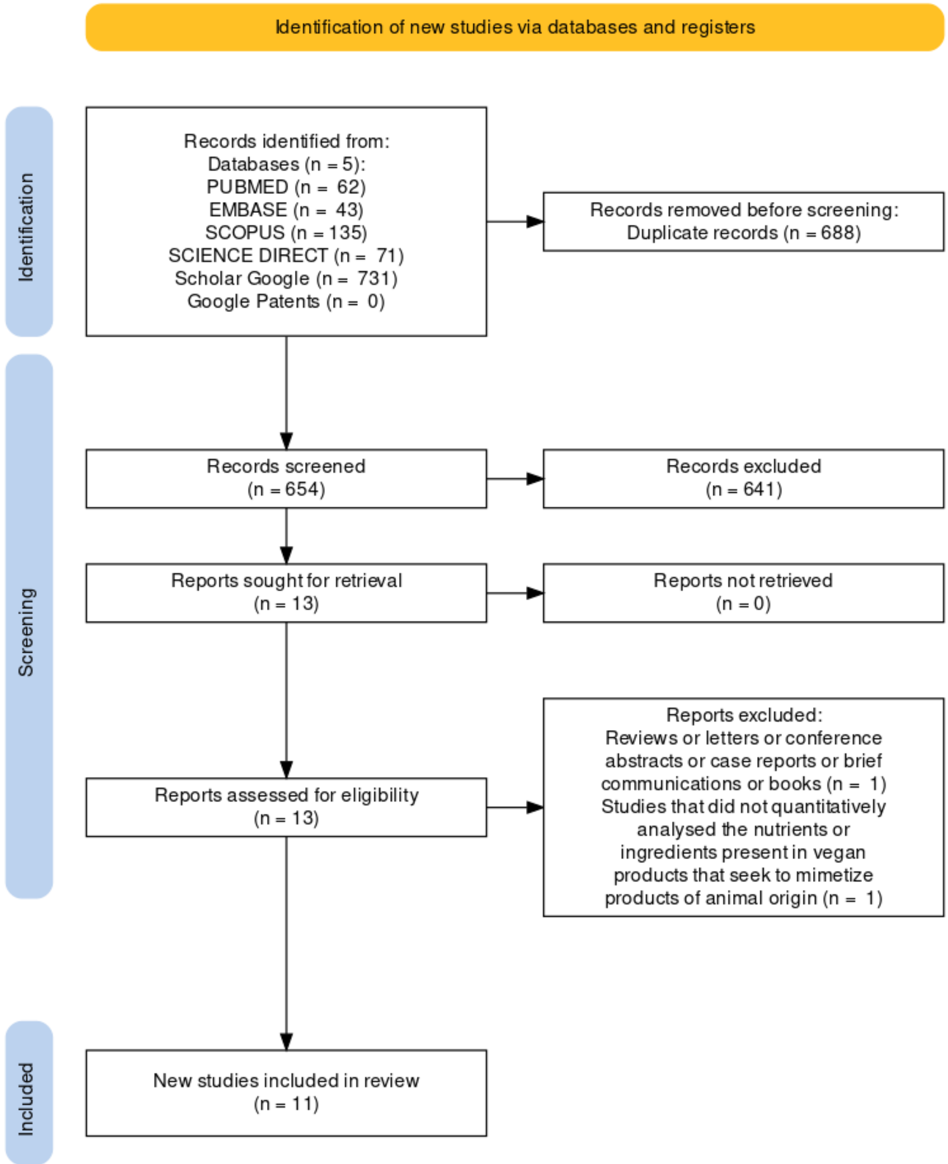

Figure 1 – Flow diagram of the literature search and selection phases adapted from PRISMA guidelines (Haddaway et al. 2022).

Data Collection

The following data were collected from the included works: authors and year of publication, country of study, source of information of the nutritional composition analysis (label or laboratory analysis of chemical composition), the nutritional composition of the products (energy, carbohydrates, sugars, protein, dietary fiber, total fat, saturated fat, sodium, iron, zinc, and vitamin B12). When available, the main ingredients used in the studied products were collected. The complete table with all collected results is available in Table S1 (Supplementary File). Different meat substitutes were grouped into different categories to evaluate the nutritional composition better. The categories and their components are listed in Table 1.

Table 1 – Developed categories and their respective components

Burgers	*Bovine meat burgers, "beef" burgers, red meat burgers*
Meat Balls	*Red beef minced balls*
Minced	*Bovine meat minced beef*
Pieces	*Red meat fillets, medallions, scallops*
Chicken Cutlets	*Chicken wings, chicken breast, chicken hamburgers*
Chicken Nuggets	*Breaded chicken, breaded chicken balls,*
Cold Cuts	*Hams, bologna, turkey breast*
Sausages	*Sausages, pepperoni*
Seafood	*Fish cakes, canned fish, tuna, shrimps, calamari, fish fingers, fish sticks, salmon, caviar, and fillet*
Cutlets	*Bovine meat cutlets*
Others	*"Vegan Roast," "Bacon-Style Rashers," and "Polony."*

Schnitzel	*German chicken schnitzel*
Various	*Meat substitutes without discrimination about the category of the product.*

The collected data were synthesized in tables using Microsoft Excel ® software (United States, 2022). Calibration exercises were performed with the designated reviewers (B.R., M.L.T., and D.C.M.) to ensure the consistency of the information collected.

Data Classification and Statistical Analysis

The nutritional composition of the collected meat substitutes from included studies was categorized in grams (g) for carbohydrates, protein, dietary fiber, total fat, and saturated fat. Iron and zinc were collected in milligrams (mg), and vitamin B12 in micrograms (mcg). In studies where energy was described as kilojoules (Kj), their respective values were converted to kilocalories (Kcal), using the conversion factor of 4,184 (1Kcal = 4,184Kj). In products where only its salt (g) content was available, its value was converted to sodium (mg), considering each gram of salt respective to 400mg of sodium.

The median, maximum, and minimum values of the nutritional composition of meat substitutes were calculated. Microsoft Excel ® software (United States, 2022) was used in this stage. A scatterplot matrix was generated based on the nutritional values collected for each product category. For graphical visualization, a word cloud was generated based on the frequencies of the implemented ingredients on included samples, given that higher frequencies are represented with more prominent words (WordClouds 2020)

Results

In all electronic databases, we identified 654 articles. We did not find registered patent of meat substitutes. In Phase 1, we selected 13 articles for their potential interest. In Phase 2, two articles were excluded for not attending the specified criteria. Our experts did not include additional articles. Therefore, 11 articles were eligible for a complete reading. All of these met the eligibility criteria, and all the included studies were published between 2019 and 2022.

Studies General Characteristics

A total of 10 countries published studies regarding the nutritional value of meat substitutes around the world: Denmark (Ložnjak Švarc et al. 2022) (n=1; 9.09%); USA (Cole et al. 2021; Harnack et al. 2021) (n=2; 18.18%); Spain (Boukid et al. 2022) (n=1; 9.09%); Latvia (Mariseva and Beitane 2020) (n=1; 9.09%); Italy (D'Alessandro et al. 2022) (n=1; 9.09%); Brazil

(Romão, Botelho, Nakano, Raposo, et al. 2022) (n=1; 9.09%); Australia (Curtain and Grafenauer 2019) (n=1; 9.09%); Sweden (Bryngelsson et al. 2022) (n=1.; 9.09%); UK (Alessandrini et al. 2021) (n=1.; 9.09%) and Norway (Tonheim et al. 2022) (n=1; 9.09%).

From all included studies, 64% (n = 7) studied only the nutritional composition of meat substitutes (Alessandrini et al. 2021; Boukid et al. 2022; Bryngelsson et al. 2022; Cole et al. 2021; Harnack et al. 2021; Ložnjak Švarc et al. 2022; Tonheim et al. 2022). The remaining four studies (36%) analyzed nutrients and ingredients (Curtain and Grafenauer 2019; D'Alessandro et al. 2022; Mariseva and Beitane 2020; Romão, Botelho, Nakano, Raposo, et al. 2022). Only one study (Ložnjak Švarc et al. 2022) performed chemical analysis to obtain the nutritional value of analyzed meat substitutes. The remaining studies (n = 10; 91%) utilized food labels as their information source.

Meat Substitutes Samples Characteristics

Regarding the categories of most frequently included meat substitutes, 54.54% (n=6) of the studies included "burgers" in their samples (Alessandrini et al. 2021; Bryngelsson et al. 2022; Cole et al. 2021; Curtain and Grafenauer 2019; D'Alessandro et al. 2022; Romão, Botelho, Nakano, Raposo, et al. 2022); 54.54% (n = 6) of the studies included "minced" (Alessandrini et al. 2021; Bryngelsson et al. 2022; Curtain and Grafenauer 2019; Harnack et al. 2021; Ložnjak Švarc et al. 2022; Romão, Botelho, Nakano, Raposo, et al. 2022); 45.45% (n=5) of the studies included "sausages" (Alessandrini et al. 2021; Bryngelsson et al. 2022; Curtain and Grafenauer 2019; Ložnjak Švarc et al. 2022; Romão, Botelho, Nakano, Raposo, et al. 2022); 36.36% (n=4) of the studies included "meat balls" (Alessandrini et al. 2021; Bryngelsson et al. 2022; D'Alessandro et al. 2022; Ložnjak Švarc et al. 2022); and "cold cuts" (Bryngelsson et al. 2022; D'Alessandro et al. 2022; Ložnjak Švarc et al. 2022; Romão, Botelho, Nakano, Raposo, et al. 2022).

In lesser frequency, 27.27% (n = 3) analyzed "seafood" (Boukid et al. 2022; Curtain and Grafenauer 2019; Romão, Botelho, Nakano, Raposo, et al. 2022), "chicken cutlets" (Alessandrini et al. 2021; Curtain and Grafenauer 2019; Romão, Botelho, Nakano, Raposo, et al. 2022) and "Chicken nuggets" (Alessandrini et al. 2021; Bryngelsson et al. 2022; Romão, Botelho, Nakano, Raposo, et al. 2022); 18.18% (n=2) of the studies evaluated "pieces" (Bryngelsson et al. 2022; Ložnjak Švarc et al. 2022) and "various" (Mariseva and Beitane 2020; Tonheim et al. 2022).

The categories "Cutlets", "Others" and "Schnitzel" were present in only one study each (Bryngelsson et al. 2022; Curtain and Grafenauer 2019; D'Alessandro et al. 2022). The collected nutritional composition for studied meat substitutes and their respective medians, maximum and minimum values are in Table 2. The complete composition of the analyzed meat substitutes of the included studies, by category of sample is available in Table S2 (Supplementary file).

Table 2 – Nutritional composition of studied meat substitutes with their medians, maximum and minimum values in 100g of the product.

Type of Product	Energy (Kcal)	Carbohydrates (g)	Sugars (g)	Protein (g)	Dietary Fiber (g)	Total fat (g)	Saturated Fat (g)	Sodium (mg)	Iron (mg)	Zinc (mg)	Vitamin B12 (mcg)
Burgers	196 (216-175)	11.13 (18.22-0)	0.94 (3.4-0)	13.15 (18.21-9.6)	4.45 (5.6-3.8)	9.17 (13-7.2)	1.6 (3.2-0)	410 (440-372)	0.039 (3.6-0)	0 (0)	0 (0)
Meat Balls	187 (211-171)	10.32(14.6-0)	1.15 (1.8-0)	13.75 (14.8-11.4)	5 (7.7-4.2)	9.8 (11.35-8.4)	0.55 (1.4-0)	430 (440-0)	0 (2.1)	0 (0)	0 (0.38)
Minced	170 (230-109)	8.95 (12.91-0)	0.2 (1.9-0)	14.9 (20.8-12.6)	5.68 (14-2.5)	5.85 (14-2.5)	0.65 (3.01-0)	272.50 (572.96-0)	0 (10)	0 (0.7)	0 (0)
Pieces	171 (198-136)	6.4 (8.4-5.3)	0.7 (1.1-0.2)	20 (28-16.05)	5 (8.1-2.3)	5.7 (7.2-2.8)	0 (0)	0 (445)	0	0 (3)	0
Chicken Cutlets	180 (201-161)	9.48 (12.6-0)	0 (0)	18.47 (21.77-13.4)	5.84 (6.79-4.7)	7.49 (9.4-5.17)	1.2 (5.04-0.63)	483.33 (520-372.38)	0 (4.8)	0 (0)	0 (0)
Chicken Nuggets	217 (233-216)	10 (17.38-0)	0 (1.1)	13.2 (16-12.97)	5.1 (5.3-4.32)	10.7 (11-10)	1.28 (1.3-0)	480 (499.62-420)	0 (2.1)	0	0 (0.38)
Cold Cuts	173 (251-142)	5.85 (17.5-4.1)	1.1 (5.9-0)	9.5 (19.64-3.1)	2.6 (5.5-2.1)	10.42 (14.2-4.6)	0 (1.73)	210 (840-0)	0 (0)	0 (0)	0 (0)
Sausages	182 (212-136)	7.8 (11.4-0)	1.15 (2.2-0)	13.2 (16-12)	4.90 (6.9-4.2)	9.925 (15.4-7.9)	0.865 (2.6-0)	493.50 (572-0)	0 (3.4)	0 (0)	0 (1.25)

Seafood	194 (243-13)	13.83 (25.35-1)	0.8 (3.3-0)	8.9 (14.9-1)	0 (6.41-0)	8.9 (11.75-0.75)	1.1 (2.63-0)	420 (1360-136)	0 (0)	0 (0)	0 (0)
Cutlets	196*	15.7*	0.9*	10.1*	3.5*	9.4*	1.2*	420*	0*	0*	0*
Others[1]	185*	13*	3.2*	14.5*	4.9*	7.9*	1.6*	568*	3.2*	0*	0*
Schinitzel	196*	11*	1.2*	17*	5.5*	11*	0*	440*	2.1*	0*	0.38*
Various[2]	214 (228-201)	7.95 (8.4-7.5)	1.45 (1.9-1)	17.7 (22.4-13)	1.8 (3.6-0)	10.75 (11.3-10.2)	1.65 (2.2-1.1)	900 (1200-600)	0 (0)	0 (0)	0 (0)

*Only one study included this category of product; [1] *"Vegan Roast," "Bacon-Style Rashers," and "Polony."*; [2] *Meat substitutes without discrimination about the category of the product.*

Higher energy values were found among the samples of “Chicken nuggets”. In contrast, lower values were present in the “Minced” category (Table 2). Regarding the carbohydrate concentration, higher values were shown in the “Seafood” category, whereas in “Cold cuts”, the values for this nutrient are the lowest (Table 2). The highest values for sugar were found among the “Others” samples, while categories such as “Chicken cutlets” and “Chicken nuggets” presented less than 1g of sugar among all samples.

The protein concentration was higher among the “Pieces” category, and the samples in “Seafood” presented the lowest content for this nutrient. Dietary fiber was most present in samples of the “Chicken cutlets” category, while most samples of “Seafood” substitutes did not present dietary fiber at all. Total and saturated fats were more present in samples of the “Various” category, while “Cold cuts” showed the lowest values.

Higher values were found in the “Various” samples regarding sodium content, but not all studies provided sodium values for their included samples. Also, most studies did not analyze iron, zinc, and vitamin B12 since these nutrients are not mandatory on food labels.

A scatterplot related to the proportion of analyzed pairs of nutrients present in each meat substitute category is available in Figure 2.

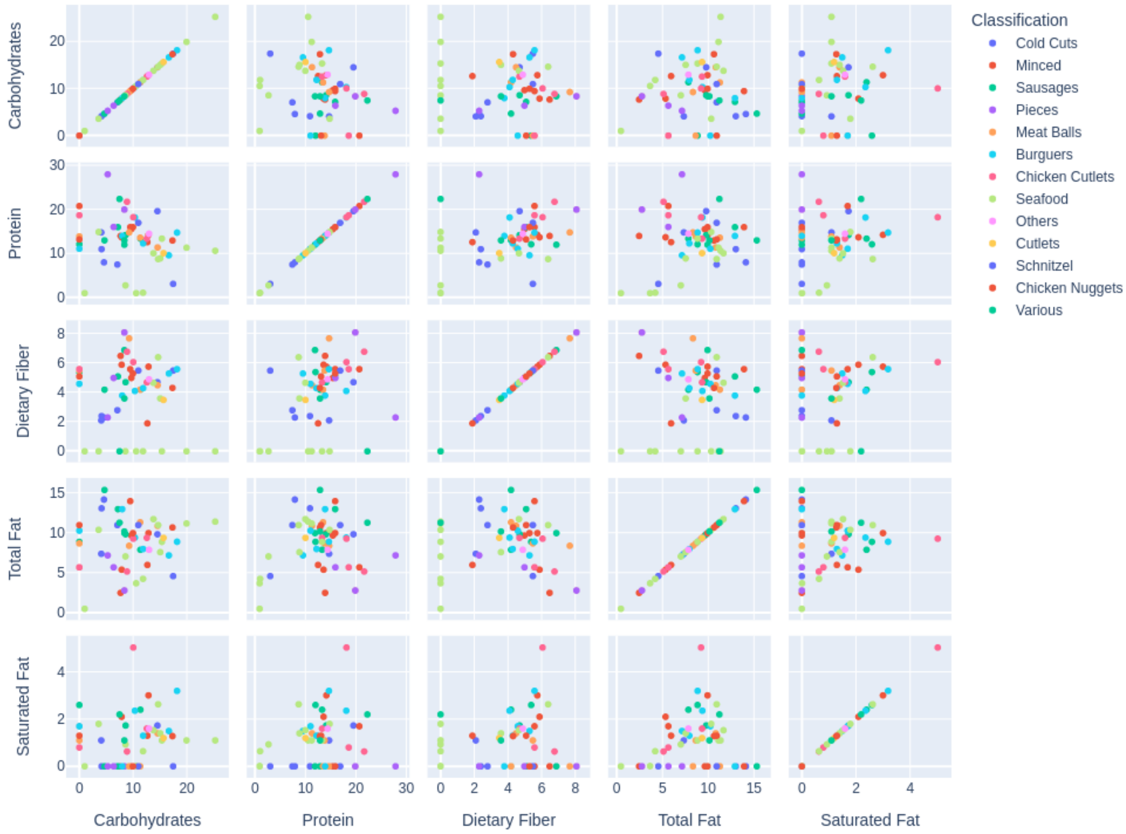

Figure 2 – Scatterplot exposing the proportions for pairs of analyzed nutrients for each meat substitute category. Numbers' units are represented in g/100g

Regarding the proportion of carbohydrates and protein, "Seafood" presents more carbohydrates in relation to its protein content, whereas "Pieces" present more protein than carbohydrate. As for the proportion of carbohydrates and dietary fiber, "Seafood" presented the lowest values, while "Pieces" presented the highest values. The proportion of carbohydrates and total fat is higher in "Seafood," with more carbohydrates than total fat content. In "Various" and "Pieces", the total fat content is higher in proportion to its carbohydrate concentration. In the "Chicken cutlets" category, the saturated fat ratio is higher than its carbohydrates, while the remaining categories tend to present less saturated fat in proportion to carbohydrates.

Regarding the proportion of protein to carbohydrates, the "Seafood" category presented more carbohydrates than protein, while "Various", "Chicken nuggets" and "Others" presented more protein than carbohydrates. Considering protein and dietary fiber, "Seafood" presented no values regarding its dietary fiber content. Therefore, this category presented more protein than dietary fiber, while the categories "Pieces" and "Cutlets" presented higher concentrations of dietary fiber than protein. The "Various" category presented the highest values for the proportion of saturated fat to protein, while "Seafood" and "Chicken cutlets" presented the lowest. "Chicken cutlets" presented the highest proportion of saturated fat than its protein content, while the other categories had lower values for fat.

"Various" and "Chicken nuggets" categories presented lower fiber proportions than total fat. On the other hand, most samples of "Pieces" presented a higher proportion of dietary fiber than their total fat content. A similar distribution between the proportions of saturated fat and dietary fiber was found in all samples, with all having more dietary fiber than saturated fat, with exception for one sample of the group of "Chicken Cutlets"

Four studies analyzed the ingredients used as meat substitutes (Curtain and Grafenauer 2019; D'Alessandro et al. 2022; Mariseva and Beitane 2020; Romão, Botelho, Nakano, Raposo, et al. 2022) (Table 3). A word cloud generated with the frequencies of the mentioned ingredients is available in Figure 3.

Table 3 – Main ingredients in meat substitutes available in the included studies

Authors	Included Categories	Main sources of protein	Main sources of fat	Main food additives
Curtain and Grafenauer (2019)	Burgers, Sausages, Minced, Chicken, Cutlets, Seafood, Others,	Soy Protein, pea protein, soybeans, hydrolyzed vegetable protein, mycoprotein, almonds.	Vegetable oil, canola oil, sunflower oil, sunflower kernels, rice bran oil, coconut oil, flax seed meal, cocoa butter, peanuts	N/A
D'Alessandro et al (2022)	Burguers, Cold Cuts, Cutlets, Meat Balls	Soy, Soy derivatives, Rice, Oats and Buckwheat	Seed Oil and Olive Oil	Modified Starch, Citric Acid, Flavouring and Coloring
Mariseva and Beitenu (2020)	Various	Soy, Wheat, Starch (Potato and Corn), Pulses, and Oats	N/A	Gellan gum, locust bean gum, guar gum, carrageenan, xanthan gum, methylcellulose, mono and diglycerides of fatty acids, mono and di acetyl tartaric acid, esters of mono and diglycerides, calcium stearoyl lactate

Romão et al. (2022)	Burgers, Minced, Chicken Nuggets, Chicken Cutlets, Chicken Cutlets, Seafood, Sausages, Cold Cuts	Soy, Gluten (Wheat), Pea Protein, Isolated Soy, and Pea Proteins	Unspecified vegetal fat, Soy Oil, Sunflower Oil, Cottonseed Oil, Coconut Fat, Coconut Oil	Methylcellulose, Xanthan Gum, Gellan Gum, Carrageenan Gum

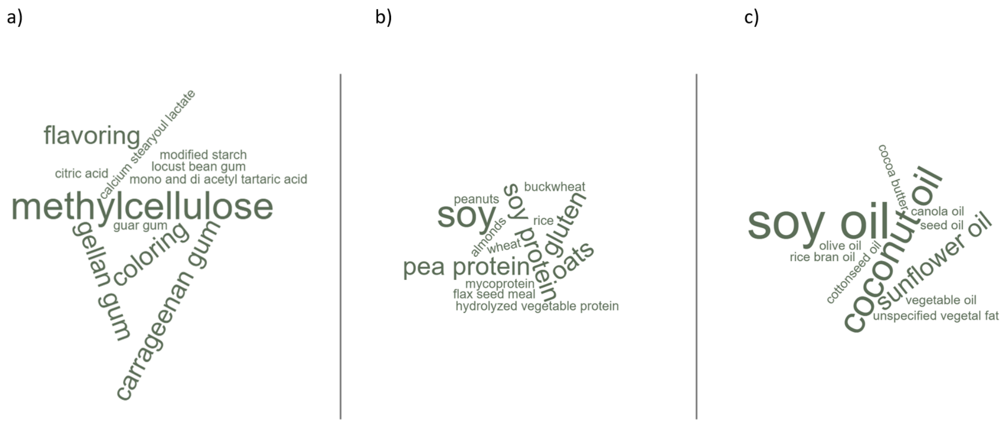

Figure 3 – Wordcloud generated with the frequencies of implemented ingredients in the included meat substitutes. Higher frequencies are represented with more prominent words in the cloud. a) Food additives; b) Protein sources; c) Fat Sources

Overall, soy-based ingredients (soybeans, soy protein, isolated soy protein) were the most implemented protein sources in the included meat substitutes, followed by pea-based ingredients (pea protein and peas). Wheat was also present as a protein source in the form of gluten. Pulses are, in general, more frequent than grains.

Thickeners and stabilizers such as methylcellulose and xanthan, gellan, carrageenan, xanthan, gellan, carrageenan, and guar gums were the most frequent additives. As for the fat sources, soy oil was the most used, followed by sunflower, cottonseed, and coconut oils. However, it is important to note that the authors did not describe the ingredients in each meat substitute category. Therefore, it is not possible to detail further information on this subject.

Discussion

Regarding the included studies, most studies were performed in the USA (Cole et al. 2021; Harnack et al. 2021). In this country, the number of adepts of vegetarianism is around 5% of the population and the number of vegans is about 3% (Gallup 2018). Also, its plant-based products market is one of the most successful in the world, with gross revenue of USD 800 Million, and a grow projection of almost 25% in size by 2025 (Global Market Insights 2020). Only one study each was produced by researchers on other countries (Denmark, Brazil, Spain, Italy, Australia, Sweden, UK and Norway) and in these countries the prevalence of vegetarianism ranges from 1.4% in Spain, from 14% in Brazil (Escribano et al. 2021).

Although different prevalences of vegetarianism were found within these countries, a common point regarding all of them is the growing of the plant-based dedicated market. In average, almost 50 million USD were invested in all the cited countries, highlighting the growing of these markets and justifying the presence of the analyzed samples in the included studies (Good Food Institute, 2020).

Most studies analyzed only the nutritional composition from food labels, and regarding this analysis, it is important to note that food label laws worldwide present tolerance for discrepancies regarding the actual nutritional value and the values described in food labels (Kumar and Kapoor 2017), therefore, a possible limitation regarding the described values is noted (Alessandrini et al. 2021; Boukid et al. 2022; Bryngelsson et al. 2022; Cole et al. 2021; Harnack et al. 2021; Tonheim et al. 2022). Also, only four of the included studies performed analysis regarding the utilized ingredients in meat substitutes (Curtain and Grafenauer 2019; D'Alessandro et al. 2022; Mariseva and Beitane 2020; Romão, Botelho, Nakano, Raposo, et al. 2022). For better evaluation of the meat substitutes overall quality, it is necessary to explore the correspondence of the found nutritional value and the implemented ingredients, since that in these products, commonly a large variety of ingredients is used (Clarys et al 2014).

Energy

In traditional diets, meat concentrates the highest amount of calories in large meals such as lunch and dinner (Chizzolini et al. 1999a). Considering the contribution of these meals as 30-

40% of an individual's total daily energy value, meat typically represents up to 70% of all calories in these meals (250-400kcal) (Spencer et al. 2003; Tokusoglu and Kemal Ünal 2003). Meat has between 65 and 80% of water, 16 to 22% of proteins, 3 to 13% of fats, and few amounts of vitamins and minerals (Araújo et al. 2011). In this sense, the high amount of protein and fat contributes to its total energy value (Araújo et al. 2011).

It is commonly observed that plant-based meat substitutes are made from a combination of legumes and cereals, products that naturally contain more carbohydrates than fats in their composition (Hoek et al. 2004; Romão, Botelho, Nakano, Raposo, et al. 2022). Thus, meat substitutes tend to have lower energy values than their animal counterparts (Romão, Botelho, Nakano, Raposo, et al. 2022; Tonheim et al. 2022). This characteristic agrees with the characteristics of plant-based diets in general, whose caloric value tends to be reduced compared to diets with a more ostensible presence of meat, such as the Western diet (Kahleova, Levin, and Barnard 2017). In the present review, the values found in the item "Energy" ranged between 170 and 217kcal, lower than those traditionally provided by meat. Therefore, the use of meat substitutes can constitute a viable alternative for an energetic reduction in diets, contributing weight loss and prevention of chronic non-communicable diseases (NCD), such as obesity, type 2 diabetes mellitus and coronary heart disease (Barnard et al. 2019; Tziva et al. 2019).

Furthermore, it is important to highlight that lower energy values were found in categories whose objective is to mimic in natura animal’s meat (Minced, pieces, cold cuts), constituting interesting options for substitution in meals, at least from the energy value point of view. In categories such as “Burgers” and “Chicken nuggets”, higher amounts of calories were found, accordingly to their animal counterparts, constituting plant-based versions of “treats” and “junk foods”.

Carbohydrates and Sugars

Carbohydrates are the most present nutrients in vegetables since they are usually present in their composition of saccharides of the most diverse sizes and complexities, such as starch and polyols (Kahleova et al., 2018). Within the context of meat substitutes, the most frequent ingredients (legumes and cereals) are rich in carbohydrates, fluctuating between 50% and 85% of their proximate composition (Frias et al. 2000; Montebello, Araújo, and Botelho 2014). Therefore, it is expected that meat substitutes present higher values of carbohydrates in comparison with meat, as confirmed in this review, with values between 5.85% and 13.83%.

In four of the included studies (Cole et al. 2021; Curtain and Grafenauer 2019; Romão, Botelho, Nakano, Raposo, et al. 2022; Tonheim et al. 2022), a comparison was made between the carbohydrate values of meat substitutes and their respective animal counterparts. In general, they pointed to significantly higher concentrations of carbohydrates in the plant-based versions, with values ranging from 7-15g/100g in plant-based meat substitutes, in comparison with meat, with 0-3g/100g (Cole et al. 2021; Curtain and Grafenauer 2019; Romão, Botelho, Nakano, Raposo, et al. 2022; Tonheim et al. 2022). These values are close to those found by other studies included in this review, demonstrating a higher concentration of carbohydrates in plant-based meat substitutes.

However, despite the greater amount of carbohydrates, this characteristic may not necessarily negatively influence the quality of diets that includes meat substitutes. In a study where the effects of a plant-based diet rich in carbohydrates originated from whole grains and legumes and reduced in fat were analyzed, the authors mentioned the effectiveness of this diet in weight loss and better quality of life (Kahleova et al. 2018). Therefore, despite the greater amount of carbohydrates in meat substitutes, since they come from legumes and cereals, the carbohydrate content would not possibly harm a diet in which meat substitutes are included, based on this ingredient alone (Kahleova et al. 2018).

The "Seafood" category presented the highest carbohydrate values among the analyzed categories. This is probably to obtain a gelatinous texture (like fish), given the inherent characteristic of carbohydrates to form stable gels with water and heating, in a physicochemical process called gelatinization (Boukid et al. 2022; Morris 1990). The "Cold cuts" category had the lowest amount of carbohydrates. This category consists of substitutes for meats used in sandwiches and snacks, such as hams, salami, and other foods from the same class, whose nature is more protein-based and usually present fewer carbohydrates amounts (Bryngelsson et al. 2022; D'Alessandro et al. 2022; Ložnjak Švarc et al. 2022; Romão, Botelho, Nakano, Raposo, et al. 2022).

Sugars were present in smaller amounts in the samples analyzed by the studies. Commonly, in plant-based substitutes, sugars are found most prominently in dairy substitutes, as they act as stabilizers and thickeners and try to mimic the characteristic sweetness of another disaccharide, lactose, which is present in dairy products (Romão, Botelho, Nakano, Borges, et al. 2022). Naturally, meats have negligible concentrations of mono and disaccharides and are not foods with a sweet taste in general. In this sense, the low use of this ingredient in plant-based meat substitutes is expected (Montebello, Araújo, and Botelho 2014). The category with the highest number of sugars was "Seafood", an ingredient possibly used to obtain some technological characteristic unrelated to flavor. However, the studies did not explore this ingredient and its respective industrial characteristics (Boukid et al. 2022; Curtain and Grafenauer 2019; Romão, Botelho, Nakano, Raposo, et al. 2022).

Dietary Fiber

Dietary fibers are provided exclusively from foods of plant origin, and their applications are manifold from the point of view of health maintenance and technological improvement of meat substitutes (Romão, Botelho, Nakano, Raposo, et al. 2022). In the context of health aspects, dietary fibers collaborate with maintaining health by favoring good intestinal functioning and collaborating with maintaining healthy intestinal microbiota (Anderson et al. 2009; Caprita et al. 2010). In addition, during the digestive process, in the intestinal lumen, both soluble and insoluble dietary fibers form bulky and viscous molecular complexes that reduce the rate of absorption of carbohydrates, saturated fats, and cholesterol, thus helping to maintain weight and prevent NCD (Anderson et al. 2009; Caprita et al. 2010).

In general, studies describe that the dietary pattern most practiced in Western countries consists of the consumption of industrialized foods of animal origin, fattier and with a lower amount of dietary fiber (Adlercreutz 2011; Martinez, Leone, and Chang 2017). In this sense, this dietary pattern is associated not only with increases in the prevalence of NCDs, but it also causes changes in the intestinal microbiota, providing the disordered growth of gram-positive bacteria, especially those of the *Clostridium* and *Proteobacteria* class, whose studies point to a relationship with brain health, among other negative changes (Adlercreutz 2011; Martinez, Leone, and Chang 2017).

Meat origin does not have dietary fiber in its composition, contrary to what was evidenced by the meat substitutes analyzed in this review, whose values ranged from 0 to 5.84g/100g. Current dietary reference intakes (DRIs) recommend daily fiber consumption of 30-35g for men and 25-32g for adult women. In this way, a single 100g serving of meat substitute (Chicken cutlets) can contribute about 16.68% of the recommended daily value (Murphy and Poos 2002). Thus, meat substitutes may be interesting alternatives for increasing dietary fiber consumption, especially in Western diets, where fiber consumption is reduced.

Regarding the technological and sensorial characteristics of the fibers, they can retain water in products in which they are present, favoring characteristics such as texture and resistance to breakage, characteristics also present in meats (Caprita et al. 2010). However, the excessive use of dietary fibers in these products results in negative characteristics in these same aspects, resulting in more rigid products requiring excessive chewing (Romão, Botelho, Nakano, Raposo, et al. 2022). Therefore, even based on plant-based matrices, which could provide even greater quantities than those found, the excessive use of fiber in meat substitutes would impair their palatability and, consequently, their commercialization.

Furthermore, dietary fiber's characteristic hygroscopicity also influences cooking oil retention. Thus, in the case of raw or pre-cooked meat substitutes, which require the use of cooking methods such as grilling or frying, this may result in an amount of fat even higher than described on the labels.

Protein

In the Western diet, proteins are mainly supplied by foods of animal origin, in greater quantity by meats, followed by eggs and dairy products (D'Alessandro et al. 2022). In addition to cultural and environmental subjects, it is important to highlight that protein stands out among the primary nutrients provided by meat, reaching almost 22% of its composition (Geiker et al. 2021). On the other hand, plant-based products commonly have lower amounts of protein, with values ranging between 0.3 and 11%, in the case of legumes, those with the highest amount of protein (Araújo et al. 2011). In this sense, protein intake stands out as one of the main concerns in eating meatless diets, demanding attention from health professionals and elaborating public health policies (Rosell, Appleby, and Key 2005). Meat substitutes are usually made from legumes, especially soy, peas, chickpeas, and beans, as well as some cereals such as wheat (gluten) and oats (Curtain and Grafenauer 2019; D'Alessandro et al. 2022; Mariseva and Beitane 2020; Romão, Botelho, Nakano, Raposo, et al. 2022). As evidenced by the studies included in this review, soy and its derivatives constituted the main protein source in meat substitutes (Figure 3).

Soybean stands out among legumes for several reasons, firstly, for economic value. Currently, the soy market has an export value estimated at around 27.39 billion dollars. It occupies about 53 million metric tons on the planet, being one of the primary commodities exported by countries such as China, Mexico, and the European Union (USDA 2022). In addition, this legume stands out for its protein value (about 38% of its proximate composition) (Goldsmith 2008). However, it is essential to note that during the cooking process, soybeans absorb water and swell around 2-3 times regarding their original size (Goldsmith 2008). In this sense, its nutritional density is diluted; therefore, larger portions are needed to obtain protein values comparable to what is provided to animal-based meat in 100g. Still concerning soybean, it is noted that multiple technologies can be used for better technological and sensory use of this legume. One of the most used technological processes in the soy industry is hydrostatic extrusion, which consists of an assisted grinding and friction heating process, which results in one of the most used products in the meat substitute industry, textured soy protein (Goldsmith 2008; Ortega et al. 2016).

Textured soy protein is an ingredient whose texture and appearance resemble meat, and its physicochemical structure, and capability of absorbing liquids and flavors enables the use of diverse ingredients for flavoring, including food additives whose composition is intended to mimic the flavor, aroma, and color of the meat (Ortega et al. 2016; Romão, Botelho, Nakano, Raposo, et al. 2022). Nevertheless, the defatted, dehydrated, and isolated soy protein extract also provides interesting sensory and technological characteristics in manufacturing meat substitutes

(Ortega et al. 2016). The same technologies can be used in other legumes, such as peas, which appear as protein alternatives for the formulation of soy-free meat substitutes, as part of the population avoids soy due to health problems or personal preferences (Katz et al. 2014; Messina and Messina 2013). Wheat gluten is also one of the most used ingredients in meat substitutes, given its protein composition with viscoelastic capacities that simultaneously contribute to the nutritional composition of these products and to sensory and physicochemical characteristics (elasticity, tenacity and resistance) (Ortolan and Steel 2017; Yonemoto, Calori-Domingues, and Franco 2007).

Since the meat substitutes analyzed are mainly composed of legumes and gluten, their nutritional composition is proportionally richer in protein in an attempt to fully replace meat of animal origin.

In the present review, the median values referring to the protein quantity of meat substitutes range between 8.9g/100g (Seafood) and 20g/100g (Pieces). However, analyzing the mean values of the same nutrient present in beef, the average value is 25g/100g (Nepa 2011), demonstrating that the protein value offered by meat substitutes is still lower than that usually offered by meat. In the case of plant-based substitutes for chicken, the median value (18.77g/100g, "Chicken Cutlets") is also lower than that offered by its animal-derived counterpart (20g/100g), reinforcing the need to develop plant-based alternatives with a higher amount of protein (Nepa 2011). The same analysis is also verified when analyzing the other included categories.

Another issue involving the use of plant proteins as substitutes for their animal counterparts is their bioavailability. There are several methodologies to assess protein quality, such as the PDCAAs (protein digestibility-corrected amino acid scores) and the DIAAS (digestible indispensable amino acid scores), the latter being the most recent and most suitable for analyzing the bioavailability of plant proteins (Food and Agriculture Organization 2011; Mathai, Liu, and Stein 2017). In general, plant proteins have a reduced amount of digestible essential amino acids, especially compared to highly digestible animal proteins such as ovalbumin, in eggs, and whey proteins from cow's milk (Mathai, Liu, and Stein 2017). However, this limitation can be circumvented by combining two or more plant proteins, as they have different digestible essential amino acid values. Some have greater amounts than others in terms of specific amino acids, such as branched-chain amino acids (Mathai, Liu, and Stein 2017). In this sense, since many meat substitutes combine at least one legume and one cereal, there is a possibility that they offer a better-quality protein combination when compared to portions of isolated legumes. However, more in vivo studies are needed to confirm this hypothesis.

Total and Saturated Fat

The total and saturated fats levels constitute one of the biggest problems concerning meat consumption. Depending on the type of cut used and the breed and diet of the animal, the meat fat content can vary between 1 and 28g/100g (Chizzolini et al. 1999b; Tokusoglu and Kemal Ünal 2003). Values for fat concentration may also vary according to the implemented cooking method.

Currently, the DRIs do not indicate maximum values of total fat consumption by age group. However, it is known that their energy contribution should be between 20 - 35% of the daily value ingested (Murphy and Poos 2002; Yates, Schlicker, and Suitor 1998). In this sense, it appears that a portion of the category with the highest total fat content (Pieces) contributes about 4.8% of the total recommended energy value for this nutrient in a diet of 2000kcal (10.75g/100g, 96.75kcal). In comparison with a typical cut of beef, it appears that it contributes 4.9% of the recommended daily intake (10.9g/100g, 98kcal). This value is close to the meat substitute with the higher total fat content (Nepa 2011). However, it is important to consider the variation in fat contents between the different categories of meat substitutes, which, as well as cuts of meat of animal origin, also have alternatives with lower fat contents.

Another important point to consider is the sources of fat used in meat substitutes. From the verified results, it is noted that the meat substitutes mostly used vegetable oils, such as soybean, sunflower, olive, and cottonseed oils (Curtain and Grafenauer 2019; D'Alessandro et al. 2022; Mariseva and Beitane 2020; Romão, Botelho, Nakano, Raposo, et al. 2022). Concerning the composition of these oils, they have primarily poly and mono-unsaturated fatty acids, whose metabolic effect is different from that of saturated fat, found in greater amounts in the meat(Ilak et al. 2021; Sun et al. 2015).

As sources of omega-6 fatty acids, these oils mainly contribute to several organic functions, such as the structure and fluidity of the plasma membrane of human body cells (Innes and Calder 2018; Patterson et al. 2012). However, these same fatty acids, when consumed in excess, act in the synthesis of pro-inflammatory cytokines, in addition to data indicating that the world consumption of omega-6 fatty acids is excessive, given their presence both at home and in the presence in industrialized foods of plant and animal origin (Innes and Calder 2018; Patterson et al. 2012). In this sense, even though they are composed of vegetable oils, the fat contents found in meat substitutes indicate that they should not be consumed excessively.

Regarding the amount of saturated fat presented by the analyzed meat substitutes, the maximum value of 1.65g/100g was found in the "Various" category, with emphasis on the "Burgers" categories (1.6g/100g) and "Chicken nuggets" (1.28g/100g). In meat substitutes, saturated fat sources typically consist of fats from coconut and palm, plant sources that behave similarly to those of animal origin (Curtain and Grafenauer 2019; Romão, Botelho, Nakano, Raposo, et al. 2022). However, compared to a typical cut of beef, which has between 3 to 9g of saturated fat per 100g serving, meat substitutes still have lower values, thus constituting better options (Nepa 2011).

In addition to the characteristics related to the nutritional quality of foods, fat also contributes to products' sensory characteristics, such as lubricity, palatability, after-taste and shelf life. All characteristics are desirable for food marketing and acceptance (Gibney 2019). Therefore, despite the lower amount of natural fat in products of plant origin, the manufacture of fat-free meat substitutes is unfeasible, as this would affect their sensory characteristics, making these products undesirable.

Sodium

Excessive sodium consumption is one of the biggest public health problems today, mainly given its ostensible use in industrialized products, as in the case of plant-based meat substitutes (Gibney 2019; Monteiro et al. 2021). Naturally, meat has reduced sodium content in its composition. In addition, it has nitrogenous compounds responsible for flavor development and collaboration in flavor development chemical reactions, such as the Maillard reaction (Zandonadi et al. 2014). The biggest problem lies in processed meats, such as hamburgers, ham and sausages, which have high sodium contents, prolonging their shelf life and palatability (Gibney 2019; Monteiro et al. 2021).

The tendency to use sodium is verified in most meat substitutes, possibly in an attempt to use flavor, given the absence of natural compounds related to this aspect in products of plant origin (Bryngelsson et al. 2022; Tyndall et al. 2022; Tziva et al. 2019).

In this review, sodium values between 210mg (Cold cuts) and 900mg (Various) were found, thus demonstrating a trend toward excess sodium in meat substitutes.

In the studies where implemented ingredients were analyzed, it important to note that salt (or sodium) was absent. Probably, salt was added only on the nutritional label, in the form of salt or sodium, or the analysis was not performed. There is also a possibility that some of these products are commercialized as salt-free options for further seasoning. In this manner, a possible limitation regarding this absence is noted.

Currently, the World Health Organization recommends a daily intake of 2300mg of sodium per day, so a 100g serving of some categories of meat substitutes can contribute up to 39% of the total recommended daily value (World Health Organization 2012).

Behaviors such as using natural seasonings, herbs, and sodium-free condiments can be alternatives for reducing sodium in meals, an attitude that is necessary for several diets, especially those aimed at controlling cardiovascular diseases (Dunteman et al. 2022; Rios-Mera et al. 2021).

Thus, in the current model of commercialization of meat substitutes, with built-in amounts of sodium, it is impossible to use strategies to formulate healthier meals, demonstrating a gap and a necessary improvement in the formulation of these products.

Iron, Zinc, and Vitamin B12

Iron is one of the minerals provided by meat, and adapting the consumption of this micronutrient in meatless diets is a well-known challenge (Haider et al. 2018; Skolmowska and Gł 2019). Traditionally, adherents of vegetarian diets tend to consume lower amounts of iron, not only because this nutrient is present in lesser amounts in plant-based foods but also because of the reduced consumption of source foods, such as dark green vegetables (Haider et al. 2018).

In addition, another problem is found in the chemical structure of the iron supplied by vegetables, whose electronic charge (+3) lacks specific intestinal receptors. Unlike, the hemic iron present in meat of animal origin, whose electronic charge is +2, it has a specific intestinal transporter, favoring its metabolism (Haider et al. 2018; Skolmowska and Gł 2019).

Current DRIs recommend daily values of iron intake between 8 and 10mg, depending on the age and gender of the person (Murphy and Poos 2002). In the context of the meat substitutes analyzed, specimens of the "Minced" category presented about 10mg of iron per 100g of products (Harnack et al. 2021), collaborating fully or mainly with the daily need for this element. However, it is important to highlight that iron is not an element of a mandatory declaration on food labels according to the legislation in force in several countries that produced the studies included in this review. Since most studies used food labels as a source of information, a limitation of this review is the lack of information on this mineral. The same problem occurs regarding zinc and vitamin B12, whose declaration is optional, not present in most of the labels analyzed by the studies.

Regarding meat-free diets, it is important to highlight that legumes and cereals are the main sources of iron and zinc. Thus, since these ingredients are the most implemented in the analyzed meat substitutes, there is a possibility that these nutrients are present in adequate amounts. However, future studies with laboratory analysis are necessary to verify it (Clarys et al. 2014; Le et al. 2018).

Vitamin B12 is produced by microorganisms and is available for metabolization into products of animal origin from the bioaccumulation process, through livestock feed (Zeuschner et al. 2013). In this sense, it is important to highlight that foods of animal origin are exclusive sources of this vitamin, and in the context of meat-free diets, they must be supplemented or acquired through fortified foods (Zeuschner et al. 2013).

Given the absence of this vitamin in foods of vegetable origin, it is common practice to fortify meat substitutes with vitamin B12. However, given this information's absence in the studies, it is impossible to analyze the contribution of this fortification in meat substitutes (Zeuschner et al. 2013).

Food Additives

Food additives are classified as substances that are not nutrients but are used in foods to improve technological and sensory characteristics (Carocho, Morales, and Ferreira 2015). In meat substitutes, one food additive classification that stands out is flavorings.

Flavoring agents can be of natural or synthetic origin, and their purpose is to impart flavor to foods. In the case of meat substitutes, the characteristic flavor of the meat is to be mimicked (Carocho, Morales, and Ferreira 2015). For example, beef has nitrogenous bases in its composition that give it a characteristic flavor, thus requiring little additional seasoning. In the case of meat substitutes, given the absence of these compounds, the use of flavorings is necessary, given the objective of these products to simulate the traditional version of meat (Montebello, Araújo, and Botelho 2014; Romão, Botelho, Nakano, Raposo, et al. 2022). In the case of the analyzed meat substitutes, these were found in all samples that included the analysis of the ingredient in their scopes (Curtain and Grafenauer 2019; D'Alessandro et al. 2022; Mariseva and Beitane 2020; Romão, Botelho, Nakano, Raposo, et al. 2022). However, these may also be present in samples for which this analysis was not performed.

Hydrocolloids were also used in the meat substitutes, such as methylcellulose and gums from diverse origins. Hydrocolloids consist of carbohydrate molecules of microbiological or plant origin, which can form gels that improve the texture, strength and tenacity of products in which they are present (Hollingworth 2010). In the case of methylcellulose, it can remain in a solid state after gelatinization, and its appearance resembles fat complexes, commonly present in beef analogs (Hollingworth 2010).

From a nutritional point of view, hydrocolloids characterize substitutes for dietary fiber since, after hydration, they form complex and viscous molecular structures that can delay the absorption of carbohydrates, such as dietary fibers and fat (Hollingworth 2010; Korus et al. 2009). Thus, its presence can be beneficial given the high value of carbohydrates present in meat substitutes.

Conclusion

This review evaluated the nutritional composition of meat substitutes commercialized worldwide. Most studies used food labels as their information source, and few analyzed the nutritional composition and implemented ingredients in meat substitutes. The results showed that meat substitutes are not similar to meat, commonly presenting lower energy values and higher amounts of carbohydrates and dietary fiber, given their plant-based origin. Also, protein values varied according to the meat substitute category, with some presenting a higher concentration than others, more specifically, in substitutes for bovine meat. In meat substitutes, the proportion of carbohydrates is higher than the protein concentration in most samples except the chicken substitutes. Furthermore, meat substitutes presented similar total and saturated fat content compared to animal-based counterparts. Ingredients such as soy, pea, and wheat were the main protein sources utilized in meat substitutes, while vegetable oils were represented as their fat source. Methylcellulose, various gums, and flavorings were the most frequently used food additives.

In general, meat substitutes presented high concentrations of sodium, possibly collaborating with an excessive sodium intake, highlighting the need for developing sodium-free alternatives. The concentration of Iron, Zinc, and Vitamin B12 was not described by most of the included samples, possibly because these nutrients do not present mandatory declaration on food labels, thus constituting a limitation of this study. Further studies are needed to develop meat substitutes with better nutritional composition, fulfilling the need for equivalent substitutes for animal-based meat.

Disclosure Statement

The authors declare no conflict of interest

References

Adlercreutz, Herman. 2011. Western Diet and Western Diseases: Some Hormonal and Biochemical Mechanisms and Associations. *Http://Dx.Doi.Org/10.1080/00365519009085798* 50 (s201). Taylor & Francis:3–23. doi:10.1080/00365519009085798.

Alessandrini, Roberta, Mhairi K. Brown, Sonia Pombo-Rodrigues, Sheena Bhageerutty, Feng J. He, and Graham A. Macgregor. 2021. Nutritional Quality of Plant-Based Meat Products Available in the UK: A Cross-Sectional Survey. *Nutrients 2021, Vol. 13, Page 4225* 13 (12). Multidisciplinary Digital Publishing Institute:4225. doi:10.3390/NU13124225.

Anderson, James W, Pat Baird, Richard H Davis Jr, Stefanie Ferreri, Mary Knudtson, Ashraf Koraym, Valerie Waters, and Christine L Williams. 2009. Health Benefits of Dietary Fiber. *Nutrition Reviews* 67 (4):188–205. doi:10.1111/j.1753-4887.2009.00189.x.

Araújo, Wilma M. C., Nancy di Pilla Montebello, Raquel B. A. Botelho, and Luiz Antônio Borgo. 2011. *Alquimia Dos Alimentos*. 2ª edição. Brasília: Senac.

Asher, Kathryn E., and Paul Peters. 2021. Meat Reduction, Vegetarianism, or Chicken Avoidance: US Omnivores' Impressions of Three Meat-Restricted Diets. *British Food Journal* 123 (1). Emerald Group Holdings Ltd.:387–404. doi:10.1108/BFJ-04-2020-0307/FULL/XML.

Barnard, Neal D., David M. Goldman, James F. Loomis, Hana Kahleova, Susan M. Levin, Stephen Neabore, and Travis C. Batts. 2019. Plant-Based Diets for Cardiovascular Safety and Performance in Endurance Sports. *Nutrients* 11 (1):1–10. doi:10.3390/nu11010130.

Boukid, Fatma, Marie Christin Baune, Mohammed Gagaoua, and Massimo Castellari. 2022. Seafood Alternatives: Assessing the Nutritional Profile of Products Sold in the Global Market. *European Food Research and Technology* 248 (7). Springer Science and Business Media Deutschland GmbH:1777–1786. doi:10.1007/S00217-022-04004-Z/TABLES/5.

Bryngelsson, Susanne, Hanieh Moshtaghian, Marta Bianchi, and Elinor Hallström. 2022. Nutritional Assessment of Plant-Based Meat Analogues on the Swedish Market. *Https://Doi.Org/10.1080/09637486.2022.2078286*, June. Taylor & Francis, 1–13. doi:10.1080/09637486.2022.2078286.

Caprita, Adrian, Rodica Căpriţă, Vasile Simulescu, and Raluca-Mădălina Drehe. 2010. Dietary Fiber: Chemical and Functional Properties. *Journal of Agroalimentary Processes and Technologies* 16 (4):406–416. http://.

Carocho, Márcio, Patricia Morales, and Isabel C.F.R. Ferreira. 2015. Natural Food Additives: Quo Vadis? *Trends in Food Science & Technology* 45 (2). Elsevier:284–295. doi:10.1016/J.TIFS.2015.06.007.

Chizzolini, R., E. Zanardi, V. Dorigoni, and S. Ghidini. 1999a. Calorific Value and Cholesterol Content of Normal and Low-Fat Meat and Meat Products. *Trends in Food Science & Technology* 10 (4–5). Elsevier:119–128. doi:10.1016/S0924-2244(99)00034-5.

Chizzolini, R., E. Zanardi, V. Dorigoni, and S. Ghidini. 1999b. Calorific Value and Cholesterol Content of Normal and Low-Fat Meat and Meat Products. *Trends in Food Science & Technology* 10 (4–5). Elsevier:119–128. doi:10.1016/S0924-2244(99)00034-5.

Clarys, Peter, Tom Deliens, Inge Huybrechts, Peter Deriemaeker, Barbara Vanaelst, Willem de Keyzer, Marcel Hebbelinck, and Patrick Mullie. 2014. Comparison of Nutritional Quality of the Vegan, Vegetarian, Semi-Vegetarian, Pesco-Vegetarian and Omnivorous Diet. *Nutrients* 6 (3):1318–1332. doi:10.3390/nu6031318.

Cole, Elizabeth, Natalie Goeler-Slough, Allison Cox, and Alissa Nolden. 2021. Examination of the Nutritional Composition of Alternative Beef Burgers Available in the United States. *Https://Doi.Org/10.1080/09637486.2021.2010035*, November. Taylor & Francis, 1–8. doi:10.1080/09637486.2021.2010035.

Curtain, Felicity, and Sara Grafenauer. 2019. Plant-Based Meat Substitutes in the Flexitarian Age: An Audit of Products on Supermarket Shelves. *Nutrients* 11 (11):1–14. doi:10.3390/nu11112603.

D'Alessandro, Claudia, Jason Pezzica, Carolina Bolli, Alice di Nicola, Azzurra Falai, Domenico Giannese, and Adamasco Cupisti. 2022. Processed Plant-Based Foods for CKD Patients: Good Choice, but Be Aware. *International Journal of Environmental Research and Public Health 2022, Vol. 19, Page 6653* 19 (11). Multidisciplinary Digital Publishing Institute:6653. doi:10.3390/IJERPH19116653.

Demartini, Eugenio, Daniel Vecchiato, Livio Finos, Simone Mattavelli, and Anna Gaviglio. 2022. Would You Buy Vegan Meatballs? The Policy Issues around Vegan and Meat-Sounding Labelling of Plant-Based Meat Alternatives. *Food Policy* 111 (August). Pergamon:102310. doi:10.1016/J.FOODPOL.2022.102310.

Derbyshire, Emma J. 2017. Flexitarian Diets and Health: A Review of the Evidence-Based Literature. *Frontiers in Nutrition* 3 (January). Frontiers Media S.A.:55. doi:10.3389/FNUT.2016.00055/BIBTEX.

Djekic, Ilija. 2015. Environmental Impact of Meat Industry – Current Status and Future Perspectives. *Procedia Food Science* 5 (January). Elsevier:61–64. doi:10.1016/J.PROFOO.2015.09.025.

Dunteman, Aubrey N., Elle N. McKenzie, Ying Yang, Youngsoo Lee, and Soo Yeun Lee. 2022. Compendium of Sodium Reduction Strategies in Foods: A Scoping Review. *Comprehensive Reviews in Food Science and Food Safety* 21 (2). John Wiley & Sons, Ltd:1300–1335. doi:10.1111/1541-4337.12915.

Elzerman, Johanna E., Lenneke Keulemans, Rosalie Sap, and Pieternel A. Luning. 2021. Situational Appropriateness of Meat Products, Meat Substitutes and Meat Alternatives as Perceived by Dutch Consumers. *Food Quality and Preference* 88 (March). Elsevier:104108. doi:10.1016/J.FOODQUAL.2020.104108.

Escribano, Alfredo J., Maria Belen Peña, Carlos Díaz-Caro, Ahmed Elghannam, Eva Crespo-Cebada, and Francisco J. Mesías. 2021. Stated Preferences for Plant-Based and Cultured Meat: A Choice Experiment Study of Spanish Consumers. *Sustainability 2021, Vol. 13, Page 8235* 13 (15). Multidisciplinary Digital Publishing Institute:8235. doi:10.3390/SU13158235.

Estruch, Ramon, Emilio Sacanella, and Emilio Ros. 2021. Should We All Go Pesco-Vegetarian? *European Heart Journal* 42 (12). Oxford Academic:1144–1146. doi:10.1093/EURHEARTJ/EHAA1088.

Food and Agriculture Organization. 2011. *Dietary Protein Quality Evaluation in Human Nutrition Report of an FAO Expert Consultation*. https://www.fao.org/ag/humannutrition/35978-02317b979a686a57aa4593304ffc17f06.pdf.

Frias, Juana, Concepción Vidal-Valverde, Cristina Sotomayor, Concepción Diaz-Pollan, and Gloria Urbano. 2000. Influence of Processing on Available Carbohydrate Content and Antinutritional Factors of Chickpeas. *European Food Research and Technology 2000 210:5* 210 (5). Springer:340–345. doi:10.1007/S002170050560.

Gallup. 2018. Snapshot: Few Americans Vegetarian or Vegan. https://news.gallup.com/poll/238328/snapshot-few-americans-vegetarian-vegan.aspx.

Geiker, Nina Rica Wium, Hanne Christine Bertram, Heddie Mejborn, Lars O. Dragsted, Lars Kristensen, Jorge R. Carrascal, Susanne Bügel, and Arne Astrup. 2021. Meat and Human Health-Current Knowledge and Research Gaps. *Foods (Basel, Switzerland)* 10 (7). Foods. doi:10.3390/FOODS10071556.

Gibney, Michael J. 2019. Ultra-Processed Foods: Definitions and Policy Issues. *Current Developments in Nutrition* 3 (2). doi:10.1093/cdn/nzy077.

Global Market Insights. 2020. U.S. Plant-Based Meat Market | Industry Report 2020-2026. https://www.gminsights.com/industry-analysis/us-plant-based-meat-market.

Goldsmith, Peter D. 2008. Soybean Production and Processing in Brazil. *Soybeans: Chemistry, Production, Processing, and Utilization*, January. AOCS Press, 773–798. doi:10.1016/B978-1-893997-64-6.50024-X.

Good Food Institute. 2021. Denmark Announces 1 Billion Kroner for Plant-Based Foods in Historic Climate Agreement - GFI Europe. https://gfieurope.org/blog/denmark-plant-based-investment-in-climate-agreement/.

Haddaway, Neal R., Matthew J. Page, Chris C. Pritchard, and Luke A. McGuinness. 2022. PRISMA2020 : An R Package and Shiny App for Producing PRISMA 2020-compliant Flow Diagrams, with Interactivity for Optimised Digital Transparency and Open Synthesis. *Campbell Systematic Reviews* 18 (2). doi:10.1002/cl2.1230.

Haider, Lisa M., Lukas Schwingshackl, Georg Hoffmann, and Cem Ekmekcioglu. 2018. The Effect of Vegetarian Diets on Iron Status in Adults: A Systematic Review and Meta-Analysis. *Critical Reviews in Food Science and Nutrition* 58 (8). Taylor and Francis Inc.:1359–1374. doi:10.1080/10408398.2016.1259210.

Hargreaves, Shila Minari, Eduardo Yoshio Nakano, and Renata Puppin Zandonadi. 2020. Brazilian Vegetarian Population—Influence of Type of Diet, Motivation and Sociodemographic Variables on Quality of Life Measured by Specific Tool (VEGQOL). *Nutrients* 12 (5):1406. doi:10.3390/nu12051406.

Harnack, Lisa, Stephanie Mork, Sruthi Valluri, Cecily Weber, Kristine Schmitz, Jennifer Stevenson, and Janet Pettit. 2021. Nutrient Composition of a Selection of Plant-Based Ground Beef Alternative Products Available in the United States. *Journal of the Academy of Nutrition and Dietetics* 121 (12). Elsevier B.V.:2401-2408.e12. doi:10.1016/j.jand.2021.05.002.

Hoek, Annet C., Pieternel A. Luning, Annette Stafleu, and Cees de Graaf. 2004. Food-Related Lifestyle and Health Attitudes of Dutch Vegetarians, Non-Vegetarian Consumers of Meat Substitutes, and Meat Consumers. *Appetite* 42 (3). Academic Press:265–272. doi:10.1016/J.APPET.2003.12.003.

Hollingworth, Clarence S. 2010. Food Hydrocolloids : Characteristics, Properties and Structures. Nova Science Publishers, 309.

Ilak, Anita Silvana, Peršuri´c Peršuri´c, Ana Težak, and Damijani´c Damijani´c. 2021. Connections between Healthy Behaviour, Perception of Olive Oil Health Benefits, and

Olive Oil Consumption Motives. *Sustainability 2021, Vol. 13, Page 7630* 13 (14). Multidisciplinary Digital Publishing Institute:7630. doi:10.3390/SU13147630.

Innes, Jacqueline K., and Philip C. Calder. 2018. Omega-6 Fatty Acids and Inflammation. *Prostaglandins, Leukotrienes and Essential Fatty Acids* 132 (May). Churchill Livingstone:41–48. doi:10.1016/J.PLEFA.2018.03.004.

Kahleova, Hana, Sara Dort, Richard Holubkov, and Neal D. Barnard. 2018. A Plant-Based High-Carbohydrate, Low-Fat Diet in Overweight Individuals in a 16-Week Randomized Clinical Trial: The Role of Carbohydrates. *Nutrients* 10 (9). Nutrients. doi:10.3390/NU10091302.

Kahleova, Hana, Susan Levin, and Neal Barnard. 2017. Cardio-Metabolic Benefits of Plant-Based Diets. *Nutrients 2017, Vol. 9, Page 848* 9 (8). Multidisciplinary Digital Publishing Institute:848. doi:10.3390/NU9080848.

Katz, Yitzhak, Pedro Gutierrez-Castrellon, Manuel Gea González, Rodolfo Rivas, Bee Wah Lee, and Pedro Alarcon. 2014. A Comprehensive Review of Sensitization and Allergy to Soy-Based Products. *Clinical Reviews in Allergy & Immunology 2014 46:3* 46 (3). Springer:272–281. doi:10.1007/S12016-013-8404-9.

Korus, Jarosław, Mariusz Witczak, Rafał Ziobro, and Lesław Juszczak. 2009. The Impact of Resistant Starch on Characteristics of Gluten-Free Dough and Bread. *Food Hydrocolloids* 23 (3):988–995. doi:10.1016/j.foodhyd.2008.07.010.

Kumar, Niraj, and Sanjeev Kapoor. 2017. Do Labels Influence Purchase Decisions of Food Products? Study of Young Consumers of an Emerging Market. *British Food Journal* 119 (2). Emerald Group Publishing Ltd.:218–229. doi:10.1108/BFJ-06-2016-0249/FULL/XML.

Le, Lap T., Joan Sabaté, Pramil N. Singh, and Karen Jaceldo-Siegl. 2018. The Design, Development and Evaluation of the Vegetarian Lifestyle Index on Dietary Patterns among Vegetarians and Non-Vegetarians. *Nutrients* 10 (5):25–27. doi:10.3390/nu10050542.

Ložnjak Švarc, Petra, Marie Bagge Jensen, Marija Langwagen, Anders Poulsen, Ellen Trolle, and Jette Jakobsen. 2022. Nutrient Content in Plant-Based Protein Products Intended for Food Composition Databases. *Journal of Food Composition and Analysis* 106 (March). Academic Press:104332. doi:10.1016/J.JFCA.2021.104332.

Mariseva, Alla, and Ilze Beitane. 2020. Assessment of Ingredients and Nutritional Value of Vegan Products in Latvian Market. In , 118–124. doi:10.22616/RRD.26.2020.018.

Martinez, Kristina B., Vanessa Leone, and Eugene B. Chang. 2017. Western Diets, Gut Dysbiosis, and Metabolic Diseases: Are They Linked? *Https://Doi.Org/10.1080/19490976.2016.1270811* 8 (2). Taylor & Francis:130–142. doi:10.1080/19490976.2016.1270811.

Mathai, John K., Yanhong Liu, and Hans H. Stein. 2017. Values for Digestible Indispensable Amino Acid Scores (DIAAS) for Some Dairy and Plant Proteins May Better Describe Protein Quality than Values Calculated Using the Concept for Protein Digestibility-Corrected Amino Acid Scores (PDCAAS). *The British Journal of Nutrition* 117 (4). Br J Nutr:490–499. doi:10.1017/S0007114517000125.

Messina, Mark, and Virginia L. Messina. 2013. Exploring the Soyfood Controversy. *Nutrition Today* 48 (2):68–75. doi:10.1097/NT.0B013E31828FFF54.

Milford, Anna Birgitte, and Charlotte Kildal. 2019. Meat Reduction by Force: The Case of “Meatless Monday” in the Norwegian Armed Forces. *Sustainability 2019, Vol. 11, Page 2741* 11 (10). Multidisciplinary Digital Publishing Institute:2741. doi:10.3390/SU11102741.

Moher, David, Alessandro Liberati, Jennifer Tetzlaff, Douglas G. Altman, and PRISMA Group. 2009. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Medicine* 6 (7):e1000097. doi:10.1371/journal.pmed.1000097.

Montebello, Nancy de Pilla, Wilma M C Araújo, and R B A Botelho. 2014. *Alquimia Dos Alimentos - Série Alimentos e Bebidas - 3ª Ed. 2014*. Edited by Senac. Senac.

Monteiro, Carlos A, Geoffrey Cannon, Renata B Levy, Jean-Claude Moubarac, Maria Lc Louzada, Fernanda Rauber, Neha Khandpur, Gustavo Cediel, Daniela Neri, Euridice Martinez-Steele, et al. 2021. Commentary Ultra-Processed Foods: What They Are and How to Identify Them. doi:10.1017/S1368980018003762.

Morris, V. J. 1990. Starch Gelation and Retrogradation. *Trends in Food Science & Technology* 1 (C). Elsevier:2–6. doi:10.1016/0924-2244(90)90002-G.

Murphy, Suzanne P, and Mary I Poos. 2002. Dietary Reference Intakes: Summary of Applications in Dietary Assessment. *Public Health Nutrition* 5 (6a). Cambridge University Press (CUP):843–849. doi:10.1079/phn2002389.

Nepa. 2011. *Tabela Brasileira de Composição de Alimentos: TACO*. Edited by Núcleo de Estudos e Pesquisas em alimentação. Vol. 4. ed. rev. Campinas: Unicamp.

Onwezen, M. C., E. P. Bouwman, M. J. Reinders, and H. Dagevos. 2021. A Systematic Review on Consumer Acceptance of Alternative Proteins: Pulses, Algae, Insects, Plant-Based Meat Alternatives, and Cultured Meat. *Appetite* 159 (April). Appetite. doi:10.1016/J.APPET.2020.105058.

Ortega, Enrique, Otávio Cavalett, Robert Bonifácio, and Marcos Watanabe. 2016. Brazilian Soybean Production: Emergy Analysis With an Expanded Scope: *Http://Dx.Doi.Org/10.1177/0270467605278367* 25 (4). Sage PublicationsSage CA: Thousand Oaks, CA:323–334. doi:10.1177/0270467605278367.

Ortolan, Fernanda, and Caroline Joy Steel. 2017. Protein Characteristics That Affect the Quality of Vital Wheat Gluten to Be Used in Baking: A Review. *Comprehensive Reviews in Food Science and Food Safety* 16 (3). John Wiley & Sons, Ltd:369–381. doi:10.1111/1541-4337.12259.

Patterson, E., R. Wall, G. F. Fitzgerald, R. P. Ross, and C. Stanton. 2012. Health Implications of High Dietary Omega-6 Polyunsaturated Fatty Acids. *Journal of Nutrition and Metabolism* 2012. Hindawi Limited. doi:10.1155/2012/539426.

Raphaely, Talia, and Dora Marinova. 2013. Flexitarianism: A More Moral Dietary Option. *International Journal of Sustainable Society* 6 (1/2). InterScience Publishers:189–211. doi:10.1504/IJSSOC.2014.057846.

Rios-Mera, Juan D., Miriam M. Selani, Iliani Patinho, Erick Saldaña, and Carmen J. Contreras-Castillo. 2021. Modification of NaCl Structure as a Sodium Reduction Strategy in Meat Products: An Overview. *Meat Science* 174 (April). Elsevier:108417. doi:10.1016/J.MEATSCI.2020.108417.

Romão, Bernardo, Raquel Braz Assunção Botelho, Eduardo Yoshio Nakano, Vinícius Ruela Pereira Borges, Maria Eduarda Machado de Holanda, António Raposo, Heesup Han, Miseldra Gil-Marín, Antonio Ariza-Montes, and Renata Puppin Zandonadi. 2022. Vegan Milk and Egg Alternatives Commercialized in Brazil: A Study of the Nutritional

Composition and Main Ingredients. *Frontiers in Public Health* 0 (October). Frontiers:4143. doi:10.3389/FPUBH.2022.964734.

Romão, Bernardo, Raquel Braz Assunção Botelho, Eduardo Yoshio Nakano, António Raposo, Heesup Han, Alejandro Vega-Muñoz, Antonio Ariza-Montes, and Renata Puppin Zandonadi. 2022. Are Vegan Alternatives to Meat Products Healthy? A Study on Nutrients and Main Ingredients of Products Commercialized in Brazil. *Frontiers in Public Health* 0. Frontiers:1565. doi:10.3389/FPUBH.2022.900598.

Rosell, Magdalena, Paul Appleby, and Tim Key. 2005. Height, Age at Menarche, Body Weight and Body Mass Index in Life-Long Vegetarians. *Public Health Nutrition* 8 (7). Cambridge University Press:870–875. doi:10.1079/PHN2005730.

Skolmowska, Dominika, and Dominika Gł. 2019. Analysis of Heme and Non-Heme Iron Intake and Iron Dietary Sources in Adolescent Menstruating Females in a National Polish Sample.

Spencer, E. A., P. N. Appleby, G. K. Davey, and T. J. Key. 2003. Diet and Body Mass Index in 38 000 EPIC-Oxford Meat-Eaters, Fish-Eaters, Vegetarians and Vegans. *International Journal of Obesity 2003 27:6* 27 (6). Nature Publishing Group:728–734. doi:10.1038/sj.ijo.0802300.

Statista. 2016. Share of People Who Follow a Vegetarian Diet Worldwide as of 2016, by Region. *Statista Research Department*. https://www.statista.com/statistics/597408/vegetarian-diet-followers-worldwide-by-region/.

Statista. 2018. Suécia: Vegetarianismo e Veganismo 2015-2018 | Statista. https://www.statista.com/statistics/684820/survey-on-vegetarianism-and-veganism-in-sweden/.

Statista. 2020. Sweden: Criteria When Buying Plant-Based Products 2020 | Statista. https://www.statista.com/statistics/1265996/important-factors-when-buying-plant-based-products-in-sweden/.

Statista. 2022. Spain: Share of Vegetarian, Flexitarian and Vegan Population by Gender 2019 | Statista. https://www.statista.com/statistics/1092565/share-of-spaniards-that-follow-a-veggie-diet-in-by-gender/.

Sun, Ye, Nithya Neelakantan, Yi Wu, Rashmi Lote-Oke, An Pan, and Rob M. van Dam. 2015. Palm Oil Consumption Increases LDL Cholesterol Compared with Vegetable Oils Low in Saturated Fat in a Meta-Analysis of Clinical Trials. *The Journal of Nutrition* 145 (7). Oxford Academic:1549–1558. doi:10.3945/JN.115.210575.

The Good Food Institute. 2020. Indústria de Proteínas Alternativas - 2020. *The Good Food Institute Brazil* 1 (1):1–32.

Tokusoglu, Özlem, and M Kemal Ünal. 2003. *Fat Replacers in Meat Products*. *Pakistan Journal of Nutrition*. Vol. 2.

Tonheim, Live Edvardsen, Elisabeth Austad, Liv Elin Torheim, and Sigrun Henjum. 2022. Plant-Based Meat and Dairy Substitutes on the Norwegian Market: Comparing Macronutrient Content in Substitutes with Equivalent Meat and Dairy Products. *Journal of Nutritional Science*, February. Cambridge University Press, 1–8. doi:10.1017/JNS.2022.6.

Tyndall, Simone M., Gregory R. Maloney, Martin B. Cole, Nicholas G. Hazell, and Mary Ann Augustin. 2022. Critical Food and Nutrition Science Challenges for Plant-Based Meat Alternative Products. *Https://Doi.Org/10.1080/10408398.2022.2107994*, August. Taylor & Francis, 1–16. doi:10.1080/10408398.2022.2107994.

Tziva, M., S. O. Negro, A. Kalfagianni, and M. P. Hekkert. 2019. Understanding the Protein Transition: The Rise of Plant-Based Meat Substitutes. *Environmental Innovation and Societal Transitions*, no. April. Elsevier:1–15. doi:10.1016/j.eist.2019.09.004.

USDA. 2022. Soybeans | USDA Foreign Agricultural Service. *Soybeans | USDA Foreign Agricultural Service*. https://www.fas.usda.gov/commodities/soybeans.

Italiani. 2022. Vegans and Vegetarians in Italy: The Number Is Increasing in Italy. https://www.italiani.it/en/vegans-and-vegetarians-in-Italy/.

Vegetarisk. 2022. Background on Food and Agriculture in Denmark. https://vegetarisk.dk/resources-on-denmark/.

WordClouds. 2020. Free Online Word Cloud Generator and Tag Cloud Creator - WordClouds.Com. https://www.wordclouds.com/.

World Health Organization. 2012. Guideline: Sodium Intake for Adults and Children. *World Health Organization*.

Yates, Allison A., Sandra A. Schlicker, and Carol W. Suitor. 1998. Dietary Reference Intakes: The New Basis for Recommendations for Calcium and Related Nutrients, B Vitamins, and Choline. *Journal of the American Dietetic Association* 98 (6). W.B. Saunders:699–706. doi:10.1016/S0002-8223(98)00160-6.

Yonemoto, P G, M a Calori-Domingues, and C M L Franco. 2007. Effect of Granule Size on the Structural and Physicochemical Characteristics of Wheat Starch. *Ciencia E Tecnologia De Alimentos* 27 (4):761–771. doi:10.1590/S0101-20612007000400015.

Zandonadi, Renata Puppin, Raquel B. A. Botelho, Verônica C. Ginani, Rita de Cássia C. A. Akutsu, Karin Eleonora de Oliveira Savio, and Wilma M. C. Araújo. 2014. Sodium and Health: New Proposal of Distribution for Major Meals. *Health* 06 (03):195–201. doi:10.4236/health.2014.63029.

Zeuschner, Carol L, Bevan D Hokin, Kate A Marsh, Angela v Saunders, Michelle A Reid, and Melinda R Ramsay. 2013. Vitamin B12 and Vegetarian Diets. *Medical Journal of Australia* 199 (S4). John Wiley & Sons, Ltd:S27–S32. doi:10.5694/MJA11.11509.

ARTIGO 2 - *Are vegan alternatives to meat products healthy? A study on nutrients and main ingredients of products commercialized in Brazil (*ROMÃO et.al, 2022)*"*

ABSTRACT

Proteins are essential components in human nutrition, and animal products are usually the primary sources of human ingestion. However, the number of adherents to vegetarian and vegan diets has grown significantly, highlighting the need for alternatives to replace animal proteins. Meat substitutes aim to mimic the nutritional value and sensory characteristics of meat. However, studies suggest differences in their composition. This study is the first to evaluate Brazilian meat substitutes' nutritional quality and ingredients. A quantitative cross-sectional survey was performed in three steps: (i) Sample mapping of products commercialized nationwide; (ii) Ingredients and nutritional data collection and classification; (iii) Statistical analysis. One hundred twenty-five meat substitutes were included and described. The primary protein sources were soy, gluten, and pea protein ingredients. Vegan meat substitutes presented similar energy and protein values, with few exceptions among samples, with vegan canned fish alternatives presenting less protein than their counterparts. Overall vegan products did not differ regarding sodium levels but showed high amounts to compose a lunch or dinner meal. Vegan meat substitutes showed higher carbohydrates, dietary fiber concentrations, and few differences regarding total and saturated fat. Vegan meat substitutes may contribute to the adherence and maintenance of vegan and vegetarian diets. However, future studies about the implemented ingredients are needed.

Keywords: meat substitutes, plant-based, meat, label, nutritional composition, ingredients

INTRODUCTION

Proteins are an essential dietary component contributing to building muscle fibers and the immune system and sustaining many vital functions. Animal-based products are one of the primary sources of human protein ingestion (1). Since ancient times, meat has been an essential component of the human diet due to its nutritional aspects (proteins of high biological value, iron, and vitamin B12), sensory characteristics, and cultural aspects (2–4). Even though the type and amount of ingested meat differ among populations and cultures, most Western countries' main meals include meat combined with vegetables (2).

The per capita global meat intake is projected to be 35 kg/year (5). Given the expected population growth and increased influx of low and middle-income countries, the global demand for animal-based products would overcome the world's capacity up to 2,050 (6). On the other hand, people are concerned about the effects of meat-eating on their health and the environment since plant-based diets have been pointed out as one measure to face climate change and non-communicable diseases (5, 7). Animal-based meals require more environmental resources (e.g., land use and freshwater) than plant-based meals. Therefore, adherence to plant-based diets is growing worldwide, mainly for health, ethical, cultural, and environmental reasons (8).

The term plant-based diet can be related to either vegetarian and vegan diets (9–12) or diets that are mostly (but not necessarily exclusively) based on plant foods (13–15). There is no data on the prevalence of plant-based diets adoption worldwide. However, vegetarianism has acquired a lot of attention and supporters, especially in Asia (19% of the population is vegetarian). Vegetarianism is most common in Africa and the Middle East (16%), followed by 8% in South and Central America and 6% in North America. Europe has the lowest prevalence, with only 5% of the population being vegetarian (16). Between 2012 and 2018, the number of vegetarians in Brazil climbed from 8 to 14% (17). Consumer interest in lowering meat consumption and opting for plant-based cuisine has sparked food industry innovations to capitalize on this trend (18).

It is essential to highlight that the acceptance of plant-based meat substitutes is related to several factors, including cost, familiarity, psychological, environmental, and cultural factors (19). The food industries tend to produce plant-based alternatives similarly to their animal-based counterparts, mainly considering physical and sensory aspects (taste, texture, visual appearance, and cooking method). They include several ingredients, such as products based on legumes, grains, nuts, fungi, and additives, such as antioxidants and thickeners (8, 18–20). However, studies suggest that plant-based meat substitutes lack nutritional quality being low in protein and rich in sodium, fat, calories, fiber, and total carbohydrates, but few studies analyzed the meat-substitute products commercialized countrywide (8, 18–20). To our knowledge, there are two investigations on the nutritional profile of substitute beef burgers in the USA and Australia (21, 22). However, none was performed in Brazil, analyzing the nutritional composition of plant-based meat substitutes. Given the expansion of plant-based meat to a broader population, the potential consequences of its consumption for public health need to be addressed based on the knowledge of the nutritional profile of plant-based meat substitutes. It is fundamental to provide adequate dietary choices and visualize potential nutritional differences between meat substitutes and their animal-protein counterparts. The central hypothesis of this study is that vegan products commercialized in Brazil do not resemble their animal counterparts regarding nutritional aspects. The secondary hypothesis is that vegan products present more carbohydrates, sodium, and lower protein than their animal counterparts. Therefore, our study aimed to evaluate the nutritional quality and the main ingredients used in vegan meat analogs commercialized in Brazil.

MATERIALS AND METHODS

This comparative cross-sectional quantitative study was conducted in three steps: (i) Sample mapping; (ii) Data collection and classification; (iii) Statistical analysis, as described below.

Sample Mapping

The inclusion criteria for the meat substitutes sample in the study were: (i) the presence of the seal "Vegan Product," offered by the Brazilian Vegetarian Society (SVB®); (ii) products commercialized in hyper and supermarket chains present in the five Brazilian regions and/or food stores with national and regional coverage. The exclusion criteria were fresh foods or other vegan products whose objective is not to mimic any meat-based counterpart based on animal protein. This study did not include vegan and regular meat products labeled with the nutritional claims "low fat" and "low salt," since they could have biased the results. E-commerce was consulted through search platforms (Google®), Brazilian online vegan products resellers, and on social media (Instagram®, Facebook®, and Twitter®), through hashtags and nominal searches to achieve national coverage of the meat substitutes sold in the Brazilian market. The investigation was conducted from February 1st, 2021, to December 1st, 2021.

The search was conducted in 3 phases: a researcher searched for the vegan products in the first phase. Then, a second researcher repeated the search process and analyzed the need to include more products. As a result, two independent academics double-checked the precision of the extracted data. Finally, a third coordinating researcher critically analyzed the data, determining the final sample based on the inclusion criteria.

Then, the meat substitutes were classified into ten categories as their meat product counterpart: *Hamburgers; Minced Beef; Meatballs; Breaded Chicken; Chicken Hamburgers; Chicken Breast; Canned fish; Fish Cakes; Sausages and Hams*.

In addition, for comparison purposes, three samples of three different Brazilian best-selling animal products to each meat product counterpart were also included in the study.

Data Collection

Data collection followed previous studies on modified versions of commercialized products (6, 23–25). Products from the most significant producers were chosen, covering most of the Brazilian market. The qualitative and quantitative data reported on the products were recorded, including firm name, brand name, descriptive name, ingredient's list, nutrient information, and serving size. Information about the ingredients and nutrient values was collected from the food labels. They allow consumers to choose healthy and adequate foods according to their dietary pattern by the nutrient profile and ingredients' list. According to the Brazilian legislation, it is mandatory to describe the serving size (g), energy value (kcal), carbohydrates (g), added sugars (g), proteins (g), fats (g), saturated fats (g), dietary fiber (g) and sodium (mg) (26). Therefore, we used these parameters to compare the products from the sample mapping phase. For standardizing and comparison purposes, all values were converted to the serving size of 100 g. To prevent the double inclusion of products, if more than one product had the same composition, they were only considered once.

Statistical Analysis

Data regarding the included samples' energy value (kcal), carbohydrates (g), added sugars (g), proteins (g), fats (g), saturated fats (g), dietary fiber (g), and sodium (mg) were calculated on their respective means ± Standard Deviations (SD). A comparison between nutritional values of meat substitutes and their respective animal protein-based products was carried out with a non-parametric Mann-Whitney test with a confidence level of 95% ($p < 0.05$). Two-tailed hypotheses were considered in the test. *Microsoft Excel® (USA*, 2021) and *SPSS® version 22.0 (IBM SPSS Statistics, Version 22.0, IBM corp., Chicago, IL USA*, 2020) were used to perform the tests.

For graphical visualization, a word cloud was generated with the implemented ingredients of vegan meal analogs, given that higher frequencies are represented with more prominent words in the cloud (*Wordclouds®, 2022*) (27). For the word cloud generation, protein sources were grouped according to their main matrix; for example, texturized soy protein, isolated soy protein, and soybeans were all grouped as “soy.” Furthermore, information regarding the ingredients was represented by percentages in a heatmap where the color indicates the ingredient's presence according to the stipulated categories. *GraphPad Prism® (San Diego, CA, USA, 2022)* was used to generate the heatmaps.

RESULTS

The total amount of 125 products were included for evaluation. Most of them was red-meat product analogue (*n* = 62; 49.6%), 25.6% (*n* = 32) were chicken-meat product analogues, 14.4% (*n* = 18) were pork-meat product analogues and 10.4% (*n* = 13) were fish-meat product analogues. Among the types of meat substitutes, 28% (*n* = 35) were classified as *Hamburgers*, 7.2% (*n* = 9) as *Minced Beef*, 14.4% (*n* = 18) as *Meatballs*, 11.2% (*n* = 14) as *Breaded Chicken*, 4.8% (*n* = 6) as *Chicken Hamburgers*, 9.6% (*n* = 12) as *Chicken Breast*, 6.4% (*n* = 8) as *Canned fish*, 4% (*n = 5)* as *Fish Cakes*, 9.6% (*n* = 12) as *Sausages* and 4.8% (*n* = 6) as *Hams*. Table 1 shows the vegan and animal samples' energy value (kcal), carbohydrates (g), proteins (g), fats (g), saturated fats (g), dietary fiber (g) and sodium (mg) by means and standard deviations (SD). Complete information regarding nutritional value, ingredient list and serving size in all included samples is available at the Supplementary Tables 1, 2.

Table 1 - Means and Standard Deviations of the nutritional values per 100g of serving of the analyzed samples.

	Energy (Kcal)			**Carbohydrates (g)**			**Protein (g)**			**Total Fat (g)**			**Saturated Fat (g)**			**Dietary Fiber (g)**			**Sodium (mg)**		
Category	Vegan	Animal	*p*	Vegan	Animal	*p*	Vegan	Animal	*p*	Vegan	Animal	*p*	Vegan	Animal	*p*	Vegan	Animal	*p*	Vegan	Animal	*p*
Hamburgers	216.18 ± 77.61	228.33 ± 46.54	0.644	18.22 ± 12.95	3.13 ± 0.57	**0.002**	14.77 ± 9.34	16.67 ± 1.91	0.168	8.91 ± 6.63	16.88 ± 4.38	**0.048**	3.20 ± 4.19	6.21 ± 1.38	0.056	5.60 ± 4.53	0.54 ± 0.94	**0.029**	434.49 ± 185.90	595.00 ± 77.59	0.074
Minced Beef*	192.81 ± 29.73	247.67 ± 6.51	**0.009**	12.91 ± 12.14	0 ± 0	**0.012**	14.25 ± 5.95	23.00 ± 1.00	0.064	10.00 ± 3.37	15.67 ± 2.08	**0.009**	3.01 ± 3.51	6.67 ± 1.15	0.064	5.77 ± 4.61	0 ± 0	**0.012**	572.96 ± 159.98	76.00 ± 4.36	**0.009**
Meatballs	156.18 ± 76.06	200.00 ± 43.37	0.307	7.36 ± 6.84	7.58 ± 3.87	0.740	17.78 ± 12.67	13.17 ± 1.61	0.740	5.55 ± 5.45	11.04 ± 3.52	**0.010**	1.20 ± 2.71	5.29 ± 1.8	**0.017**	5.58 ± 5.72	0.42 ± 0.36	**0.047**	451.60 ± 212.22	649.17 ± 85.49	0.125
Breaded Chicken	216.12 ± 62.28	220.51 ± 35.43	0.953	17.39 ± 9.80	15.13 ± 2.91	0.768	12.97 ± 2.76	13.33 ± 1.94	0.768	10.7 ± 6.37	11.79 ± 3.87	0.591	1.28 ± 1.25	4.08 ± 1.06	**0.021**	4.32 ± 1.85	1.56 ± 0.24	0.068	499.62 ± 194.57	489.49 ± 128.34	1,000
Chicken Hamburgers	201.92 ± 67.97	202.92 ± 43.68	1,000	10.07 ± 6.81	3.08 ± 0.14	0.167	18.25 ± 15.87	16.67 ± 1.91	0.262	9.29 ± 5.87	13.42 ± 3.47	0.381	5.04 ± 5.45	4.17 ± 1.39	0.905	6.08 ± 7.13	0.75 ± 0.66	0.095	372.78 ± 190.54	546.25 ± 245.95	0.381
Chicken Breast*	173.63 ± 67.62	163.33 ± 2.89	1,000	8.90 ± 5.70	0 ± 0	**0.009**	21.77 ± 14.00	30.67 ± 0.58	0.101	5.17 ± 4.96	3.53 ± 0.12	0.734	0.63 ± 0.66	1.00 ± 0	0.557	6.79 ± 6.27	0 ± 0	**0.009**	458.67 ± 244.82	74.00 ± 0	0.081
Canned Fish (tuna and sardines)	194.22 ± 87.77	159.33 ± 28.04	0.630	14.70 ± 5.68	0 ± 0	**0.013**	8.75 ± 4.64	24.89 ± 2.99	**0.012**	11.00 ± 7.07	6.73 ± 4.08	0.630	2.63 ± 1.56	2.10 ± 1.23	0.630	6.41 ± 5.58	0 ± 0	**0.013**	416.02 ± 186.91	415.44 ± 133.51	0.921
Fish Cakes	193.70 ± 60.85	164.25 ± 44.95	0.571	13.83 ± 9.24	9.56 ± 9.45	0.786	10.07 ± 3.99	16.24 ± 12.18	1,000	11.75 ± 6.85	8.72 ± 1.97	0.393	1.53 ± 1.11	2.09 ± 1.49	0.571	4.67 ± 2.77	2.59 ± 4.01	0.25	482.03 ± 60.89	221.27 ± 157.05	**0.036**
Sausages	189.69 ± 47.55	272.67 ± 44.38	**0.031**	8.63 ± 6.05	2.67 ± 0.95	**0.018**	14.20 ± 3.46	14.93 ± 2.31	0.536	9.85 ± 4.40	22.33 ± 5.51	**0.009**	1.73 ± 2.00	7.47 ± 1.50	**0.018**	4.71 ± 5.08	0 ± 0	**0.008**	572.35 ± 119.33	1122.67 ± 326.01	**0.009**
Hams	251.97 ± 121.17	159.17 ± 124.13	0.262	14.57 ± 18.83	3.08 ± 4.11	0.167	19.64 ± 12.85	14.42 ± 2.13	0.167	12.83 ± 7.49	9.75 ± 12.99	0.381	0.99 ± 0.52	3.33 ± 4.47	0.905	5.61 ± 3.09	0 ± 0	**0.043**	954.03 ± 300.41	1065.83 ± 417.41	0.714

It is considered significantly different when $p < 0.05$, highlighted in bold numbers; * Samples of raw and unseasoned meat (animal) were considered.

In the vegan products, *hams* presented the highest energy concentration (251.97 ± 127.17 kcal/100 g), and *meatballs* offered the lowest (156.18 ± 76.06 kcal/100 g). Among the animal products, *sausages* were classified with the highest energy values (272.67 ± 44.38 kcal/100 g) among all samples, and the *canned fish*, had the lowest (159.33 ± 28.04).

Significant differences ($p < 0.05$) were found in *minced beef* and *sausages* comparing vegan and animal products, with the animal protein-based versions presenting the highest values **(**192.81 kcal ± 29.73/100 g) and (189.69 kcal ± 47.55/100 g).

Statistical analysis showed significant differences between vegan and animal versions of hamburgers, minced beef, chicken breast, canned fish, and sausages regarding the carbohydrate content. In these samples, vegan products presented higher values for carbohydrates than their animal counterparts. The *hamburger* (18.22g ± 12.95/100 g) was the category with the highest carbohydrate content among vegan products and breaded chicken among animal products (15.13 ± 2.91).

Between all animal counterparts, *chicken breast, minced beef, and canned fish* did not present carbohydrates in their composition. Vegan *meatballs* presented the lowest values among all vegan products (7.36 g ± 6.84/100 g).

Protein values varied from 8.75 g ± 4.6/100 g (vegan canned fish) to 21.77 g ± 14.00 (vegan chicken breast) among vegan samples. Animal protein *chicken breast* also presented the highest value (30.67 g ± 0.58/100 g) among all animal protein samples. Furthermore, meatballs have the lowest values (13.17 g ± 1.61/100 g) for animal products. Only *canned fish* samples presented statistical differences between vegan and animal counterparts.

Significant differences were found regarding total fat values between animal and vegan versions of *hamburgers, minced beef, meatballs, and sausages. The vegan versions presented* lower values than their animal counterparts. Among the vegan products, *hams* presented the highest value (12.83 g ± 7.49/100 g) for fat, while *chicken breast* (5.17 g ± 4.96/100 g) showed the lowest. Animal-based versions of *sausages* presented 22.33 g ± 5.51/100 g of total fat, the highest value among animal products, and chicken breast, the lowest (3.53 g ± 0.12/100 g). Regarding saturated fat, statistical differences were found between vegan and animal options of *meatballs, breaded chicken, and sausages*, with the animal options presenting higher content than vegan ones. Among vegan options, *chicken hamburgers* showed the highest concentration of saturated fat (5.04 g ± 5.45/100 g), while in the animal counterparts, *sausages* presented the highest values (7.47 g ± 1.50/100 g). *Chicken* *breast* showed the lowest values for saturated fat in both animal and vegan options, presenting 1.00 g ± 0.00/100 g and 0.63 g ± 0.66/100 g, respectively.

Regarding dietary fiber, vegan *chicken breast* presented the highest values among all samples (6.79 g ± 6.27/100 g), while vegan *breaded chicken* presented the lowest (4.32 g ± 1.85/100 g). Significant differences were found between 70% (*n* = 7) of the vegan options and their animal counterparts, with the vegan options presenting higher fiber content. Animal-based options of *minced beef, chicken breast, canned fish, sausages, and hams* did not show any dietary fiber.

Significant differences were found between vegan and animal counterparts in *minced beef and fish cakes. The vegan versions of these products presented higher concentrations of sodium than* their animal counterparts. *Sausages* also presented statistical differences between animal and vegan options; however, the animal option presented higher sodium values (1,122 g ± 326.01/100 g) than its vegan counterpart (572.35 g ± 119.33/100 g). No differences were found between animal and vegan samples of *hamburgers, chicken breast, canned fish, meatballs, chicken hamburgers, sausages, and hams*.

A word cloud with a graphical representation of all implemented ingredients in vegan meat analogs is available in Figure 1. The information regarding the frequency of mentioning the main protein and fat sources in food labels and the food additives in all samples of vegan meat analogs are available in Table 2.

Figure 1 - Word cloud generated with the frequencies of implemented ingredients on vegan meat analogues. Higher frequencies were proportionally represented with larger graphic representations.

Table 2 - Main protein and fat sources and food additives implemented in all samples of vegan meat alternatives

Protein Source	%	Fat Source	%	Food Additive	%
Gluten	44%	Unspecified Vegetal Fat	32.8%	Methylcellulose	58%
Texturized Soy Protein	39.2%	Soy Oil	26.4%	Natural Aroma	31.2%
Soy Protein	22.4%	Sunflower Oil	12%	Ascorbic Acid	18.4%
Isolated Soy Protein	20.8%	Olive Oil	10.4%	Caramel color	10.4%
Pea Protein	15.2%	Cottonseed Oil	6.4%	Carregenaan Gum	5.2%
Chickpeas	9.6%	Palm Oil	6.4%	Citric Acid	2.4%
Peas	8%	Coconut Oil	4%	Guar Gum	1.6%
Texturized Pea Protein	7.2%	Coconut Fat	1.6%		
Soy	7.2%	Palm Fat	1.6%		
Isolated Pea Protein	5.6%				
Chickpea Flour	6.4%				
Beans	4.8%				

Regarding all utilized ingredients, culinary ingredients such as water, salt, sugar, and spices (including onion, garlic, paprika, smoked paprika, nutritional yeast, and yeast extract) were found in most samples (96%). Soy-based protein-rich products were the most used protein sources (77%), followed by gluten in 44% of the samples.

Ingredients derived from legumes (soy, peas, chickpeas, and beans) are the most used in the studied samples. Different presentations of ingredients based on the same legume were implemented in the vegan meat alternatives. Texturized soy protein, soy protein, and isolated soy protein are soy-based, and texturized pea protein, pea protein, and isolated pea protein are pea-based. Chickpeas and chickpea flour were also used, and beans were used in a lower quantity. It is important to note that all samples combined at least two or more protein sources (Supplementary Table 1). A single sample (0.8%, $n = 1$) utilized cashew fiber as its only protein source.

Unspecified vegetal fat was present in most samples (32.8%); however, while not described in nutritional labels, it was not possible to determine the source of this fat.

The distribution of the ingredients with frequencies higher than 1.5% among specified categories is described in the heatmap (Figure 2).

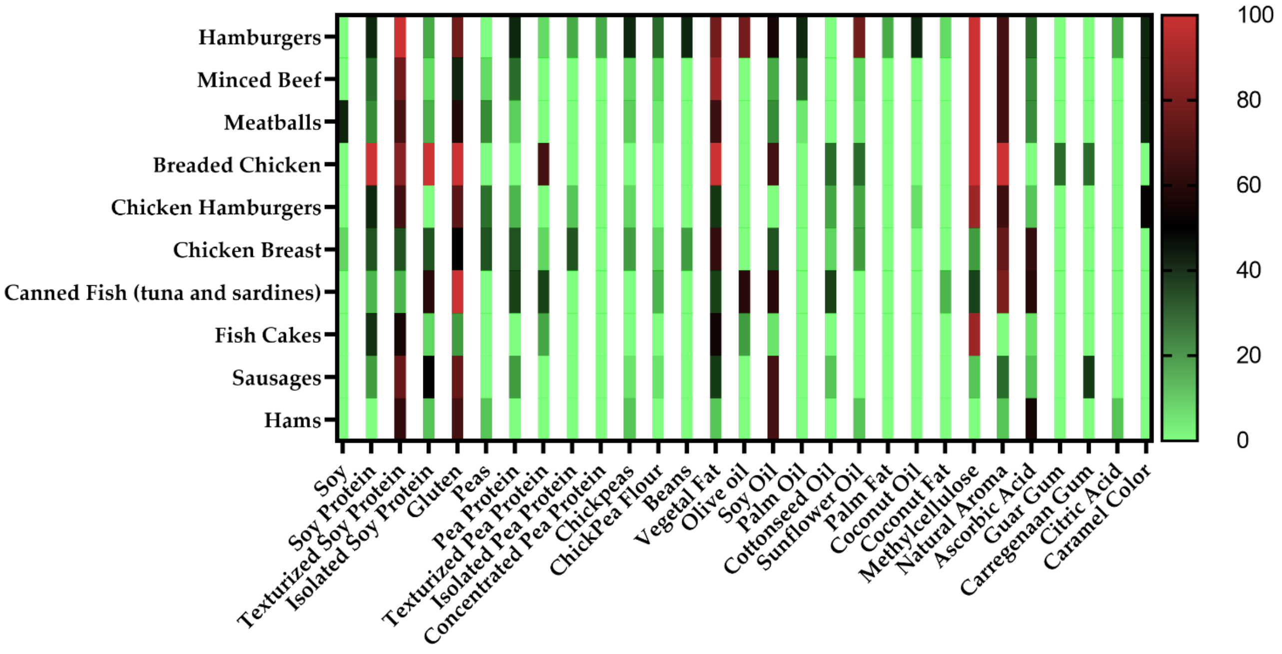

Figure 2 - Percentages of frequencies of implemented ingredients in vegan meat alternatives in a heatmap. Colored clusters represent different frequencies according to the scale placed in the right side.

In hamburgers, texturized soy protein was present in 100% of the samples, while gluten was in 77.7%. Pea protein was present in only 44% of the samples. Vegetal fat, soy oil, and sunflower oil were used equally among samples (77%). Regarding food additives, methylcellulose was found in 100% of the hamburger samples, a natural aroma in 66%, and caramel color in 44%.

Minced beef samples presented texturized soy protein (77%), gluten (44%), and pea protein (33%) as their primary protein sources. Chickpeas and chickpea flour were found in lower quantities, with a frequency of 11% for both ingredients. Vegetal fat was also predominately used as a fat source (88%), followed by palm oil (33%) and soy oil (22%). In meatballs, soy (as soybeans) was present in 44% of the samples, however, texturized soy protein (67%) and gluten (57%) were present in higher quantities, following the tendency among bovine meat substitutes. Regarding food additives, methylcellulose was also present in 100% of the minced beef and meatballs samples, followed by a natural aroma (66%) and caramel color (44%).

All samples of breaded chicken presented soy protein, isolated soy protein, and gluten. Other protein sources such as texturized protein sources (77%) and texturized pea protein (66%) were also present. As for the implemented fat sources, vegetal fat was found in 100% of the samples, followed by soy oil (77%) and both cottonseed and sunflower oils with 33%. Methylcellulose was present in 100% of breaded chicken samples, similar to bovine meat alternatives. Guar and carrageenan gums were used in 33.3% of breaded chicken samples.

Chicken hamburgers used mainly gluten (72%), texturized soy protein (66%), peas (33%), pea protein (20%), isolated pea protein (12%), and chickpeas (9%) as their protein sources. Vegetal fat was the most used lipid source (44%). Methylcellulose and a natural aroma were the most used food additives, with 88 and 65%, respectively.

A more diverse distribution of protein sources was found on chicken breast alternatives. Gluten (50%), soy protein (37%), texturized soy protein (37%), peas (37%), pea protein (37%), chickpeas (25%), beans (25%), texturized pea protein (17.5%) and chickpea flour (12%) were utilized. Vegetal fat was the most predominant lipid source with 62.5%, followed by soy oil with 37.5% and cottonseed oil with 12.5%. Additives such as natural aroma (72%), ascorbic acid (62.5%), and methylcellulose (25%) were present in this category.

Canned fish presented as protein sources, gluten (100%), isolated soy protein (60%), both texturized and regular pea protein (40%), texturized soy protein (20%) and chickpea flour (20%). Both olive and soy oil were used in 60% of canned fish samples, while vegetal fat and cottonseed oil were present in 40% of the samples of this same category. Coconut fat was found in 20% of the canned fish samples. Considering food additives, a natural aroma was found in 80% of the samples, followed by ascorbic acid (60%) and methylcellulose (40%).

The primary protein source presented in fish cakes were texturized soy protein (55%), soy protein (43%), gluten (25%), texturized pea protein (23%), and isolated soy protein (12%). Similar to the other categories, vegetal fat was the primary lipid source with 54%. Olive oil was the second most used (25%), followed by soy oil (8.33%). Methylcellulose and ascorbic acid were the only additives used, with 88 and 8.33%, respectively.

Gluten and texturized soy protein were present in 75% of the plant-based sausages, while soy and pea protein were used in 25% of the samples. Chickpeas and chickpea flour were used in only 8.33% of the samples. Soy oil was the most used fat source in this category, present in 66.67% of the samples. Vegetal fat was present in 41.67% of the samples, followed by cottonseed oil in 16.67% of the studied products. Carrageenan gum was the most used additive in 41.67% of the samples. A natural aroma was found in 33.33% of the samples, and ascorbic acid and methylcellulose in 16.66% of them.

Gluten was utilized in 66% of hams, followed by texturized soy protein (62%), while chickpeas and peas were found in 16.7% of ham samples. Soy oil was the predominant fat source in hams, present in 66% of the samples. Both vegetal fat and cottonseed oil were used in 16.66% of the samples. Ascorbic acid was the most utilized food additive, present in 55% of the samples. Sixteen percentage of the studied samples used a natural aroma and citric acid.

DISCUSSION

This study is the first on the nutritional quality of vegan meat substitutes commercialized in Brazil. Plant-based vegan and vegetarian diets are well-known for their association with longevity, higher quality of life, and protection of various non-communicable diseases (28–31). However, the excessive consumption of industrialized foods that substitute animal-based products goes oppositely, and information is scarce regarding this practice within vegetarian and vegan diets (32, 33).

Regarding energy values, despite being a point of attention, vegans and vegetarians tend not to present differences in energy intake compared to omnivorous individuals (28). Therefore, the consumption of industrialized foods might exert a similar influence independently of the adopted diet. A primary concern related to industrialized food consumption is that this product commonly presents a higher energy density and collaborates with an excessive energy intake. It has already been associated with an increased prevalence of diseases related to excessive body mass, such as coronary heart disease and type II diabetes, thus constituting a public health problem (34–36). Brazilian vegan meat substitutes in our study tended to present similar energy values to their animal counterparts. Differences were only found in *minced beef* and *sausages*, different from another study conducted in the United States, wherein general, all vegan meat substitutes presented lower energy values (21).

Given the natural carbohydrate-rich nature of plant-based foods, vegan and vegetarian diets usually present a higher amount of this macronutrient (21, 33, 34). This is possible due to the use of plant-based matrixes, which tend to present fiber in their composition, in contrast with animal-protein meat, which usually does not present this nutrient. Included vegan products presented differences regarding their concentration of carbohydrates in hamburgers, minced beef, chicken breast, canned fish, and sausages, with the vegan options presenting higher values than their animal counterparts.

It is important to highlight that there are diverse carbohydrates in vegetable products, such as starch, polyols, fructose, and galactooligosaccharides. In meat products, starch sources are used due to their properties related to texture improvement, shelf-life extension, cohesiveness, and elasticity, especially in the case of hamburgers, sausages, and hams. These proprieties are mostly associated with starches' capacity to form stable gels through gelatinization (37). In addition, they can also be technological substitutes for fat (38). This tendency is also evident in researched meat substitutes worldwide, where corn and potato starches were implemented (22). Although added sugar is an important carbohydrate present in industrialized preparations (39, 40) and mandatory in labels, according to the Brazilian legislation, the studied meat substitute did not present any added sugar, or no considerable amounts were present in the chosen serving sizes. A major problem involving Brazilian nutritional labels is that nutritional values are described based on the chosen portion by the manufacturer (26), which does not necessarily reflect the usual consumed portion of the product. Thus, nutrients with insignificant amounts (<1%) in the chosen portion are not shown on the nutrition label, and possibly, when adopting the usual amount of consumption, these nutrients would have expressive values that should be described on nutrition labels (41).

Both Protein Intake and Quality Are Important Regarding Vegan and Vegetarian Diets (42). Although it is entirely possible to obtain the proper amount of protein intake in this type of diet, issues related to the nature of the vegetal protein source must be considered. Essential amino acids cannot be synthesized by any endogenous human metabolic pathway (42). Regarding animal protein, usually, a single portion of meat has a satisfactory amount of these amino acids. At the same time, in vegetable sources, one or more sources must be combined to reach the adequate intake (9, 42). Usually, legumes have reduced amounts of methionine, while cereals have a lower lysine concentration. Therefore, combined portions of cereals and legumes should be consumed (42).

Legumes such as soy, chickpeas, peas, and cereals such as wheat usually function as protein sources in meat substitutes. In the included samples, gluten was the second most present protein source. Gluten is a protein complex in cereals such as wheat, rye, and barley that presents unique characteristics on food as adhesion, elasticity, cohesion, and enhance the texture of food products (43). Commonly, its isolated form is sold in the form of vital wheat gluten, an ingredient consisting of isolated starch-free wheat gluten, dehydrated and in flour granulometry (44). This ingredient forms an elastic, tenacious and consistent net whose texture can resemble some types of meat, especially those with a firmer texture, as evidenced in the samples where it was most used, such as hamburgers, breaded chicken, chicken hamburgers, canned fish, sausages, and hams. However, it is important to mention that worldwide there is about 10% of the population (45, 46) following a gluten-free diet (GFD). The high use of gluten in vegan products might limit the consumption of this kind of product by people who need to follow a GFD and opt to follow the vegan dietary pattern.

Soy stood out as the main protein source used in the studied samples, in the forms of texturized soy protein, soy protein, and isolated soy protein. Texturized soy protein is obtained by a thermoplastic extrusion process. Regarding its texture and appearance, this ingredient is sensory similar to animal meat; thus, since its invention, it is already widely used as a meat substitute (47). Isolated soy protein also functions as a texture improver since its proteins behave stably during the cooking process, resulting in firmer products and contributing to coloring by favoring the Maillard reaction (48).

Soybeans characterize one of Brazil's largest production markets, whose profits correspond to a significant portion of the country's gross domestic product (GDP) and move about US$20 billion a year (49, 50). Thus, given its high availability, soybean is widely used in industrialized products, both of animal and plant origin, given its technological characteristics that are considered desirable by the industry (51).

Soy has an aminogram comparable to meat, milk, and egg proteins concerning its nutritional value. From a dietary point of view, it is one of the most used foods to replace ingredients of animal origin (47, 48).

However, one of the main obstacles to soybean consumption is its high allergenic potential. Currently, soy allergy occurs on 0.5% in the general population, with an even higher number in children (about 12%) (52). Thus, one of the emerging alternatives to replace soy in vegan meat substitutes is pea-derived protein. With the same technology used in soy protein derivatives, pea protein has similar nutritional and sensory points of view. It is widely used in products whose goal is to offer soy-free alternatives (53, 54). As evidenced in the study, meat analogs commercialized in Brazil used pea protein in its textured, isolated, and pure form, but in lower quantities compared to soy protein-based ingredients.

Another alternative to protein sources is other legumes, as evidenced by the use of chickpeas and beans. The included samples used only cooked and without processing technology. However, characteristics such as moisture retention, protein concentration, and, consequently, the sensory aspect are impaired without the technological processes employed, for example, thermoplastic extrusion or protein isolation) (47). In this sense, the predominant use of textured versions of proteins derived from legumes was evidenced in the present study instead of unprocessed versions of legumes.

The protein sources used in Brazilian vegan meat analogs are similar to those evidenced in studies conducted in other countries. However, the other studies showed lower protein concentrations than their animal counterparts, thus emphasizing the importance of choosing and combining ingredients for this purpose (21, 22).

Studied vegan versions presented lower values regarding total and saturated fat amounts mainly because vegetables usually present reduced content of these nutrients (9). Fats are essential components in developing processed foods, as their presence is responsible for the high palatability, aftertaste, "crunchiness," and color commonly associated with this type of product (55). In this sense, given their lower concentration of total and saturated fats and when considering the purposes of vegan meat substitutes, the moderated use of these products in place of their animal counterparts can be beneficial. However, although fats and saturated fats are present in smaller amounts in vegan meat substitutes than their animal counterparts, the presence of these nutrients should be carefully analyzed, as their excessive consumption is intimately linked with the development of non-communicable chronic diseases (27–29, 35, 44)].

Unspecified vegetable fat was the most used source of fat in the studied samples. Although unspecified, the vegetable fat used in industrialized products is usually hydrogenated. This ingredient is obtained from the hydrogenation of vegetable oils, and it adds desirable characteristics from an industrial point of view, such as longer shelf life and greater palatability (38). A characteristic resulting from the hydrogenation of plant oil is its melting point. In the form of vegetable oils, with their reduced melting point, these fat sources remain liquid at room temperature. Hydrogenated vegetable fat, on the contrary, remains solid, thus preserving the sensory characteristics of the food (38). However, it is already well-known that excessive consumption of this type of fat is associated with an increase in the prevalence of chronic non-communicable diseases, thus reinforcing the need for caution regarding its consumption

(55, 56). Oils such as soybean, cottonseed, sunflower, and palm were also used in the studied products. Concerning the excessive consumption of these oils, it is noteworthy that these are sources of omega-6 fatty acids, compounds directly related to the production of pro-inflammatory cytokines. Thus, they should then have their consumption moderated (57, 58). Olive oil was used more pronouncedly in the canned fish category, probably because some of these products are commercialized ready for consumption, not requiring cooking and therefore not resulting in physicochemical changes of this oil. However, olive oil tends to present a higher cost; therefore, its use in industrialized products is usually limited.

Dietary fiber is a naturally plant-derived nutrient, and its consumption is associated with weight maintenance and better health of the gut microbiota (40, 59). In technological aspects, the addition of dietary fiber provides favorable characteristics such as greater moisture retention, thus contributing to the texture. However, excessive amounts of fiber can result in more rigid products, increasing chewing, thus constituting sensory impairment (60). All meat substitutes had higher dietary fiber values than their animal-derived counterparts since animal products tend to have low (or not have) fiber. In the last Brazilian survey of risk factors for chronic diseases *(Vigitel)*, the results showed a lower consumption of vegetables and fruits by the Brazilian population, resulting in a lower intake of dietary fibers can be based on food composition (61). To obtain appropriate intake, the World Health Organization (WHO) recommends consuming at least 400 g of fruits and vegetables (equal to five servings) daily (62). When the recommended daily consumption of five meals was assessed in a research of a Brazilian vegetarian's statewide sample, just 38% of them displayed adequate intake (31) compared to 21% of the general Brazilian population (63). In this sense, vegan meat substitutes could compose Brazilian meals to improve fiber intake among Brazilians (vegetarians or not).

However, it is important to consider that dietary fiber has the physical ability to retain liquids such as water or oil (59, 64). In the context of meat substitutes sold for subsequent cooking, this physical characteristic of dietary fibers can collaborate with greater retention of lipids (when using a cooking method with oil or fat) and, consequently, in higher concentrations of lipids and energy values (64).

The high sodium level in meat substitutes is a trend already evidenced by studies in other countries (21, 22). In the present study, only the vegan versions of *minced beef* and *fish cakes* showed significant differences compared to their animal counterparts, in this case, with higher values. Nevertheless, it is worth noting that the animal version of *minced* *beef* corresponds to raw fresh food without adding salt, in contrast with the vegan versions that are already commercialized with seasoning. The presence of nitrogenous bases in beef gives it its own accentuated flavor, thus reducing adding salt and other seasonings (64). The animal-based protein has substances in its composition that give its characteristic and accentuated flavor. Besides, its concentration and distribution of amino acids and reducing sugars favor the Maillard reaction, which contributes considerably to the development of these foods (64).

Fish cakes are preparations commonly made with saltwater fish and other seafood. In this sense, the addition of sodium was probably intended to mimic the characteristic flavor of these animal proteins. However, despite a few differences regarding sodium, it is necessary to analyze the contribution of meat substitutes with the recommendation of total daily sodium intake. Currently, WHO recommends a daily value of 2,300 mg of sodium/day (65). Considering lunch in Brazil as a contributor of 40% of the total daily value, a limit of 920 mg of sodium would be established (66). In this sense, 100 g of the included meat substitutes would contribute on average, with sodium values referring to about 30–50% of the lunch. A typical Brazilian food-service lunch comprises a main dish (high in protein—in which products evaluated in this study could be included) and garnishes, rice, beans, and salads, and their respective average contribution regarding sodium values. Therefore, meat substitutes might contribute to an excessive sodium intake since they represent, for some products, almost 50% of the total sodium recommendation for the lunch meal (66).

Food additives are not food compounds but they are used in food products to improve technological and sensory characteristics (67). Methylcellulose was the most used food additive in the studied samples. This ingredient is a hydrocolloid derived from cellulose whose action is directly related to improving the texture and emulsion of phases (68). When used in meat preparations, this ingredient contributes directly to the texture, humidity, agglutination, and integrity of the preparations, already being commonly used in sausages, compacted fillets, hams, and burgers (38). Another hydrocolloid, carrageenan gum, was utilized in sausages and breaded chicken, and it performs similarly to methylcellulose (67, 68). Citric and ascorbic acids are common food additives from the class of preservatives, used to improve durability and shelf-life by reducing oxidation and water activity (67). A major concern related to artificial food additives is caramel color. This additive is widely used in industrialized preparations and has long been associated with high carcinogenic potential (69). However, recent studies have established a safe consumption limit, thus denying its genotoxic and carcinogenic potential (70).

Our study demonstrated a pattern similar to that practiced in other countries regarding the choice of implemented ingredients. Studies in other countries have shown the recurrent use of soy, wheat, and pea proteins as sensory and nutritional substitutes for meat, such as the use of fat sources such as vegetable oil, canola oil, and coconut fat (21, 22). Corn and potato starches were also used (21, 22).

The Brazilian market for meat substitutes is similar to the consumption pattern practiced by Brazilians. The present study found a higher frequency of red meat substitutes, followed by poultry, pigs, and fish. In Brazil, red meat's daily per capita consumption is 63.2 g, poultry is 36.5 g, fish is 23.4 g, and pork is 8.3 g (71). However, stratifying the data, the consumption of beef burgers is about 3 g daily *per capita*, and poultry meat burgers 0.9 g/day (71).

It is crucial to note that the Brazilian market for meat substitutes has positive growth projections, being valued at US$17 million in its first 3 months of launch (72). Despite this, surveys reveal a surge in the prevalence of vegetarianism in Brazil and an increase in the intention to purchase products classified as vegan (73). Therefore, it is crucial to invest in healthy alternatives that support the ethical and nutritional characteristics of plant-based vegetarian and vegan diets. Regarding the general characteristics of Brazilian vegan meat substitutes, potential benefits associated with their consumption may be noted, since their dietary fiber value is higher than the values found in animal protein counterparts. According to the WHO, a total of 25 g of dietary fiber should be consumed daily (62), and recent research on food consumption in Brazil points to a decrease in vegetable consumption in general, consequently leading to a reduction in the consumption of dietary fibers, which already tends to be reduced (61). However, despite the benefits resulting from the increased consumption of dietary fibers, it is noteworthy that these products are also incorporated with increased saturated fat and sodium levels, therefore, even though these are classified as plant-based products, these should still be interpreted as industrialized products, and their consumption should not be encouraged in a daily habit.

Despite being close in terms of nutritional value, different ingredients can influence human health in different ways and, in the case of these products, the extensive use of artificial coloring and flavoring is necessary to obtain similar sensory aspects (22, 74). Therefore, further studies are needed to analyze the ingredients implemented in vegan meat substitutes.

One potential drawback of our investigation was the absence of laboratory chemical analysis to confirm the label information. According to the Brazilian legislation, nutritional labels can be based on food composition tables and present a discrepancy level of 20% (for more or less) between its actual chemical composition and the one described on the label (26). Thus, possible divergences related to Brazilian vegan meat substitutes real chemical composition may be present, as found in a study with other types of products (75).

CONCLUSIONS

This study on the nutritional quality of vegan products commercialized in Brazil did not wholly confirm our hypothesis since most of them were similar to their animal counterparts on their labels' nutritional composition. Vegan meat substitutes presented similar energy and protein values, with few exceptions among samples, with vegan canned fish alternatives showing less protein than their counterparts. Naturally, vegan meat substitutes presented a higher concentration of carbohydrates and dietary fiber, given that plant-based ingredients also tend to present considerable amounts of these nutrients. Soy (mainly texturized soy protein) and gluten were most used as protein-sources in vegan products studied. Pea protein-derived ingredients were also used in the meat-free alternatives. Total and saturated fat was present in higher quantities among animal meat samples. Vegan meat analogs utilized vegetal fat as the main source. Regarding the sodium content, differences were found only in two groups, the vegan versions of minced beef and fish cakes, those with more sodium than their animal counterparts. Methylcellulose and natural aroma were the most implemented food additives.

Vegan meat substitutes did not differ from their respective animal counterparts. However, further studies aiming to research the chemical composition of these products with certified laboratory methods are needed. The Brazilian market for vegan meat substitutes is growing prosperously. Thus, there is a notorious demand for healthy alternatives contributing to adherence to vegetarian and vegan diets.

REFERENCES

1. Henchion M, Hayes M, Mullen AM, Fenelon M, Tiwari B. Future protein supply and demand: strategies and factors influencing a sustainable equilibrium. *Foods.* (2017) 6:53. doi: 10.3390/FOODS6070053

PubMed Abstract | CrossRef Full Text | Google Scholar

2. Geiker NRW, Bertram HC, Mejborn H, Dragsted LO, Kristensen L, Carrascal JR, et al. Meat and human health—current knowledge and research gaps. *Foods.* (2021) 10:1556. doi: 10.3390/FOODS10071556

PubMed Abstract | CrossRef Full Text | Google Scholar

3. Henchion M, McCarthy M, Resconi VC, Troy D. Meat consumption: trends and quality matters. *Meat Sci.* (2014) 98:561–8. doi: 10.1016/J.MEATSCI.2014.06.007

PubMed Abstract | CrossRef Full Text | Google Scholar

4. Ilak AS, Peršuri'c P, TeŽak A, Damijani'c D. Connections between healthy behaviour, perception of olive oil health benefits, and olive oil consumption motives. *Sustainability.* (2021) 13:7630. doi: 10.3390/SU13147630

CrossRef Full Text | Google Scholar

5. Statista. *Where Meat Consumption Is Highest & Lowest | Statista. Meat Consumption.* (2019). Available online at: https://www.statista.com/chart/16889/total-per-capita-meat-consumption-worldwide/ (accessed July 10, 2019).

6. Tonheim LE, Austad E, Torheim LE, Henjum S. Plant-based meat and dairy substitutes on the Norwegian market: comparing macronutrient content in substitutes with equivalent meat and dairy products. *J Nutrit Sci.* (2022) 11:1–8. doi: 10.1017/JNS.2022.6

PubMed Abstract | CrossRef Full Text | Google Scholar

7. FAO. *World Agriculture: Towards 2015/2030. World Agriculture : Towards 2015/2030 An Fao Perspective444.* Available online at: http://www.fao.org/3/y4252e/y4252e05b.htm (accessed July 10, 2019).

Google Scholar

8. Curtain F, Grafenauer S. Plant-based meat substitutes in the flexitarian age: an audit of products on supermarket shelves. *Nutrients.* (2019) 11:2603. doi: 10.3390/NU11112603

PubMed Abstract | CrossRef Full Text | Google Scholar

9. Barnard ND, Goldman DM, Loomis JF, Kahleova H, Levin SM, Neabore S, et al. Plant-based diets for cardiovascular safety and performance in endurance sports. *Nutrients.* (2019) 11:1–10. doi: 10.3390/nu11010130
PubMed Abstract | CrossRef Full Text
10. Kahleova H, Tura A, Klementova M, Thieme L, Haluzik M, Pavlovicova R, et al. A plant-based meal stimulates incretin and insulin secretion more than an energy-and macronutrient-matched standard meal in type 2 diabetes: a randomized crossover study. *Nutrients.* (2019) 11:1–11. doi: 10.3390/nu11030486
PubMed Abstract | CrossRef Full Text | Google Scholar
11. Najjar RS, Moore CE, Montgomery BD. Consumption of a defined, plant-based diet reduces lipoprotein(a), inflammation, and other atherogenic lipoproteins and particles within 4 weeks. *Clin Cardiol.* (2018) 41:1062–8. doi: 10.1002/clc.23027
PubMed Abstract | CrossRef Full Text | Google Scholar
12. Kahleova H, Dort S, Holubkov R, Barnard ND. A plant-based high-carbohydrate, low-fat diet in overweight individuals in a 16-week randomized clinical trial: the role of carbohydrates. *Nutrients.* (2018) 10:1–14. doi: 10.3390/nu10091302
PubMed Abstract | CrossRef Full Text | Google Scholar
13. Najjar RS, Feresin RG. Plant-based diets in the reduction of body fat: physiological effects and biochemical insights. *Nutrients.* (2019) 11:1–19. doi: 10.3390/nu11112712
PubMed Abstract | CrossRef Full Text
14. Satija A, Bhupathiraju SN, Spiegelman D, Chiuve SE, Manson JAE, Willett W, et al. Healthful and unhealthful plant-based diets and the risk of coronary heart disease in U.S. *Adults J Am Coll Cardiol.* (2017) 70:411–422. doi: 10.1016/j.jacc.2017.05.047
PubMed Abstract | CrossRef Full Text | Google Scholar
15. Satija A, Bhupathiraju SN, Rimm EB, Spiegelman D, Chiuve SE, Borgi L, et al. Plant-based dietary patterns and incidence of type 2 diabetes in US men and women: results from three prospective cohort studies. *PLoS Med.* (2016) 13:1–18. doi: 10.1371/journal.pmed.1002039
PubMed Abstract | CrossRef Full Text | Google Scholar
16. Statista. *Vegetarian Diet Followers Worldwide by Region.* (2016). Available online at: https://www.statista.com/statistics/597408/vegetarian-diet-followers-worldwide-by-region/ (accessed January 2, 2019).

17. Inteligência I. *14% da população se declara vegetariana.* (2018). Available online at: http://www.ibopeinteligencia.com/noticias-e-pesquisas/14-da-populacao-se-declara-vegetariana/ (accessed July 10, 2018).
18. Aschemann-Witzel J, Gantriis RF, Fraga P, Perez-Cueto FJA. Plant-based food and protein trend from a business perspective: markets, consumers, and the challenges and opportunities in the future. *Crit Rev Food Sci Nutr*. (2020) 61:3119–28. doi: 10.1080/10408398.2020.1793730
PubMed Abstract | CrossRef Full Text | Google Scholar
19. Onwezen MC, Bouwman EP, Reinders MJ, Dagevos H. A systematic review on consumer acceptance of alternative proteins: pulses, algae, insects, plant-based meat alternatives, and cultured meat. *Appetite.* (2021) 159:105058. doi: 10.1016/J.APPET.2020.105058
PubMed Abstract | CrossRef Full Text | Google Scholar
20. Boukid F. Plant-based meat analogues: from niche to mainstream. *Eur Food Res Technol.* (2020) 247:297–308. doi: 10.1007/S00217-020-03630-9
CrossRef Full Text | Google Scholar
21. Cole E, Goeler-Slough N, Cox A, Nolden A. Examination of the nutritional composition of alternative beef burgers available in the United States. *Int J Food Sci Nutr*. (2021) 73:425–32. doi: 10.1080/09637486.2021.2010035
PubMed Abstract | CrossRef Full Text | Google Scholar
22. Curtain F, Grafenauer S. Plant-based meat substitutes in the flexitarian age: an audit of products on supermarket shelves. *Nutrients.* (2019) 11:1–14. doi: 10.3390/nu11112603
PubMed Abstract | CrossRef Full Text
23. Calvo-Lerma J, Crespo-Escobar P, Martínez-Barona S, Fornés-Ferrer V, Donat E, Ribes-Koninckx C. Differences in the macronutrient and dietary fibre profile of gluten-free products as compared to their gluten-containing counterparts. *Eur J Clin Nutr.* (2019) 73:930–6. doi: 10.1038/s41430-018-0385-6
PubMed Abstract | CrossRef Full Text | Google Scholar
24. Cornicelli M, Saba M, Machello N, Silano M, Neuhold S. Nutritional composition of gluten-free food versus regular food sold in the Italian market. *Digest Liver Dis.* (2018) 50:1305–8. doi: 10.1016/j.dld.2018.04.028
PubMed Abstract | CrossRef Full Text | Google Scholar

25. Fresán U, Rippin H. Nutritional quality of plant-based cheese available in spanish supermarkets: how do they compare to dairy cheese? *Nutrients.* (2021) 13:3291. doi: 10.3390/NU13093291
PubMed Abstract | CrossRef Full Text | Google Scholar
26. Brasil. Resolução RDC nº 360, de 23 de dezembro de 2003. Aprova o Regulamento Técnico sobre Rotulagem Nutricional de Alimentos Embalados, tornando obrigatória a rotulagem nutricional. *Agencia Nacional de Vigilância Sanitária.* (2003) 1:1–9.
27. WordCloud. *Free Online Word Cloud Generator and tag Cloud Creator - WordClouds.com* (2020).
28. Clarys P, Deliens T, Huybrechts I, Deriemaeker P, Vanaelst B, de Keyzer W, et al. Comparison of nutritional quality of the vegan, vegetarian, semi-vegetarian, pesco-vegetarian and omnivorous diet. *Nutrients.* (2014) 6:1318–32. doi: 10.3390/nu6031318
PubMed Abstract | CrossRef Full Text | Google Scholar
29. Gili R v., Leeson S, Montes-Chañi EM, Xutuc D, Contreras-Guillén IA, Guerrero-Flores GN, et al. Healthy vegan lifestyle habits among argentinian vegetarians and non-vegetarians. *Nutrients.* (2019) 11:1–18. doi: 10.3390/nu11010154
PubMed Abstract | CrossRef Full Text | Google Scholar
30. Leitzmann C. Vegetarian nutrition: past, present, future. *Am J Clin Nutrit.* (2014) 100:1–7. doi: 10.3945/ajcn.113.071365
PubMed Abstract | CrossRef Full Text | Google Scholar
31. Hargreaves SM, Araújo WMC, Nakano EY, Zandonadi RP. Brazilian vegetarians diet quality markers and comparison with the general population: a nationwide cross-sectional study. *PLoS ONE.* (2020) 15:1–21. doi: 10.1371/journal.pone.0232954
PubMed Abstract | CrossRef Full Text | Google Scholar
32. Monteiro CA, Cannon G, Levy RB, Moubarac J-C, Louzada ML, Rauber F, et al. Commentary ultra-processed foods: what they are and how to identify them. *Public Health Nutr*. (2021) 22:936–41. doi: 10.1017/S1368980018003762
PubMed Abstract | CrossRef Full Text | Google Scholar
33. Moubarac JC, Batal M, Louzada ML, Martinez Steele E, Monteiro CA. Consumption of ultra-processed foods predicts diet quality in Canada. *Appetite.* (2017) 108:512–20. doi: 10.1016/J.APPET.2016.11.006
PubMed Abstract | CrossRef Full Text | Google Scholar

34. Louzada ML da C, Baraldi LG, Steele EM, Martins APB, Canella DS, Moubarac JC, et al. Consumption of ultra-processed foods and obesity in Brazilian adolescents and adults. *Prev Med.* (2015) 81:9–15. doi: 10.1016/J.YPMED.2015.07.018
PubMed Abstract | CrossRef Full Text | Google Scholar
35. Hall KD, Ayuketah A, Brychta R, Cai H, Cassimatis T, Chen KY, et al. Erratum: ultra-processed diets cause excess calorie intake and weight gain: an inpatient randomized controlled trial of ad libitum food intake *Cell Metabolism*. (2019) 30:226. doi: 10.1016/j.cmet.2019.05.020
PubMed Abstract | CrossRef Full Text | Google Scholar
36. Leite Canhada S, Cristine Luft V, Giatti L, Bartholow Duncan B, Chor D, de Jesus da Fonseca MM, et al. Ultra-processed foods, incident overweight and obesity, and longitudinal changes in weight and waist circumference: the Brazilian longitudinal study of adult health (ELSA-Brasil). *Public Health Nutrit.* (2019) 23:1076–86. doi: 10.1017/S1368980019002854
PubMed Abstract | CrossRef Full Text | Google Scholar
37. Svegmark K, Hermansson A. Microstructure and rheological properties of composites of potato starch granules and amylose: a comparison of observed and predicted structures. *Food Structure.* (1993) 12:181–93.
Google Scholar
38. Tokusoglu Ö, Kemal Ünal M. *Fat Replacers in Meat Products.* Food Science Common (2003). 196 p.
39. Kiely LJ, Hickey RM. *Characterization and Analysis of Food-Sourced Carbohydrates.* Science Alert (2022). p. 67–95.
40. Mitmesser S, Combs M. Prebiotics: inulin and other oligosaccharides. *Microb Gastroint Pathophysiol.* (2017) 1:201–8. doi: 10.1016/B978-0-12-804024-9.00023-9
CrossRef Full Text | Google Scholar
41. Cavada G da S, Paiva FF, Helbig E, Borges LR. Rotulagem nutricional: você sabe o que está comendo? *Brazil J Food Technol.* (2012) 15:84–8. doi: 10.1590/S1981-67232012005000043
CrossRef Full Text | Google Scholar
42. Mariotti F, Gardner CD. Dietary protein and amino acids in vegetarian diets—A review. *Nutrients.* (2019) 11:1–19. doi: 10.3390/nu11112661
PubMed Abstract | CrossRef Full Text

43. Yonemoto PG, Calori-Domingues M a, Franco CML. Effect of granule size on the structural and physicochemical characteristics of wheat starch. *Ciencia E Tecnol Alimentos.* (2007) 27:761–71. doi: 10.1590/S0101-20612007000400015
CrossRef Full Text | Google Scholar
44. Ortolan F, Steel CJ. Protein characteristics that affect the quality of vital wheat gluten to be used in baking: a review. *Comp Rev Food Sci Food Safety.* (2017) 16:369–81. doi: 10.1111/1541-4337.12259
PubMed Abstract | CrossRef Full Text | Google Scholar
45. Melini V, Melini F. Gluten-free diet: Gaps and needs for a healthier diet. *Nutrients.* (2019) 11:1–21. doi: 10.3390/nu11010170
PubMed Abstract | CrossRef Full Text
46. Anna S, C BJ, Carolina C, Katri K, Sapone A, Bai JC, et al. Spectrum of gluten-related disorders : consensus on new nomenclature and classification. *BMC Med.* (2012) 10:13. doi: 10.1186/1741-7015-10-13
PubMed Abstract | CrossRef Full Text
47. Riaz MN. Texturized soy protein as an ingredient. *Prot Food Proc.* (2004) 1:517–58.
Google Scholar
48. Singh P, Kumar R, Sabapathy SN, Bawa AS. Functional and edible uses of soy protein products. *Comp Rev Food Sci Food Safety.* (2008) 7:14–28. doi: 10.1111/J.1541-4337.2007.00025.X
CrossRef Full Text | Google Scholar
49. Ortega E, Cavalett O, Bonifácio R, Watanabe M. Brazilian soybean production: emergy analysis with an expanded scope. *Bull Sci Technol Soc*. (2016) 25:323–34. doi: 10.1177/0270467605278367
CrossRef Full Text | Google Scholar
50. Goldsmith PD. Soybean production and processing in brazil. *Soybeans Chem Prod Proc Utili.* (2008) 1:773–98. doi: 10.1016/B978-1-893997-64-6.50024-X
CrossRef Full Text | Google Scholar
51. de Sousa ISF, Busch L. Networks and agricultural development: the case of soybean production and consumption in Brazil. *Rural Sociol.* (1998) 63:349–71. doi: 10.1111/RUSO.1998.63.3.349
CrossRef Full Text | Google Scholar

52. Katz Y, Gutierrez-Castrellon P, González MG, Rivas R, Lee BW, Alarcon P. A comprehensive review of sensitization and allergy to soy-based products. *Clin Rev Allergy Immunol.* (2014) 46:272–81. doi: 10.1007/S12016-013-8404-9
PubMed Abstract | CrossRef Full Text | Google Scholar
53. Samard S, Ryu GH. Physicochemical and functional characteristics of plant protein-based meat analogs. *J Food Proc Preserv.* (2019) 43:e14123. doi: 10.1111/JFPP.14123
CrossRef Full Text | Google Scholar
54. Wang N, Bhirud PR, Tyler RT. Extrusion texturization of air-classified pea protein. *J Food Sci.* (1999) 64:509–13. doi: 10.1111/J.1365-2621.1999.TB15073.X
CrossRef Full Text | Google Scholar
55. Gibney MJ. Ultra-processed foods: definitions and policy issues. *Curr Dev Nutrit.* (2019) 3:2–7. doi: 10.1093/cdn/nzy077
PubMed Abstract | CrossRef Full Text | Google Scholar
56. Crimarco A, Matthew· Landry J, Gardner CD. Ultra-processed foods, weight gain, and co-morbidity risk. *Curr Obesity Rep.* (2021) 1:3–9. doi: 10.1007/s13679-021-00460-y
PubMed Abstract | CrossRef Full Text | Google Scholar
57. Innes JK, Calder PC. Omega-6 fatty acids and inflammation. *Prostagl Leukotr Essential Fatty Acids.* (2018) 132:41–8. doi: 10.1016/J.PLEFA.2018.03.004
PubMed Abstract | CrossRef Full Text | Google Scholar
58. Patterson E, Wall R, Fitzgerald GF, Ross RP, Stanton C. Health implications of high dietary omega-6 polyunsaturated fatty acids. *J Nutrit Metab.* (2012) 2012:2–23. doi: 10.1155/2012/539426
PubMed Abstract | CrossRef Full Text | Google Scholar
59. Anderson JW, Baird P, Davis Jr RH, Ferreri S, Knudtson M, Koraym A, et al. Health benefits of dietary fiber. *Nutrit Rev.* (2009) 67:188–205. doi: 10.1111/j.1753-4887.2009.00189.x
PubMed Abstract | CrossRef Full Text | Google Scholar
60. Caprita A, Căpriță R, Simulescu V, Drehe R-M. The effect of temperature on soluble dietary fiber fraction in cereals. *J Agroaliment Processes Technol.* (2011) 17:214–7. Available online at: https://www.journal-of-agroalimentary.ro/admin/articole/26822L86_Caprita_Vol.4_2010_406-416.pdf
Google Scholar

61. Brasil. *Vigilância De Fatores De Risco E Proteção Para Doenças Crônicas Por Inquérito Telefônico - Vigitel*. Brasília (2020). 1–126p.
62. WHO. *Diet, Nutrition and Prevention of Chronic Disease. Report of a WHO Study Group (WHO Technical Report Series 797)* World Health Organization, Geneva (2003).
63. Ministério da Saúde. *Vigitel Brasil 2018: Vigilância de Fatores de Risco e Proteção Para Doenças Crônicas Por Inquerito Telefônico.* Brasília (2019). 131p.
64. Araújo WMC, Montebello N di P, Botelho RBA, Borgo LA. *Alquimia dos Alimentos*. 2ª edição. Brasília: Senac (2011). 259–63p.
Google Scholar
65. World Health Organization (WHO). *Salt Reduction. Salt Reduction.* (2020). Available online at: https://www.who.int/news-room/fact-sheets/detail/salt-reduction (accessed December 12, 2021).
66. Zandonadi RP, Botelho RBA, Ginani VC, Akutsu R de CCA, de Oliveira Savio KE, Araújo WMC. Sodium and health: new proposal of distribution for major meals. *Health N Hav.* (2014) 06:195–201. doi: 10.4236/health.2014.63029
CrossRef Full Text | Google Scholar
67. Carocho M, Morales P, Ferreira ICFR. Natural food additives: Quo vadis? *Trends Food Sci Technol.* (2015) 45:284–95. doi: 10.1016/J.TIFS.2015.06.007
CrossRef Full Text | Google Scholar
68. Hollingworth CS. *Food hydrocolloids : characteristics, properties and structures*. Nova Science Publishers (2010) 309.
69. Smith TJS, Wolfson JA, Jiao D, Crupain MJ, Rangan U, Sapkota A, et al. Caramel color in soft drinks and exposure to 4-methylimidazole: a quantitative risk assessment. *PLoS ONE.* (2015) 10:e0118138. doi: 10.1371/JOURNAL.PONE.0118138
PubMed Abstract | CrossRef Full Text | Google Scholar
70. Vollmuth TA. Caramel color safety – an update. *Food Chem Toxicol.* (2018) 111:578–96. doi: 10.1016/J.FCT.2017.12.004
PubMed Abstract | CrossRef Full Text | Google Scholar
71. IBGE. *Instituto Brasileiro de Geografia e Estatística, Coordenação de Trabalho e Rendimento. Pesquisa de Orçamentos Familiares: 2008-2009. Análise do Consumo Alimentar Pessoal no Brasil*. Brasília: Governo do Brasil (2011). 150 p.

72. The Good Food Institute. Indústria de proteínas alternativas - 2020. *Good Food Inst Brazil.* Instituto Brasileiro de Opinião Pública e Estatística (2020) 1:1–32.

73. IBOPE. *Pesquisa de Opinião Pública sobre Vegetarianismo*. (2018). 1–24p.

74. Tziva M, Negro SO, Kalfagianni A, Hekkert MP. Understanding the protein transition: the rise of plant-based meat substitutes. *Environ Innov Soc Trans.* (2019) 15:217–31. doi: 10.1016/j.eist.2019.09.004

CrossRef Full Text | Google Scholar

75. Romão B, Botelho RBA, Alencar ER, da Silva VSN, Pacheco MTB, Zandonadi RP. Chemical composition and glycemic index of gluten-free bread commercialized in Brazil. *Nutrients.* (2020) 12:2234. doi: 10.3390/nu12082234

PubMed Abstract | CrossRef Full Text | Google Scholar

Artigo 3 – "*Vegan milk and egg alternatives commercialized in Brazil: A study of the nutritional composition and main ingredients".* (ROMÃO et al., 2022)

Vegan milk and egg alternatives commercialized in Brazil: A study of the nutritional composition and main ingredients

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Abstract: Worldwide, there is an increasing demand for plant-based food due to sustainable, health, ethical, religious, philosophical, and economic reasons. Therefore, a growing number of people adhering to vegetarian and vegan diets is observed. Substitution of animal dairy and egg is challenging from both sensory and nutritional aspects. Yet, there are no data regarding the nutritional value and ingredients of Brazilian commercial dairy and egg substitutes.

Therefore, this study aimed to analyze the nutritional composition and implemented ingredients in commercial vegan alternatives to dairy and eggs. A cross-sectional quantitative study was carried out in four steps: (i) sample mapping; (ii) data collection and (iii) statistical analysis. A total of 152 samples were included. No differences were found between the energy value and total fat of vegan products and their animal counterparts. Vegan products presented higher amounts of carbohydrates and dietary fiber, and only the vegan versions of beverages and cheeses presented less protein than their counterparts. Cashews, rice, coconut and soy were the most implemented ingredients in dairy substitutes. Emulsions of oil, starch, and isolated protein were used in vegan egg products. Most vegan beverages presented sugar in their composition. Vegan alternatives of dairy and eggs might be suitable for substituting their animal counterparts; however, the need for formulations with higher protein concentrations in vegan beverages and cheese is highlighted.

Keywords: vegan products; dairy alternatives; egg substitutes; plant-based protein; dairy-free cheese

1. Introduction

Worldwide there is an increasing demand for plant-based food due to sustainable, health, ethical, religious, philosophical, and economic reasons (1). Therefore, a growing number of people adhering to vegetarian and vegan diets is observed, which voluntarily exclude animal food groups partially or totally (2). Worldwide, vegetarianism is distributed across continents, with prevalences of 19% in Asia, 16% in Africa, 8% in South and Central America, 6% in North America and only 5% in Europe (3). In Brazil, 14% of the population identifies themselves as vegetarians (4). Besides vegetarian and vegan diets, there are also considerable prevalences of cow's milk allergy (CMA; affecting 0.5 to 3.0% of individuals), lactose intolerance (LI; affecting 65% to 70% of individuals) and egg allergy (EA; affecting 0.5 to 2.0% in infants) stand out (5,6). Therefore, the need for alternatives for these groups of foods and their derivatives is highlighted.

Cow’s milk is a common staple food and its consumption is present in the dietary habit of almost 6 billion people (7,8). In countries such as India, the European Union - EU) and the United States - US), its yearly consumption revolves between 83 to 21 million metric tons (7). In addition to its consumption in the unprocessed form, milk derivatives such as yogurts and cheeses are highly present in the dietary habit of the overall world population (9). Chicken eggs are another staple food in the world food habit, with its consumption being an average of 161 eggs per capita/year (10). Both foods stand out for their nutritional quality, being sources of high biological value proteins, saturated fats, vitamins, and minerals (11,12). Yet, milk and eggs and their derivatives contribute to desirable technological and sensory characteristics in various food preparations (13). Therefore, finding alternatives to milk and eggs in food is a challenge and food industry is constantly searching for pant-based alternatives.

The use of plant-based milk alternatives is already implemented since the end of the 20th century and as for currently, it constitutes a market valued at around 3.9 billion dollars (USD) (14). As for the egg substitutes, although there is no data regarding the market value for this specific subject, projections regarding the plant-based alternatives market demonstrate continuous growth, especially in Americas and Europe (15,16). Consumers often look for options that sensorily counter the characteristics of cow's milk and eggs. However, since these characteristics depend on intrinsic compounds of animal origin, there is the possibility of divergences in their plant-based counterparts' nutritional value and ingredient list (17–19). Commonly, plant-based milk alternatives consist of water-soluble extracts based on soybeans, cashews, almonds, coconut, hazelnuts, pseudocereals, and legumes (17). On egg substitutes, different ingredients are used according to the product's characteristics, usually, it consists of emulsions of vegetable fats or isolated vegetable proteins (20–22).

Multiple studies have studied the nutritional composition of plant-based cow's milk alternatives, mainly from versions developed by researchers (12,23–34). In general, a lower concentration of protein, energy and calcium is noted, however, with beneficial bioactive compounds such as β-sisterol and β-glucan (17,32). However, few studies have analyzed the nutritional composition and ingredients of both vegan milk derivatives and vegetable alternatives for egg-based products, especially regarding versions marketed and available to the population (9,35–37). Therefore, there is a knowledge gap in this data. To our best knowledge, there are no studies conducted in Brazil on the nutritional composition and ingredients used in commercial vegan substitutes for eggs and milk, so this study aimed to analyze the nutritional value and ingredients as described in data offered by food labels.

2. Materials and Methods

A quantitative, comparative cross-sectional study was performed in three steps: (i) Sample mapping; (ii) Data collection and classification and (iii) Statistical analysis.

i. Sample Mapping

The inclusion criteria for the milk and egg substitute sample in the study were: (i) Products sold in market chains with coverage in Brazil's five regions and/or food stores with national or regional coverage; (ii) Products with the "Vegan Product" seal, provided by the Brazilian Vegetarian Society (SVB ®). Fresh foods and vegan products that do not intend to mimic animal-based milk or eggs were not included. Also, products with nutritional claims of reduced amounts of salt, sodium, sugar, or total fat were excluded to avoid possible bias in the results. E-commerce was consulted through search platforms (Google ®; Bing ®), Brazilian online vegan products resellers, and on social media (Instagram ®, Facebook ®, and Twitter ®), through hashtags and nominal searches to achieve national coverage of the milk and egg substitutes sold in the Brazilian market. The investigation was conducted from February 1st, 2021, to January 1st, 2022. The search was conducted in 3 moments, following a previously established protocol(38): (i) first, a researcher searched for vegan products; (ii) then, a second researcher repeated the search process and analyzed the need to include more products; (iii) as a result, two independent academics double-checked the precision of the extracted data; (iv) finally, a third coordinating researcher critically analyzed the data, determining the final sample based on the inclusion criteria. After the search step, the included milk alternatives were classified as beverages, yogurts and cheese, and the egg alternatives as Mayonnaise and Eggs. In addition, we used to compare vegan counterparts, three samples of three different Brazilian products most selling animal milk and eggs to each class of vegan counterpart.

ii. Data collection

Data collection was performed according to previous studies (9,36–39). The qualitative and quantitative data reported on the products' food labels were recorded, including firm name, brand name, descriptive name, ingredient list, nutrient information, and serving size. Information about the ingredients and nutrient values was collected from the food label. According to the Brazilian legislation, it is mandatory to describe the serving size (g), energy value (kcal), carbohydrates (g), added sugars (g), proteins (g), fats (g), saturated fats (g), dietary fiber (g) and sodium (mg) (40). Nutrients with an optional declaration such as added sugar (g) were also collected when available. The nutritional value of powdered versions of beverages was included proportionally as the concentration of nutrients according to their label suggested dilution. Therefore, we used these parameters to compare the products from the sample mapping phase. For standardizing and comparison purposes, all values were converted to a serving size of 100g. To prevent the double inclusion of products, if more than one product had the same composition, they were only considered once.

iii. Statistical Analysis

Data regarding the included samples' energy value (kcal), carbohydrates (g), added sugars (g), proteins (g), fats (g), saturated fats (g), dietary fiber (g), and sodium (mg) were calculated on their respective means ± Standard Deviations (SD). A comparison between nutritional values of milk and egg substitutes and their respective animal protein-based products was carried out with a non-parametric Mann-Whitney' test with a confidence level of 95% ($p < 0.05$). Two-tailed hypotheses were considered in the test. Microsoft Excel ® (USA, 2021) and SPSS ® version 22.0 (IBM SPSS Statistics, Version 22.0, IBM corp., Chicago, IL USA, 2020) were used to perform the tests.

For graphical visualization, a word cloud was generated with the implemented ingredients of vegan milk and egg analogs, given that higher frequencies are represented with more prominent words in the cloud (Wordclouds ®, 2022) (41). For the word cloud generation, protein sources were grouped according to their main matrix; for example, coconut cream, shredded coconut, and dry coconut were all classified as "coconut". The range of the nutritional values was expressed visually through the parallel coordinate's technique, where the minimum and maximum values are depicted at the bottom and the top of the axis, respectively (42). Furthermore, information regarding the ingredients was represented by percentages in a heatmap where the color indicates the ingredient's presence according to the stipulated categories. GraphPad Prism ® (San Diego, CA, USA, 2022) was used to generate the heatmaps.

3. Results

A total of 152 samples were included in the study. From all samples, 89.47% were vegan alternatives of milk derivatives (n = 136), given that from all samples, 52% was classified as beverages (n = 80), 7.2% as yogurts (n = 11), 29.6% as cheese (n = 45). 10.52% of the samples were classified as egg replacers (n = 16), given that from all included products, 9.2% was classified as mayonnaise (n = 14) and 1.3% as eggs (n = 2). Table 1 presents the vegan and animal samples' energy value (kcal), carbohydrates (g), proteins (g), fats (g), saturated fats (g), dietary fiber (g), and sodium (mg) by means and standard deviations (SD). Complete information regarding nutritional value, ingredient list, and serving size in all included samples is available in the supplementary file (Table S1).

Table 1 - Means and Standard Deviations (SD) of the nutritional values per 100g of serving of the included samples.

Samples	Energy (Kcal)			Carbohydrates (g)			Protein (g)			Total Fat (g)			Saturated Fat (g)			Dietary Fiber (g)			Sodium (mg)		
	Vegan	Animal	p	Vegan	Animal	p	Vegan	Animal	p	Vegan	Animal	p	Vegan	Animal	p	Vegan	Animal	p	Vegan	Animal	p
Beverages	40.80 ± 14.36	46.00 ± 11.95	0.602	5.31 ± 3.77	4.63 ± 0.32	0.918	**1.05 ± 0.87**	**3.10 ± 0.10**	**0.002**	1.69 ± 1.27	1.50 ± 1.50	0.918	0.37 ± 0.50	1.05 ± 1.00	0.304	0.63 ± 0.95	0 ± 0	0.098	**30.65 ± 22.88**	**69.33 ± 1.53**	**0.05**
Yogurts	78.52 ± 37.98	70.31 ± 32.94	1,000	7.56 ± 4.92	8.51 ± 5.88	0.368	1.70 ± 2.21	3.74 ± 0.23	0.225	4.67 ± 5.16	2.31 ± 2.11	0.769	3.31 ± 1.96	1.41 ± 1.31	0.06	**0.69 ± 0.49**	**0 ± 0**	**0.011**	**37.43 ± 39.87**	**85.66 ± 52.13**	**0.032**
Cheese	281.89 ± 87.24	265.56 ± 5.09	0.657	**13.97 ± 8.23**	**2.89 ± 0.77**	**0.001**	**5.11 ± 4.24**	**9.89 ± 1.84**	**0.032**	27.85 ± 33.97	23.89 ± 0.19	0.873	6.81 ± 6.28	14.78 ± 0.96	0.066	0.95 ± 1.15	0 ± 0	0.156	348.43 ± 268.48	445.56 ± 56.80	0.213
Mayonnaise	320.36 ± 145.56	391.67 ± 250.97	0.591	4.62 ± 3.98	8.33 ± 0.83	0.068	2.77 ± 5.43	0 ± 0	0.197	31.68 ± 18.63	40.28 ± 29.37	0.509	**4.27 ± 3.75**	**21.67 ± 25.04**	**0.012**	55.95 ± 209.35	0 ± 0	0.859	597.74 ± 221.7	830.56 ± 258.92	0.244
Eggs	325.00 ± 106.07	557.48 ± 45.15	0.2	**25.07 ± 11.21**	**5.61 ± 3.42**	**0.02**	42.64 ± 2.32	45.27 ± 5.02	0.8	12.57 ± 6.46	38.62 ± 3.96	0.2	**0 ± 0**	**12.6 ± 1.64**	**0.02**	**13.43 ± 0.81**	**0 ± 0**	**0.02**	240.00 ± 339.41	507.52 ± 25.09	0.4

It is considered statistically different when $p < 0.05$, at Mann-whitney's test, with results highlighted in bold numbers

No differences were found between vegan and animal products regarding energy values (kcal). Cheese and eggs vegan options presented higher carbohydrates than their animal counterparts. The vegan cheese alternatives presented an average of 389% more carbohydrates than their counterparts; vegan eggs presented 339% more carbohydrates than their animal counterparts.

Animal products presented higher protein concentrations than vegan alternatives only in the categories of beverages and cheese. A difference of 61% in protein was found between vegan and animal samples of beverages, while in the cheese category, the difference was 93%.

No differences were found in total fat between vegan and animal samples. Greater concentrations of saturated fats were found in the animal counterparts of mayonnaise (21.67 ± 25.04g/100g) and eggs (12.6 ± 1.64/100g), statistical differences were found only in these groups.

Yogurts and eggs vegan alternatives presented higher dietary fiber than their animal counterparts (Table 1). Animal-based beverages and yogurts presented higher amounts of sodium than their vegan counterparts. There were no significant differences between other animal and vegan products.

A comparison between the range of the nutritional values of the evaluated samples (standardized per 100g of product, maximum and minimum values) according to their categories is presented in Figure 1 for beverages, yogurts, and cheese and in Figure 2 for mayonnaise and eggs.

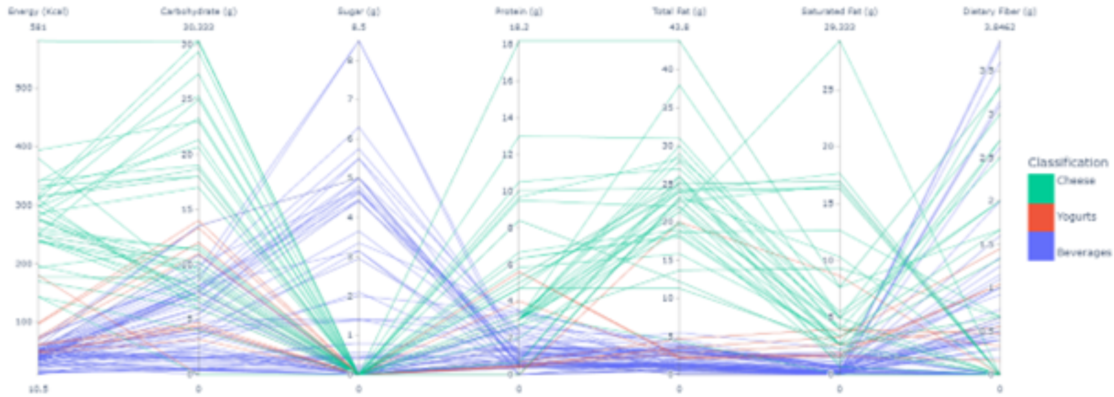

Figure 1 - Comparison between the range of the nutritional values of the evaluated samples (standardized per 100g of product, maximum and minimum values)

Figure 1 highlights that most vegan beverages tend to present energy values lower than 100kcal/100g; up to 14% of carbohydrates; up to 4% of protein; up to 5.2% of total fat; up to 2.5% of saturated fat and up to 4% of dietary fiber. The sugar content varied a lot in samples, from 0 to 8.5%. In yogurts, the samples' energy value ranged from 70-100kcal/100g; up to 7% of carbohydrates, 2% of protein; 5% of total fat, 2% of saturated fat and 0.7% of dietary fiber. As for cheese, the included samples' energy value ranged from 180-300kcal/100g, presenting up to 14% of carbohydrates, 5% of protein, 28% of total fat, 7% of saturated fat and 1% of dietary fiber.

In figure 2, mayonnaise presented energy values ranging from 186-591kcal/100g, presenting carbohydrates, protein, total fat, saturated and dietary fiber of 13%, 2%, 30%, 4%, and 13%.

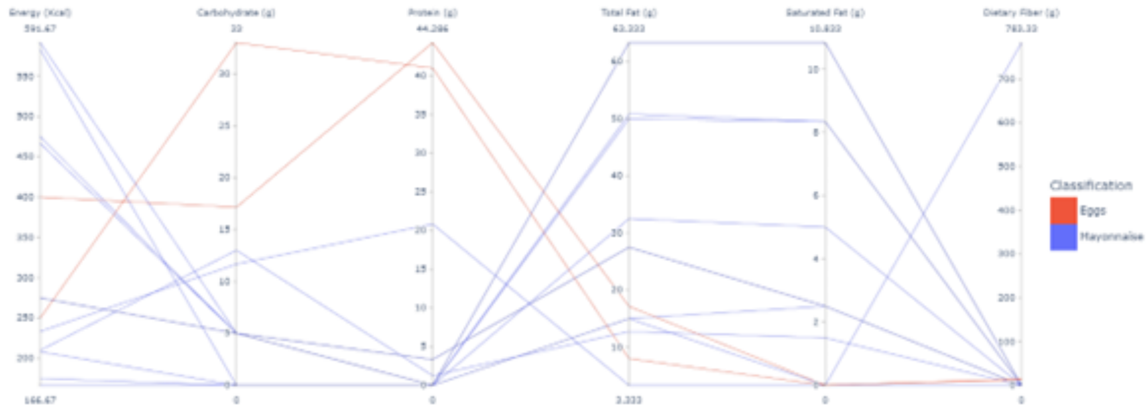

Figure 2 - Range of the nutritional values of the included egg substitutes

The word clouds generated from the frequencies of the ingredients of the included samples is expressed in Figure 3 for the milk derivatives (beverages, yogurts and cheese) and Figure 4 for egg replacers, mayonnaise and eggs.

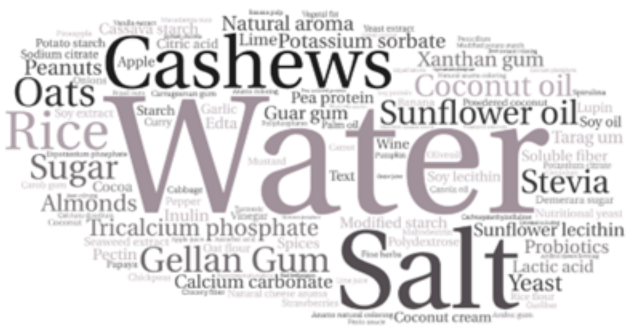

Figure 3 – Word cloud generated from the frequencies of used ingredients in beverages, yogurts, and cheese

Figure 4 – Word cloud generated from the frequencies of used ingredients in mayonnaise and eggs

Among the vegan milk derivatives (89.4% of the samples), the most abundant ingredient was water, present in 81.6% of the samples, followed by salt, implemented in 68%. Sugar was present in 60% of the samples. Regarding the main matrixes utilized in these products, cashews were the most used (38.2% of the samples), followed by coconut (22%), rice (16.9%), oats (14.7%), soy (13.9%), almonds (13.2%), pea protein (11.7%), peanuts (5.14%) and carob (2.9%). Combinations of two or more sources were found in 17% of the samples, being the combination of rice and coconut was the most frequent one (56%), coconut and cashews (26%), oats and cashews (14%) and soy and pea protein (11%). Coconut oil was the most used fat source (25% of the samples), followed by soy oil, only 2.9%. Food additives such as natural aroma, calcium carbonate, tricalcium phosphate, sodium citrate and potassium citrate were used in 49.2%, 35%, 22.7%, 3.6% and 3.6%, respectively. Also, thickeners and gums were used, in the form of gellan gum (26.4%), xanthan gum (18.3%), modified starch (13.9%), polydextrose (5.1%), tara gum (4.4%), inulin (2.9%), carob gum (2.9%) and arabic gum (2.9%).

Regarding the egg replacers, salt and vinegar were present in 100% of the samples, followed by lactic acid (85%), starch (72%), lime juice (71%), mustard (71.4%), garlic (71.4%), sugar (64.2%), potassium sorbate (64.2%), calcium disodium (64.2%), unspecified vegetable oil (42.8%), natural aroma (42.8%), canola oil (35.7%) and pea protein (35.7%).

The percentual distribution of the frequency of ingredients in the group of milk derivatives with frequencies higher than 1.5% among specified categories is described in the heatmap in Figure 5. The heatmap of egg and mayonnaise was not constructed due to the low number of samples found in the market.

In beverages, water was the most common ingredient, present in 75% of the samples, followed by sugar in 76.3% of the products. Salt was present in 63% of the samples. As for the main matrixes, rice was the most abundant one, utilized in 28.7% of the samples, while other matrixes such as oats, coconut, almonds, cashews, soy, peanuts, pea protein and carob were utilized in 25%, 23.7%, 22.5%, 13.75%, 2.5%, 12.5% and 5% respectively. Sunflower oil and was the most used fat source utilized, present in 32% of the samples. Coconut oil was utilized in 5% of the samples. Thickeners were also included in this category, as gellan gum (40%), xanthan gum (13.7%), guar gum (12.5%), polydextrose (8.7%), tara gum (7.5%), inulin (5%), carob bum (5) and arabic gum (5%). Calcium carbonate was the most utilized food additive, present in 55% of the samples. Other food additives, such as tricalcium phosphate, sunflower lecithin, natural aroma, sodium citrate and potassium citrate, were implemented in 33.7%, 22.5%, 22%, 6.25% and 6.25%, respectively.

Regarding yogurts, water was utilized in 100% of the samples; in sequence, sugar was present in 90.9% of the included products. Coconut and pea proteins were the most common matrixes in this category, given that coconut was utilized in 100% of the samples and pea protein in 54.4%. Other matrixes, such as soy (36.3%) and peanuts (9%) were also utilized. Modified starch was used in 90% of the samples, followed by xanthan and gellan gum (36.3%) and sunflower lecithin (36.3%). Natural aroma was implemented in all samples (100%).

Among cheese samples, salt was present in 96% of the samples and water in 88.8%. Cashews were the main matrix in this category, present in 77.7% of the samples. Other implemented matrixes were soy (8.8%), peanuts (8.8%) and chickpeas (8.8%). Modified starch was also utilized as a matrix in 20% of the samples. Coconut oil was the main fat source, implemented in 66.6% of the samples, followed by sunflower oil, 17.7% and soy oil 8.8% Xanthan gum was present 22.2% of the samples and guar gum in 8.8%. Food additives such as natural aroma (84.4%), calcium carbonate (8.8%) and tricalcium phosphate (6.6%) were also utilized in these samples.

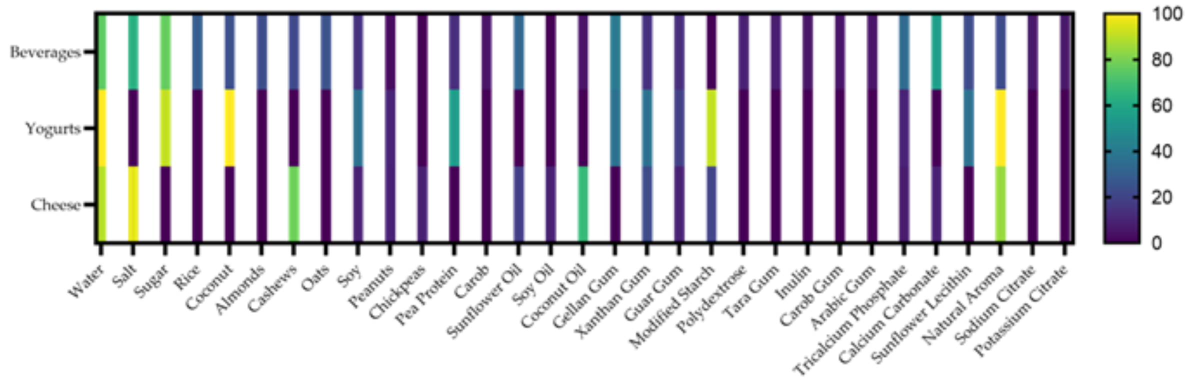

Figure 5 – Percentages of frequencies of implemented ingredients in vegan milk derivatives in a heatmap. Colored clusters represent different frequencies according to the scale placed on the right side

In the mayonnaise category, lactic acid was present in 100% of the samples, starch in 85%, lime juice in 85%, mustard in 71% , garlic in 71%, sugar 64%, potassium sorbate 64%, calcium disodium 64% , unspecified vegetable oil in 56% and canola oil in 50%.

The main ingredients in the vegan egg category were isolated proteins (pea protein, 100%) and also starch and chickpea flour (100% of the samples).

4. Discussion

Plant-based vegan diets are strongly associated with better health status, given their bioactive compound-rich nature and usually providing less calories, equal protein, and more dietary fiber (43–46). However, vegan industrial products aiming to replace their animal counterparts tend to point the other way, with potential nutritional impairments (38).

Regarding the energy values of the studied samples, no differences were found between vegan products and their animal counterparts. Usually, vegan products tend to present lower energy values, given that plant-based matrixes are commonly poor in compounds with a higher energy density, such as saturated fats (19,36,38,39). This tendency is also evident in vegan milk and egg derivatives, as found by other studies analyzing developed formulations and different markets worldwide (17,26,28,36,37).

Vegetables are known sources of carbohydrates; however, differences were found only between animal and vegan versions of cheese and eggs, given that these products are based on nuts and legumes, respectively, groups of foods naturally rich in carbohydrates (47,48). Nevertheless, being carbohydrate-rich is a common feature among all plant-based alternatives, regardless of their purpose of substitution (milk, eggs, meat, poultry, etc.) (17,19,38,39,49,50). Also, this study' results suggest that there's an evident pattern regarding the proportion of this nutrient in plant-based milk and egg alternatives around the world (17,37,39,51,52).

In their animal versions, both eggs and milk derivatives are well known for providing high-quality protein (casein, whey protein and albumin) (11,53), usually presenting also higher concentrations of this nutrient in comparison with their vegan counterparts (17,22). In the case of our study, animal counterparts presented higher concentrations of protein. However, differences were found only regarding beverages and cheese. Plant-based beverages are commonly made of water-soluble extracts of cereals, pseudocereals and general pulses such as soy, oats, coconut, cashews, and almonds (23), and this type of ingredient tends to present lower concentrations of protein, especially when in comparison to dairy (17). Another issue regarding plant-based beverages revolves around protein quality, specifically concerning the present amino acids in their formulations. Vegetable proteins usually present limitations regarding the amino acids in their structure, with lower levels of essential amino acids, more specifically, methionine and lysine (54,55). Thus, to better assimilate vegetal protein, two or more sources should be combined (55).

In the included samples, a similar pattern regarding plant-based beverages around the world was found. Usually, commercial alternatives are frequently based on soy, cashews, coconut, and almonds, respectively, with also versions providing combinations of two or more sources for better nutritional and sensory aspects (24,26,39,52). However, in our study, differently than found in other countries, the most frequent matrix was rice instead of soy (52,56), followed by oats, coconut, and almonds. Probably, the controversies around soy consumption and its effect on consumers' perception regarding health issues led to a decrease in the production of soy-based beverages. Also, vegetal beverages are widely consumed by infants; therefore, increasing prevalence of soy allergy in infants may result in a decrease in the use of soy as a matrix for these products (57,58).However, given the protein-rich nature of soy, its reduced use might have exerted an effect on our findings regarding the lower protein quantity in vegan beverages (1.05 ± 0.87/100g) than commercial cow's milk (3.10 ± 0.10g/100g) (59). As for the included vegan yogurts, coconut was the most utilized matrix, probably because it's higher fat content may result in a product with improved viscosity, texture, lubricity and tastes, especially in comparison with animal-based yogurt, a product known for these characteristics (60, 61). Yet, although coconut was utilized as the main ingredient, soy and pea protein were also frequently incorporated, thus, contributing to higher concentrations of protein with no differences from their animal counterparts.

Another main concern regarding plant-based beverages is the presence of sugar. In cow's milk, a striking sensory characteristic is a mild sweetness, in this case, provided by lactose (53). In an attempt to mimic this sensory characteristic, most plant beverages implement sucrose replacing lactose (25). One point to be considered is that although both molecules are disaccharides, because of their molecular nature, sucrose has a considerably stronger sweet power than lactose (62). In addition, excessive sucrose consumption is a public health problem, as it may contribute to an increase in the prevalence of chronic non-communicable diseases (47).

Currently, the worldwide recommendation for sucrose consumption is 50g/day (47). Therefore, considering that according to our study, a usual serving of 200g of vegetable beverage presents on average 16g of sucrose, a serving of vegetable beverage results in 32% of the recommended daily intake of sugar in only one portion.

Animal-based cheese is usually produced from the curds of coagulated milk (mostly β-casein) or even proteins derived from the wastewater whey (13), with optional fermentation and different concentrations of fat (13). In the case of vegan cheese alternatives, cashews are primarily used given their saturated fat-rich nature, which provides better sensory characteristics, such as structure, stability, lubricity, and better aftertaste (63). Yet, though better sensory aspects are obtained with the use of cashews, nutritional impairments regarding the protein content might be present. Similarly, to found in studies performed in other countries, Brazilian's vegan cheese alternatives are mainly based on cashews, with few samples being based on modified starch, soy, and peanuts (9,36,37). Also, the pattern of products with less protein than their animal counterparts and even quantities of total and saturated fat was also found (9,36,37). Cashews are part of the oilseeds category, seeds with a high concentration of different kinds of fats. In the case of cashews, these nuts are rich in saturated and monounsaturated fats which, when present in food, confer characteristics such as greater stability at room temperature, better texture, lubricity, creaminess and aftertaste (13). Thus, this nut constitutes an adequate product to substitute characteristics provided by cow's milk fat in cheeses.

The vegan egg category did not show differences regarding the protein content in comparison with their animal counterparts; probably, since egg replacers were based on a mixture of isolated proteins (pea protein) and protein-rich flours (chickpea flour), this difference was not found. Nevertheless, different characteristics and technological applications broadly differentiate the two categories of products.

Considering the differences in protein profile between animal and vegan egg substitutes, animal eggs perform many roles in food products (13). Albumin, the main protein in chicken eggs, can act as a stabilizer in bakery products, also improving texture, especially when used in foam form. Also, chicken egg's yolk is rich in phospholipids, naturalemulsifiers that contribute to products' stability, durability and texture, while also providing desirable coloring given its carotenoid-rich nature (13). In this sense, although isolated proteins and legume flours are also used as ingredients that will enhance sensory characteristics similarly to animal egg, their performance is reduced compared to animal eggs. Therefore, although there are no differences in the average value of proteins, the different molecular composition of these products results in different characteristics in the products in which they are used (64–66).

Generally, animal products present higher concentrations of total and saturated fat and this tendency was also found in this study's results. More specifically, in the category of egg substitutes (mayonnaise and eggs), higher amounts with significant differences in saturated fat were found, possibly, because chicken eggs, used in this type of formulation present, on average, 37.4% of saturated fat in their composition (11,67). Vegetables are usually a source of mono and polyunsaturated fatty acids, with coconut and palm oil being the most prominent sources of vegetal saturated fats (22,68,69).

Coconut oil is a very interesting fat from an industrial point of view because it has resistance to high temperatures being suitable for cooking. In addition, it can remain solid at room temperature, independent of processes such as hydrogenation (60,70). More specifically, this oil was most used in the category of cheese, probably because of its technological capacity to provide stability and texture to vegan cheeses while also improving its shelf-life, given the presence of lauric acid, an intrinsic fatty acid present in coconut oil, with fungicidal characteristics (60,70).

In the case of vegan beverages, sunflower oil was the most implemented fat source. Sunflower oil is rich in monounsaturated fatty acids, and it is widely implemented in industrial food processes because of its emulsifying capacity (71,72). Plant-based beverages consist of non-homogenous solutions of water-soluble plant extracts (17). Therefore, the need for emulsifiers is highlighted, given that the implementation of sunflower oil provides a more stable, homogenous, and sensory desirable product (71,72). Yet, another sunflower-based product, sunflower lecithin, an efficient emulsifier, is also widely implemented among the included samples (beverages and yogurts), probably with the same objective (73). Mayonnaise consists of fatty emulsions, and vegetable oils and chicken eggs are commonly used (13). In egg yolk, compounds of the phospholipid class stabilize the liquid and fatty phases resulting in a creamy and sensory appropriate product (11). In the included vegan samples of mayonnaise, the same process is employed using unspecified vegetable oils and canola oil; however, in the absence of chicken eggs' phospholipids, starches are utilized to sustain the emulsion through rheological characteristics such as gelatinization (74).

To a large extent, vegan substitutes for meat and dairy tend to present higher amounts of dietary fiber (9,35,38,39), given that vegetables are the best-known sources of this nutrient (75). In our study, although vegan versions presented generally higher amounts of fiber than their animal counterparts, differences were found only between vegan and animal versions of yogurts and eggs. This is probably because animal versions of both categories typically do not present any dietary fiber in their composition (67).

The consumption of dietary fibers is essential for maintaining health, since it favors the intestine's functioning and normal blood glucose and cholesterol levels (76). Individuals who adhere to vegetarian and vegan diets usually consume adequate or higher amounts of fiber than those recommended by the dietary reference intakes (61,62). However, the same is not true in which regards Brazilian omnivore diets. Recent studies have shown that the Brazilian's eating habits present a decrease in the consumption of vegetables, whole grains, and legumes in favor of industrialized foods with lower amounts of these nutrients (77). Therefore, since there is no difference between vegan and animal yogurts, regarding the protein value, the consumption of this combined with a balanced diet may contribute to the improvement of this scenario.

Vegan options showed lower sodium concentrations, with significant differences between vegan and animal versions of beverages and yogurts, possibly due to the higher intrinsic sodium content of cow's milk and also the use of preservatives whose composition also presents this compound (25,53). Nevertheless, these results are aligned with the trend presented by studies conducted in other countries where, in general, vegan versions presented lower sodium content than their animal counterparts (9,35,38,39). Salt was utilized in most cheese vegan analogs given that usually, cheese is a salted product.

When comparing cow's milk analogs, one issue that emerges is the need for food additives. Food additives consist of legalized food substances, which are not nutrients, but add food-friendly technological characteristics (78). In the case of vegan milk derivatives, the use of hydrocolloids, such as xanthan, gellan and carob gums, were found in the samples. Hydrocolloids provide stability and texture to food preparations forming stable gels in water (79). In the case of beverages, yogurts, and mayonnaise, this characteristic contributes to the emulsion of the liquid (water) and solid (soluble vegetable extract) phases of the product

(80,81). In dairy-free cheeses and vegan mayonnaise, those gels are responsible for the final texture and stability at room temperature (9,36).

Preservatives are another class of food additives that stands out in the included samples. Calcium carbonate, tricalcium phosphate, sodium citrate and potassium citrate were widely implemented in yogurts, beverages, cheese, and mayonnaise. These preservatives contribute to the shelf-life extension of these foods by functioning as bactericidal substances and delaying the intrinsic enzymatic deterioration of these products (82). Moreover, calcium carbonate also acts as a calcium food supplement, enriching vegan preparations and making them comparable with their animal counterparts (17). However, according to Brazil's legislation (40), announcing the total calcium content on the products' food labels is not mandatory. Therefore, although many products present calcium carbonate in their composition, it was not possible to perform an accurate evaluation and comparison with animal counterparts.

One potential limitation of our study was the absence of laboratory chemical analysis to confirm the label information. According to the Brazilian legislation, nutritional labels can be based on food composition tables and present a discrepancy level of 20% (for more or less) between its actual chemical composition and that one described on the label (40). Thus, possible divergences may be present, as evidenced by other studies that also utilized food labels as their information source (9,19,37–39).

5. Conclusions

From the above, it is possible to conclude that the market for vegan alternatives for dairy products and eggs is growing prosperously in Brazil. In general, no differences were found regarding the energy value of vegan and animal versions of all samples included. Only the categories of cheese and eggs presented more carbohydrates than their animal counterparts. Only the animal versions of cheese and beverages showed more protein than their vegan counterparts. No differences were found regarding the total fat content of the samples, however, the animal samples of mayonnaise and eggs showed more saturated fats. Yogurts and vegan eggs showed more fiber than their animal counterparts. Regarding the ingredients used, cashew nuts were the most used matrices in vegan dairy products; however, rice and coconut were the most prominent in the included beverages. In vegan beverages, most of the samples presented added sugar. Gums, thickeners and preservatives were the most widely used food additives in all categories. Finally, most samples of egg substitutes consist of mayonnaise, based on vegetable oil and starch emulsions with added isolated plant proteins. Total egg substitutes were based on proteins isolated in powder and legume flours. Vegan dairy and egg alternatives might be suitable for substitution of their animal counterparts; however, the need for new formulations of vegan beverages and cheeses with a higher concentration of protein is highlighted.

Supplementary Materials: Table S1: Full information on serving size and nutritional value of included milk and egg substitutes

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References

1. Sabaté J, Soret S. Sustainability of plant-based diets: back to the future. *The American Journal of Clinical Nutrition* (2014) 100:476S-482S. doi: 10.3945/AJCN.113.071522

2. Leitzmann C. Vegetarian nutrition: Past, present, future. *American Journal of Clinical Nutrition* (2014) 100:1–7. doi: 10.3945/ajcn.113.071365

3. • Vegetarian diet followers worldwide by region, 2016 | Statista. https://www.statista.com/statistics/597408/vegetarian-diet-followers-worldwide-by-region/ [Accessed May 1, 2022]

4. IBOPE. Pesquisa de Opinião Pública sobre Vegetarianismo. (2018). 1–24 p. https://www.svb.org.br/images/Documentos/JOB_0416_VEGETARIANISMO.pdf

5. Flom JD, Sicherer SH. Epidemiology of cow's milk allergy. *Nutrients* (2019) 11: doi: 10.3390/NU11051051

6. National Institute of Health. Lactose intolerance: Genetics Home Reference. *Genetic Home Reference* (2018)1–5.

7. Statista. • Global consumption of milk per year by country 2021 | Statista. (2022) https://www.statista.com/statistics/272003/global-annual-consumption-of-milk-by-region/ [Accessed May 1, 2022]

8. Embrapa KS-CT, 2019 undefined. O mercado consumidor de leite e derivados. *ainfo.cnptia.embrapa.br* https://ainfo.cnptia.embrapa.br/digital/bitstream/item/199791/1/CT-120-MercadoConsumidorKennya.pdf [Accessed May 1, 2022]

9. Fresán U, Rippin H. Nutritional Quality of Plant-Based Cheese Available in Spanish Supermarkets: How Do They Compare to Dairy Cheese? *Nutrients 2021, Vol 13, Page 3291* (2021) 13:3291. doi: 10.3390/NU13093291

10. Global Egg Production Continues to Grow - International Egg Commission. https://www.internationalegg.com/resource/global-egg-production-continues-to-grow/ [Accessed May 1, 2022]

11. Réhault-Godbert S, Guyot N, Nys Y. The Golden Egg: Nutritional Value, Bioactivities, and Emerging Benefits for Human Health. *Nutrients 2019, Vol 11, Page 684* (2019) 11:684. doi: 10.3390/NU11030684

12. Singhal S, Baker RD, Baker SS. A Comparison of the Nutritional Value of Cow's Milk and Nondairy Beverages. *Journal of Pediatric Gastroenterology and Nutrition* (2017) 64:799–805. doi: 10.1097/MPG.0000000000001380

13. Montebello N de P, Araújo WMC, Botelho RBA. *Alquimia Dos Alimentos - Série Alimentos e Bebidas - 3ª Ed. 2014*. Senac, editor. Senac (2014).

14. Statista. Global: Plant-based milk & derivatives market 2026 | Statista. *Global: Plant-based milk & derivatives market 2026 | Statista* (2022)34. https://www.statista.com/statistics/1284493/global-plant-based-milk-and-derivatives-market-by-region/ [Accessed May 1, 2022]

15. Révillion JPP, Kapp C, Badejo MS, Dias VDV. O mercado de alimentos vegetarianos e veganos: características e perspectivas. *Cadernos de Ciência & Tecnologia* (2020) 37:26603. doi: 10.35977/0104-1096.CCT2020.V37.26603

16. Ginsberg C. The Market for Vegetarian Foods. *The Vegetarian Resource Guide* (2018)1–9. http://www.vrg.org/nutshell/market.htm#market

17. Fructuoso I, Romão B, Han H, Raposo A, Ariza-Montes A, Araya-Castillo L, Zandonadi RP. An Overview on Nutritional Aspects of Plant-Based Beverages Used as Substitutes for Cow's Milk. *Nutrients 2021, Vol 13, Page 2650* (2021) 13:2650. doi: 10.3390/NU13082650

18. Adise S, Gavdanovich I, Zellner DA. Looks like chicken: Exploring the law of similarity in evaluation of foods of animal origin and their vegan substitutes. *Food Quality and Preference* (2015) 41:52–59. doi: 10.1016/j.foodqual.2014.10.007

19. Curtain F, Grafenauer S. Plant-based meat substitutes in the flexitarian age: An audit of products on supermarket shelves. *Nutrients* (2019) 11:1–14. doi: 10.3390/nu11112603

20. Raikos V, Hayes H, Ni H. Aquafaba from commercially canned chickpeas as potential egg replacer for the development of vegan mayonnaise: recipe optimisation and storage stability. *International Journal of Food Science & Technology* (2020) 55:1935–1942. doi: 10.1111/IJFS.14427

21. Söderberg J. Functional properties of legume proteins compared to egg proteins and their potential as egg replacers in vegan food - Epsilon Archive for Student Projects. Swedish University of Agricultural Sciences (2013). 43 p. https://stud.epsilon.slu.se/6240/ [Accessed May 2, 2022]

22. Brennan C, Mustafa R, Boukid F, Gagaoua M. Vegan Egg: A Future-Proof Food Ingredient? *Foods 2022, Vol 11, Page 161* (2022) 11:161. doi: 10.3390/FOODS11020161

23. Paul AA, Kumar S, Kumar V, Sharma R. Milk Analog: Plant based alternatives to conventional milk, production, potential and health concerns. *Critical Reviews in Food Science and Nutrition* (2019) 60:1–19. doi: 10.1080/10408398.2019.1674243

24. Vanga SK, Raghavan V. How well do plant based alternatives fare nutritionally compared to cow's milk? *Journal of Food Science and Technology* (2018) 55:10–20. doi: 10.1007/S13197-017-2915-Y

25. Scholz-Ahrens KE, Ahrens F, Barth CA. Nutritional and health attributes of milk and milk imitations. *European Journal of Nutrition* (2020) 59:19–34. doi: 10.1007/S00394-019-01936-3

26. Chalupa-Krebzdak S, Long CJ, Bohrer BM. Nutrient density and nutritional value of milk and plant-based milk alternatives. *International Dairy Journal* (2018) 87:84–92. doi: 10.1016/J.IDAIRYJ.2018.07.018

27. Zhang YY, Hughes J, Grafenauer S. Got mylk? The emerging role of australian plant-based milk alternatives as a cow's milk substitute. *Nutrients* (2020) 12: doi: 10.3390/nu12051254

28. Verduci E, D'elios S, Cerrato L, Comberiati P, Calvani M, Palazzo S, Martelli A, Landi M, Trikamjee T, Peroni DG. Cow's milk substitutes for children: Nutritional aspects of milk from different mammalian species, special formula and plant-based beverages. *Nutrients* (2019) 11:3–4. doi: 10.3390/nu11081739

29. FM M. Nutritional and Sensory Properties of Cashew Seed (Anacardium occidentale) Milk. *Modern Concepts & Developments in Agronomy* (2017) 1: doi: 10.31031/MCDA.2017.01.000501

30. Damasceno LRAD, Botelho RBA, de Alencar ER. Development of novel plant-based milk based on chickpea and coconut. *Lwt - Food Science and Technology* (2020) 128:1–9. doi: 10.1016/j.lwt.2020.109479

31. Jeske S, Zannini E, Arendt EK. Evaluation of Physicochemical and Glycaemic Properties of Commercial Plant-Based Milk Substitutes. *Plant Foods for Human Nutrition* (2017) 72:26–33. doi: 10.1007/S11130-016-0583-0

32. Ravindran S, RadhaiSri S. Probiotic oats milk drink with microencapsulated Lactobacillus plantarum – an alternative to dairy products. *Nutrition and Food Science* (2020) 51:471–482. doi: 10.1108/NFS-03-2020-0073

33. Aydar EF, Tutuncu S, Ozcelik B. Plant-based milk substitutes: Bioactive compounds, conventional and novel processes, bioavailability studies, and health effects. *Journal of Functional Foods* (2020) 70: doi: 10.1016/J.JFF.2020.103975

34. Mäkinen OE, Wanhalinna V, Zannini E, Arendt EK. Foods for Special Dietary Needs: Non-dairy Plant-based Milk Substitutes and Fermented Dairy-type Products. *Critical Reviews in Food Science and Nutrition* (2016) 56:339–349. doi: 10.1080/10408398.2012.761950

35. Craig WJ, Brothers CJ. Nutritional Content and Health Profile of Non-Dairy Plant-Based Yogurt Alternatives. *Nutrients 2021, Vol 13, Page 4069* (2021) 13:4069. doi: 10.3390/NU13114069

36. Boukid F, Lamri M, Dar BN, Garron M, Castellari M. Vegan Alternatives to Processed Cheese and Yogurt Launched in the European Market during 2020: A Nutritional Challenge? *Foods 2021, Vol 10, Page 2782* (2021) 10:2782. doi: 10.3390/FOODS10112782

37. Craig WJ, Mangels AR, Brothers CJ. Nutritional Profiles of Non-Dairy Plant-Based Cheese Alternatives. *Nutrients 2022, Vol 14, Page 1247* (2022) 14:1247. doi: 10.3390/NU14061247

38. Romão B, Botelho RBA, Nakano EY, Raposo A, Han H, Vega-Muñoz A, Ariza-Montes A, Zandonadi RP. Are vegan alternatives to meat products healthy? A study on nutrients and main ingredients of products commercialized in Brazil. *Frontiers in Public Health* (2022) 0:1565. doi: 10.3389/FPUBH.2022.900598

39. Tonheim LE, Austad E, Torheim LE, Henjum S. Plant-based meat and dairy substitutes on the Norwegian market: comparing macronutrient content in substitutes with equivalent meat and dairy products. *Journal of Nutritional Science* (2022)1–8. doi: 10.1017/JNS.2022.6

40. Brasil. Resolução RDC nº 360, de 23 de dezembro de 2003. Aprova o Regulamento Técnico sobre Rotulagem Nutricional de Alimentos Embalados, tornando obrigatória a rotulagem nutricional. *Agencia Nacional de Vigilância Sanitária (ANVISA)* (2003) 1:1–9. http://portal.anvisa.gov.br/documents/33880/2568070/res0360_23_12_2003.pdf/5d4fc713-9c66-4512-b3c1-afee57e7d9bc

41. WordCloud. Free online word cloud generator and tag cloud creator - WordClouds.com. (2020)1.

42. Inselberg A. The plane with parallel coordinates. *The Visual Computer 1985 1:2* (1985) 1:69–91. doi: 10.1007/BF01898350

43. Barnard ND, Goldman DM, Loomis JF, Kahleova H, Levin SM, Neabore S, Batts TC. Plant-based diets for cardiovascular safety and performance in endurance sports. *Nutrients* (2019) 11:1–10. doi: 10.3390/nu11010130

44. Lynch H, Johnston C, Wharton C. Plant-based diets: Considerations for environmental impact, protein quality, and exercise performance. *Nutrients* (2018) 10:1–16. doi: 10.3390/nu10121841

45. Chang C-M, Chiu THT, Chang C-C, Lin M-N, Lin C-L. Plant-Based Diet, Cholesterol, and Risk of Gallstone Disease: A Prospective Study. *Nutrients* (2019) 11:335. doi: 10.3390/nu11020335

46. Najjar RS, Feresin RG. Plant-based diets in the reduction of body fat: Physiological effects and biochemical insights. *Nutrients* (2019) 11: doi: 10.3390/nu11112712

47. Mann J, Cummings JH, Englyst HN, Key T, Liu S, Riccardi G, Summerbell C, Uauy R, van Dam RM, Venn B, et al. FAO/WHO Scientific Update on carbohydrates in human nutrition: Conclusions. *European Journal of Clinical Nutrition* (2007) 61:S132–S137. doi: 10.1038/sj.ejcn.1602943

48. Kiely LJ, Hickey RM. "Characterization and Analysis of Food-Sourced Carbohydrates.," (2022). p. 67–95 doi: 10.1007/978-1-0716-1685-7_4

49. Tziva M, Negro SO, Kalfagianni A, Hekkert MP. Understanding the protein transition: The rise of plant-based meat substitutes. *Environmental Innovation and Societal Transitions* (2019)1–15. doi: 10.1016/j.eist.2019.09.004

50. Samard S, Ryu GH. Physicochemical and functional characteristics of plant protein-based meat analogs. *Journal of Food Processing and Preservation* (2019) 43:e14123. doi: 10.1111/JFPP.14123

51. Mäkinen OE, Wanhalinna V, Zannini E, Arendt EK. Foods for Special Dietary Needs: Non-dairy Plant-based Milk Substitutes and Fermented Dairy-type Products. *Critical Reviews in Food Science and Nutrition* (2016) 56:339–349. doi: 10.1080/10408398.2012.761950

52. Sousa A, Bolanz KAK. Nutritional Implications of an Increasing Consumption of Non-Dairy Plant-Based Beverages Instead of Cow's Milk in Switzerland. *Advances in Dairy Research* (2017) 05: doi: 10.4172/2329-888X.1000197

53. Tobey JA. Milk and Milk Products. *American Journal of Public Health and the Nations Health* (1930) 20:564–564. doi: 10.2105/ajph.20.5.564-a

54. Food and Agriculture Organization. Dietary protein quality evaluation in human nutrition Report of an FAO Expert Consultation. (2011). 79 p. https://www.fao.org/ag/humannutrition/35978-02317b979a686a57aa4593304ffc17f06.pdf [Accessed May 14, 2022]

55. Mariotti F, Gardner CD. Dietary protein and amino acids in vegetarian diets—A review. *Nutrients* (2019) 11:1–19. doi: 10.3390/nu11112661

56. Craig WJ, Fresán U. International analysis of the nutritional content and a review of health benefits of non-dairy plant-based beverages. *Nutrients* (2021) 13:1–14. doi: 10.3390/NU13030842

57. Muraro MA, Giampietro PG, Galli E. Soy formulas and nonbovine milk. *Annals of Allergy, Asthma & Immunology* (2002) 89:97–101. doi: 10.1016/S1081-1206(10)62132-1

58. Schiano AN, Nishku S, Racette CM, Drake MA. Parents' implicit perceptions of dairy milk and plant-based milk alternatives. *Journal of Dairy Science* (2022) 105:4946–4960. doi: 10.3168/JDS.2021-21626

59. Messina M, Messina VL. Exploring the soyfood controversy. *Nutrition Today* (2013) 48:68–75. doi: 10.1097/NT.0B013E31828FFF54

60. Canapi EC, Agustin YT v., Moro EA, Pedrosa E, Bendaño MLJ. Coconut Oil. *Bailey's Industrial Oil and Fat Products* (2005) doi: 10.1002/047167849X.BIO054

61. Rincon L, Braz Assunção Botelho R, de Alencar ER. Development of novel plant-based milk based on chickpea and coconut. *LWT* (2020) 128: doi: 10.1016/J.LWT.2020.109479

62. van Laar ADE, Grootaert C, van Camp J. Rare mono- and disaccharides as healthy alternative for traditional sugars and sweeteners? *https://doi.org/101080/1040839820201743966* (2020) 61:713–741. doi: 10.1080/10408398.2020.1743966

63. Short EC, Kinchla AJ, Nolden AA. Plant-Based Cheeses: A Systematic Review of Sensory Evaluation Studies and Strategies to Increase Consumer Acceptance. *Foods 2021, Vol 10, Page 725* (2021) 10:725. doi: 10.3390/FOODS10040725

64. Mustafa R, He Y, Shim YY, Reaney MJT. Aquafaba, wastewater from chickpea canning, functions as an egg replacer in sponge cake. *International Journal of Food Science and Technology* (2018) 53:2247–2255. doi: 10.1111/IJFS.13813

65. Rachwa-Rosiak D, Nebesny E, Budryn G. Chickpeas—Composition, Nutritional Value, Health Benefits, Application to Bread and Snacks: A Review. *Critical Reviews in Food Science and Nutrition* (2015) 55:1135–1143. doi: 10.1080/10408398.2012.687418

66. Gómez M, Oliete B, Rosell CM, Pando V, Fernández E. Studies on cake quality made of wheat-chickpea flour blends. *LWT - Food Science and Technology* (2008) 41:1701–1709. doi: 10.1016/j.lwt.2007.11.024

67. Nepa. Tabela brasileira de composição de alimentos: TACO. Núcleo de Estudos e Pesquisas em alimentação, editor. Campinas: Unicamp (2011).

68. Sun Y, Neelakantan N, Wu Y, Lote-Oke R, Pan A, van Dam RM. Palm Oil Consumption Increases LDL Cholesterol Compared with Vegetable Oils Low in Saturated Fat in a Meta-Analysis of Clinical Trials. *The Journal of Nutrition* (2015) 145:1549–1558. doi: 10.3945/JN.115.210575

69. Muralidharan J, Galiè S, Hernández-Alonso P, Bulló M, Salas-Salvadó J. Plant-Based Fat, Dietary Patterns Rich in Vegetable Fat and Gut Microbiota Modulation. *Frontiers in Nutrition* (2019) 6:157. doi: 10.3389/FNUT.2019.00157/BIBTEX

70. Marina AM, Che Man YB, Amin I. Virgin coconut oil: emerging functional food oil. *Trends in Food Science & Technology* (2009) 20:481–487. doi: 10.1016/J.TIFS.2009.06.003

71. Desrumaux A, Marcand J. Formation of sunflower oil emulsions stabilized by whey proteins with high-pressure homogenization (up to 350 MPa): effect of pressure on emulsion

characteristics. *International Journal of Food Science & Technology* (2002) 37:263–269. doi: 10.1046/J.1365-2621.2002.00565.X

72. Maskan M, Göğüş F. Effect of sugar on the rheological properties of sunflower oil–water emulsions. *Journal of Food Engineering* (2000) 43:173–177. doi: 10.1016/S0260-8774(99)00147-8

73. Holló J, Perédi J, Ruzics A, Jeránek M, Erdélyi A. Sunflower lecithin and possibilities for utilization. *Journal of the American Oil Chemists' Society 1993 70:10* (1993) 70:997–1001. doi: 10.1007/BF02543026

74. Morris VJ. Starch gelation and retrogradation. *Trends in Food Science & Technology* (1990) 1:2–6. doi: 10.1016/0924-2244(90)90002-G

75. Anderson JW, Baird P, Davis Jr RH, Ferreri S, Knudtson M, Koraym A, Waters V, Williams CL. Health benefits of dietary fiber. *Nutrition Reviews* (2009) 67:188–205. doi: 10.1111/j.1753-4887.2009.00189.x

76. Caprita A, Căpriţă R, Simulescu V, Drehe R-M. Dietary Fiber: Chemical and Functional Properties. *Journal of Agroalimentary Processes and Technologies* (2010) 16:406–416. http://

77. Brasil. VIGILÂNCIA DE FATORES DE RISCO E PROTEÇÃO PARA DOENÇAS CRÔNICAS POR INQUÉRITO TELEFÔNICO - VIGITEL. Brasília (2020). 1–126 p. www.saude.gov.br/svs

78. Carocho M, Morales P, Ferreira ICFR. Natural food additives: Quo vadis? *Trends in Food Science & Technology* (2015) 45:284–295. doi: 10.1016/J.TIFS.2015.06.007

79. Hollingworth CS. Food hydrocolloids : characteristics, properties and structures. (2010)309.

80. Paul AA, Kumar S, Kumar V, Sharma R. Milk Analog: Plant based alternatives to conventional milk, production, potential and health concerns. *Critical Reviews in Food Science and Nutrition* (2020) 60:3005–3023. doi: 10.1080/10408398.2019.1674243

81. Silva ARA, Silva MMN, Ribeiro BD. Health issues and technological aspects of plant-based alternative milk. *Food Research International* (2020) 131: doi: 10.1016/J.FOODRES.2019.108972

82. Singh P, Gandhi N. Milk Preservatives and Adulterants: Processing, Regulatory and Safety Issues. *https://doi.org/101080/875591292014994818* (2015) 31:236–261. doi: 10.1080/87559129.2014.994818

CAPÍTULO 3

Neste capítulo constam as considerações finais e as referências bibliográficas.

1. Conclusões gerais e Considerações Finais

O objetivo deste trabalho foi analisar os ingredientes e a composição nutricional de substitutos veganos para carne, leite e ovos. A partir da pesquisa, foi possível ter um panorama mundial acerca dos ingredientes e composição nutricional de substitutos veganos para carne, e nacional, para substitutos de laticínios, ovos e seus equivalentes de origem animal. Este trabalho resultou no desenvolvimento de uma revisão integrativa e em dois artigos originais.

Com a revisão integrativa, verificou-se que os estudos acerca dos substitutos de carnes concentra-se majoritariamente no hemisfério norte do planeta, distribuído em países da América do Norte e Europa, cujos índices de desenvolvimento humano são mais elevados e o mercado para estes produtos é mais desenvolvido.

De forma geral, tanto no contexto mundial, através do evidenciado pela revisão integrativa, quanto no nacional (Brasil), demonstrado pelo estudo experimental, verificou-se que a maioria dos substitutos de carne eram compostos por leguminosas (principalmente soja, ervilha, feijão e grão de bico), cereais (como trigo e aveia) e aditivos alimentares (flavorizantes, aromatizantes e agentes de textura como hidrocoloides). Os substitutos de carne apresentaram maiores teores de carboidratos e fibras dietéticas quando comparados às demais categorias. O teor de proteínas variou entre as diferentes categorias de substitutos de carne, com maior concentração nos substitutos de carne bovina.

A premissa da existência dos substitutos de carne concentra-se, em parte, na necessidade de atender aos indivíduos que adotam de padrões alimentares sem carne, mas sobretudo, na necessidade ambiental de busca por alternativas de produção mais sustentáveis que as praticadas pelo mercado pecuário. Entretanto, é necessário um ponto de atenção no que diz respeito aos principais ingredientes utilizados nesses produtos. Considerando-se os locais de produção dos ingredientes utilizados na produção destes produtos, destaca-se a possibilidade de necessidade ostensiva de importação de insumos, de modo que a produção deixe de ser sustentável. Assim, são necessários mais estudos para avaliar a sustentabilidade dos substitutos veganos para produtos de origem animal e o estímulo ao uso de ingredientes com produção local e sazonal.

Dentro do contexto de substitutos de laticínios comercializados no Brasil, uma principal problemática é a qualidade nutricional destes. Como evidenciado pelo estudo experimental, apesar de não haver diferenças entre os valores energéticos, de sódio e gorduras totais e saturadas, ao analisar-se de forma comparativa tanto a concentração proteica de bebidas vegetais, quanto de queijos veganos, observou-se que estes apresentaram menores concentrações que seus equivalentes de origem animal. Portanto, ao realizar a substituição integral de produtos de origem animal por estes produtos, a principal problemática consiste na não equivalência destes do ponto de vista nutricional e isto se torna mais problemático visto que leites e seus derivados de origem animal fornecem proteínas de alta digestibilidade, contribuindo de forma substancial para a ingestão proteica da maioria da população brasileira. Outra questão encontra-se na concentração de cálcio destes mesmos produtos, visto que seus principais ingredientes não consistem em alimentos-fonte, provavelmente os substitutos de laticínios não se adequam de forma comparativa ao fornecido por seus equivalentes de origem animal. Contudo, é importante destacar uma limitação do estudo que consiste no uso dos rótulos alimentares como fonte de informação. É sabido que os rótulos alimentares comumente apresentam discrepâncias em relação à real composição química dos produtos, além da não obrigatoriedade da declaração de alguns nutrientes, como o cálcio. Assim, mesmo com a implementação de sais de cálcio nestes produtos, a ausência da declaração deste nutriente nos rótulos alimentares dos substitutos de laticínios consiste numa importante limitação na análise da qualidade nutricional destes produtos. Assim, observa-se a necessidade de estudos futuros para avaliar a quantidade de cálcio nesse grupo de alimentos, além de ficar clara a necessidade de melhor participação por parte da indústria de alimentos, dado que apesar de não obrigatória a declaração deste nutriente, sua presença nos rótulos nutricionais pode favorecer melhores escolhas e conhecimento por parte dos consumidores.

Em relação aos ovos, destaca-se o número reduzido de substitutos encontrados no mercado brasileiro. Os ovos *in natura* fazem parte do hábito alimentar dos brasileiros consumido puto ou em preparações ao longo do dia e como, visto pelo estudo experimental, este ramo do mercado atualmente consiste apenas na comercialização de substitutos para maioneses, demostrando assim uma carência de produtos nesse nicho específico do mercado.

Este trabalho não tem a pretensão de exaurir a temática vista, sua complexidade e limitações próprias do estudo. Por outro lado, espera-se ter contribuído para ampliar as discussões sobre a qualidade nutricional de substitutos veganos para carne, laticínios e ovos. Objetiva-se, também, auxiliar o incremento do conhecimento de profissionais da saúde e instituições governamentais a desenvolver estratégias para melhorar as limitações nutricionais apontadas nos produtos incluídos neste estudo, a fim de contribuir com a saúde da população que consome estes alimentos. Ressalta-se que são necessárias pesquisas em nível laboratorial para determinação da real composição química destes produtos, para melhor elucidação do tema e constante crescimento da literatura científica.

2. Referências Bibliográficas

AGRAWAL, Sutapa; MILLETT, Christopher J.; DHILLON, Preet K.; SUBRAMANIAN, Sv; EBRAHIM, Shah. Type of vegetarian diet, obesity and diabetes in adult Indian population. **Nutrition Journal**, *[S. l.]*, v. 13, n. 1, p. 1–18, 2014. DOI: 10.1186/1475-2891-13-89/TABLES/7. Disponível em: https://link.springer.com/articles/10.1186/1475-2891-13-89. Acesso em: 30 jul. 2022.

ALESSANDRINI, Roberta; BROWN, Mhairi K.; POMBO-RODRIGUES, Sonia; BHAGEERUTTY, Sheena; HE, Feng J.; MACGREGOR, Graham A. Nutritional Quality of Plant-Based Meat Products Available in the UK: A Cross-Sectional Survey. **Nutrients 2021, Vol. 13, Page 4225**, *[S. l.]*, v. 13, n. 12, p. 4225, 2021. DOI: 10.3390/NU13124225. Disponível em: https://www.mdpi.com/2072-6643/13/12/4225/htm. Acesso em: 26 jul. 2022.

ALTOMARE, Roberta; CACCIABAUDO, Francesco; DAMIANO, Giuseppe; PALUMBO, Vincenzo Davide; GIOVIALE, Maria Concetta; BELLAVIA, Maurizio; TOMASELLO, Giovanni; LO MONTE, Attilio Ignazio. The Mediterranean Diet: A History of Health. **Iranian Journal of Public Health**, *[S. l.]*, v. 42, n. 5, p. 449, 2013. Disponível em: /pmc/articles/PMC3684452/. Acesso em: 1 ago. 2022.

AMINE, E. K. et al. **Diet, nutrition and the prevention of chronic diseasesWorld Health Organization - Technical Report Series**. [s.l: s.n.]. DOI: 10.1093/ajcn/60.4.644a.

APPEL, Lawrence J. Editorial: Dietary patterns and longevity expanding the blue zones. **Circulation**, *[S. l.]*, v. 118, n. 3, p. 214–215, 2008. DOI: 10.1161/CIRCULATIONAHA.108.788497. Disponível em: https://www.ahajournals.org/doi/abs/10.1161/CIRCULATIONAHA.108.788497. Acesso em: 31 jul. 2022.

ASCHEMANN-WITZEL, Jessica; GANTRIIS, Rebecca Futtrup; FRAGA, Paola; PEREZ-CUETO, Federico J. A. Plant-based food and protein trend from a business perspective: markets, consumers, and the challenges and opportunities in the future. **Critical reviews in food science and nutrition**, *[S. l.]*, v. 61, n. 18, p. 1–10, 2021. DOI: 10.1080/10408398.2020.1793730. Disponível em: https://pubmed.ncbi.nlm.nih.gov/32654499/. Acesso em: 7 ago. 2022.

ASHER, Kathryn E.; PETERS, Paul. Meat reduction, vegetarianism, or chicken avoidance: US omnivores' impressions of three meat-restricted diets. **British Food Journal**, *[S. l.]*, v. 123, n. 1, p. 387–404, 2021. DOI: 10.1108/BFJ-04-2020-0307/FULL/XML. Acesso em: 30 jul. 2022.

BAINES, Surinder; POWERS, Jennifer; BROWN, Wendy J. How does the health and well-being of young Australian vegetarian and semi-vegetarian women compare with non-vegetarians? **Public Health Nutrition**, *[S. l.]*, v. 10, n. 5, p. 436–442, 2007. DOI: 10.1017/S1368980007217938. Disponível em: https://www.cambridge.org/core/journals/public-health-nutrition/article/how-does-the-health-and-wellbeing-of-young-australian-vegetarian-and-semivegetarian-women-compare-with-nonvegetarians/1B49FD85C44CCDA7AEF40972F28B29BF. Acesso em: 30 jul. 2022.

BARNARD, Neal D.; GOLDMAN, David M.; LOOMIS, James F.; KAHLEOVA, Hana; LEVIN, Susan M.; NEABORE, Stephen; BATTS, Travis C. Plant-based diets for cardiovascular safety and performance in endurance sports. **Nutrients**, *[S. l.]*, v. 11, n. 1, p. 1–10, 2019. DOI: 10.3390/nu11010130.

BOUKID, Fatma; CASTELLARI, Massimo. Veggie burgers in the EU market: a nutritional challenge? **European Food Research and Technology**, *[S. l.]*, v. 247, n. 10, p. 2445–2453, 2021. DOI: 10.1007/S00217-021-03808-9/FIGURES/2. Disponível em: https://link.springer.com/article/10.1007/s00217-021-03808-9. Acesso em: 26 jul. 2022.

BOUKID, Fatma; LAMRI, Melisa; DAR, Basharat Nabi; GARRON, Marta; CASTELLARI, Massimo. Vegan Alternatives to Processed Cheese and Yogurt Launched in the European Market during 2020: A Nutritional Challenge? **Foods 2021, Vol. 10,**

Page 2782, *[S. l.]*, v. 10, n. 11, p. 2782, 2021. DOI: 10.3390/FOODS10112782. Disponível em: https://www.mdpi.com/2304-8158/10/11/2782/htm. Acesso em: 2 maio. 2022.

BRASIL. Resolução RDC nº 360, de 23 de dezembro de 2003. Aprova o Regulamento Técnico sobre Rotulagem Nutricional de Alimentos Embalados, tornando obrigatória a rotulagem nutricional. **Agencia Nacional de Vigilância Sanitária (ANVISA)**, *[S. l.]*, v. 1, n. 1, p. 1–9, 2003. Disponível em: http://portal.anvisa.gov.br/documents/33880/2568070/res0360_23_12_2003.pdf/5d4fc713-9c66-4512-b3c1-afee57e7d9bc.

BRENNAN, Charles; MUSTAFA, Rana; BOUKID, Fatma; GAGAOUA, Mohammed. Vegan Egg: A Future-Proof Food Ingredient? **Foods 2022, Vol. 11, Page 161**, *[S. l.]*, v. 11, n. 2, p. 161, 2022. DOI: 10.3390/FOODS11020161. Disponível em: https://www.mdpi.com/2304-8158/11/2/161/htm. Acesso em: 2 maio. 2022.

BRYNGELSSON, Susanne; MOSHTAGHIAN, Hanieh; BIANCHI, Marta; HALLSTRÖM, Elinor. Nutritional assessment of plant-based meat analogues on the Swedish market. **International Journal of Food Sciences and Nutrition**, *[S. l.]*, p. 1–13, 2022. a. DOI: 10.1080/09637486.2022.2078286. Disponível em: https://www.tandfonline.com/doi/abs/10.1080/09637486.2022.2078286. Acesso em: 26 jul. 2022.

BRYNGELSSON, Susanne; MOSHTAGHIAN, Hanieh; BIANCHI, Marta; HALLSTRÖM, Elinor. Nutritional assessment of plant-based meat analogues on the Swedish market. **https://doi.org/10.1080/09637486.2022.2078286**, *[S. l.]*, p. 1–13, 2022. b. DOI: 10.1080/09637486.2022.2078286. Disponível em: https://www.tandfonline.com/doi/abs/10.1080/09637486.2022.2078286. Acesso em: 7 ago. 2022.

BUHL, Tina F.; CHRISTENSEN, Claus H.; HAMMERSHØJ, Marianne. **Aquafaba as an egg white substitute in food foams and emulsions: Protein composition and functional behavior**. [s.l.] : Elsevier Ltd, 2019. DOI: 10.1016/j.foodhyd.2019.05.041. Disponível em: https://linkinghub.elsevier.com/retrieve/pii/S0268005X18321349.

CHALUPA-KREBZDAK, Sebastian; LONG, Chloe J.; BOHRER, Benjamin M. Nutrient density and nutritional value of milk and plant-based milk alternatives. **International Dairy Journal**, *[S. l.]*, v. 87, p. 84–92, 2018. a. DOI: 10.1016/J.IDAIRYJ.2018.07.018. Acesso em: 9 ago. 2022.

CHALUPA-KREBZDAK, Sebastian; LONG, Chloe J.; BOHRER, Benjamin M. Nutrient density and nutritional value of milk and plant-based milk alternatives. **International Dairy Journal**, *[S. l.]*, v. 87, p. 84–92, 2018. b. DOI: 10.1016/J.IDAIRYJ.2018.07.018. Acesso em: 1 maio. 2022.

CHINEA MONTESDEOCA, Cristina; SUÁREZ, Ernesto; HERNÁNDEZ, Bernardo; ROLO-GONZÁLEZ, Gladys. Meat-free diets and their relationship with the meaning of food and eco-friendly purchase and consumption behaviours. **British Food Journal**, *[S. l.]*, 2021. DOI: 10.1108/BFJ-03-2021-0309/FULL/HTML. Acesso em: 30 jul. 2022.

CLARYS, Peter; DELIENS, Tom; HUYBRECHTS, Inge; DERIEMAEKER, Peter; VANAELST, Barbara; DE KEYZER, Willem; HEBBELINCK, Marcel; MULLIE, Patrick. Comparison of nutritional quality of the vegan, vegetarian, semi-vegetarian, pesco-vegetarian and omnivorous diet. **Nutrients**, *[S. l.]*, v. 6, n. 3, p. 1318–1332, 2014. DOI: 10.3390/nu6031318.

COLE, Elizabeth; GOELER-SLOUGH, Natalie; COX, Allison; NOLDEN, Alissa. Examination of the nutritional composition of alternative beef burgers available in the United States. **https://doi.org/10.1080/09637486.2021.2010035**, *[S. l.]*, p. 1–8, 2021. DOI: 10.1080/09637486.2021.2010035. Disponível em: https://www.tandfonline.com/doi/abs/10.1080/09637486.2021.2010035. Acesso em: 5 dez. 2021.

COLLARD, Kalyn M.; MCCORMICK, David P. A Nutritional Comparison of Cow's Milk and Alternative Milk Products. **Academic Pediatrics**, *[S. l.]*, v. 21, n. 6, p. 1067–1069, 2021. a. DOI: 10.1016/J.ACAP.2020.12.007. Acesso em: 9 ago. 2022.

COLLARD, Kalyn M.; MCCORMICK, David P. A Nutritional Comparison of Cow's Milk and Alternative Milk Products. **Academic Pediatrics**, *[S. l.]*, v. 21, n. 6, p. 1067–1069, 2021. b. DOI: 10.1016/J.ACAP.2020.12.007. Acesso em: 18 maio. 2022.

CRAIG, Winston J.; BROTHERS, Cecilia J. Nutritional Content and Health Profile of Non-Dairy Plant-Based Yogurt Alternatives. **Nutrients 2021, Vol. 13, Page 4069**, *[S. l.]*, v. 13, n. 11, p. 4069, 2021. DOI: 10.3390/NU13114069. Disponível em: https://www.mdpi.com/2072-6643/13/11/4069/htm. Acesso em: 2 maio. 2022.

CRIMARCO, Anthony; MATTHEW, ·; LANDRY, J.; GARDNER, Christopher D. Ultra-processed Foods, Weight Gain, and Co-morbidity Risk. **Current Obesity Reports** , *[S. l.]*, v. 1, n. 1, p. 3–9, 2021. DOI: 10.1007/s13679-021-00460-y. Disponível em: https://doi.org/10.1007/s13679-021-00460-y.

CURTAIN, Felicity; GRAFENAUER, Sara. Plant-based meat substitutes in the flexitarian age: An audit of products on supermarket shelves. **Nutrients**, *[S. l.]*, v. 11, n. 11, p. 1–14, 2019. DOI: 10.3390/nu11112603.

DAMASCENO, Luana Rincon Arruda Daguer; BOTELHO, Raquel Braz Assunção; DE ALENCAR, Ernandes Rodrigues. Development of novel plant-based milk based on chickpea and coconut. **Lwt - Food Science and Technology**, *[S. l.]*, v. 128, p. 1–9, 2020. DOI: 10.1016/j.lwt.2020.109479.

DE SOUZA, Antônio Carlos. **Desgourmetizando o veganismo:Discursos políticos nas práticas comunicacionais e de consumo coletivo**. 2022. ESPM, *[S. l.]*, 2022. Disponível em: https://tede2.espm.br/bitstream/tede/620/2/antonio_carlos _de_souza.pdf.

DEEKS, JJ; FRAMPTON, GK; GLANVILLE, J.; GREINER, M.; HIGGINS, J. P. T.; LOVEI, G. L.; OCONNOR, A. M.; PULLIN, A. S.; RAJIC, A. Application of systematic review methodology to food and feed safety assessments to support decision making. **EFSA Journal**, *[S. l.]*, v. 8, n. 6, p. 1637, 2010. DOI: 10.2903/j.efsa.2010.1637.

DEMARTINI, Eugenio; VECCHIATO, Daniel; FINOS, Livio; MATTAVELLI, Simone; GAVIGLIO, Anna. Would you buy vegan meatballs? The policy issues around vegan and meat-sounding labelling of plant-based meat alternatives. **Food Policy**, *[S. l.]*, v. 111, p. 102310, 2022. DOI: 10.1016/J.FOODPOL.2022.102310. Disponível em: https://linkinghub.elsevier.com/retrieve/pii/S0306919222000860. Acesso em: 7 ago. 2022.

DERBYSHIRE, Emma J. Flexitarian Diets and Health: A Review of the Evidence-Based Literature. **Frontiers in Nutrition**, *[S. l.]*, v. 3, p. 55, 2017. DOI: 10.3389/FNUT.2016.00055/BIBTEX. Acesso em: 26 jul. 2022.

ESTRUCH, Ramon; SACANELLA, Emilio; ROS, Emilio. Should we all go pesco-vegetarian? **European Heart Journal**, *[S. l.]*, v. 42, n. 12, p. 1144–1146, 2021. DOI: 10.1093/EURHEARTJ/EHAA1088. Disponível em: https://academic.oup.com/eurheartj/article/42/12/1144/6061416. Acesso em: 30 jul. 2022.

FAISAL MANZOOR, Muhammad. Nutritional and Sensory Properties of Cashew Seed (Anacardium occidentale) Milk Impact of non-thermal processing on the quality of almond milk View project Extraction and Utilization of Manihot esculenta crantz and Trapa natans Starch as a Stabilizer in S. **Mod Concep Dev Agrono.**, *[S. l.]*, v. 1, n. 1, p. 12, 2017. DOI: 10.31031/MCDA.2017.01.000501. Disponível em: http://www.crimsonpublishers.com. Acesso em: 14 maio. 2022.

FEHÉR, András; GAZDECKI, Michal; VÉHA, Miklós; SZAKÁLY, Márk; SZAKÁLY, Zoltán. A Comprehensive Review of the Benefits of and the Barriers to the Switch to a Plant-Based Diet. **Sustainability 2020, Vol. 12, Page 4136**, *[S. l.]*, v. 12, n. 10, p. 4136, 2020. DOI: 10.3390/SU12104136. Disponível em: https://www.mdpi.com/2071-1050/12/10/4136/htm. Acesso em: 1 ago. 2022.

FISCHER, Johan. Markets, religion, regulation: Kosher, halal and Hindu vegetarianism in global perspective. **Geoforum**, *[S. l.]*, v. 69, p. 67–70, 2016. DOI: 10.1016/J.GEOFORUM.2015.12.011. Acesso em: 27 jul. 2022.

FLOM, Julie D.; SICHERER, Scott H. Epidemiology of cow's milk allergy. **Nutrients**, *[S. l.]*, v. 11, n. 5, 2019. DOI: 10.3390/NU11051051. Acesso em: 1 maio. 2022.

FOOD AND AGRICULTURE ORGANIZATION. **Dietary protein quality evaluation in human nutrition Report of an FAO Expert Consultation**. [s.l: s.n.]. Disponível em: https://www.fao.org/ag/humannutrition/35978-02317b979a686a57aa4593304ffc17f06.pdf. Acesso em: 14 maio. 2022.

FORESTELL, Catherine A. Flexitarian Diet and Weight Control: Healthy or Risky Eating Behavior? **Frontiers in Nutrition**, *[S. l.]*, v. 5, p. 59, 2018. DOI: 10.3389/FNUT.2018.00059/BIBTEX. Acesso em: 31 jul. 2022.

FRESÁN, Ujué; RIPPIN, Holly. Nutritional Quality of Plant-Based Cheese Available in Spanish Supermarkets: How Do They Compare to Dairy Cheese? **Nutrients 2021, Vol. 13, Page 3291**, *[S. l.]*, v. 13, n. 9, p. 3291, 2021. DOI: 10.3390/NU13093291. Disponível em: https://www.mdpi.com/2072-6643/13/9/3291/htm. Acesso em: 11 fev. 2022.

FRUCTUOSO, Isabel; ROMÃO, Bernardo; HAN, Heesup; RAPOSO, António; ARIZA-MONTES, Antonio; ARAYA-CASTILLO, Luis; ZANDONADI, Renata Puppin. An Overview on Nutritional Aspects of Plant-Based Beverages Used as Substitutes for Cow's Milk. **Nutrients 2021, Vol. 13, Page 2650**, *[S. l.]*, v. 13, n. 8, p. 2650, 2021. DOI: 10.3390/NU13082650. Disponível em: https://www.mdpi.com/2072-6643/13/8/2650/htm. Acesso em: 1 maio. 2022.

GEHRING, Joséphine et al. Consumption of Ultra-Processed Foods by Pesco-Vegetarians, Vegetarians, and Vegans: Associations with Duration and Age at Diet Initiation. **The Journal of Nutrition**, *[S. l.]*, v. 151, n. 1, p. 120–131, 2021. DOI: 10.1093/JN/NXAA196. Disponível em: https://academic.oup.com/jn/article/151/1/120/5874423. Acesso em: 30 jul. 2022.

GEIKER, Nina Rica Wium; BERTRAM, Hanne Christine; MEJBORN, Heddie; DRAGSTED, Lars O.; KRISTENSEN, Lars; CARRASCAL, Jorge R.; BÜGEL, Susanne; ASTRUP, Arne. Meat and Human Health-Current Knowledge and Research Gaps. **Foods (Basel, Switzerland)**, *[S. l.]*, v. 10, n. 7, 2021. DOI: 10.3390/FOODS10071556. Disponível em: https://pubmed.ncbi.nlm.nih.gov/34359429/. Acesso em: 26 jul. 2022.

HARGREAVES, Shila Minari; NAKANO, Eduardo Yoshio; ZANDONADI, Renata Puppin. Brazilian Vegetarian Population—Influence of Type of Diet, Motivation and Sociodemographic Variables on Quality of Life Measured by Specific Tool (VEGQOL). **Nutrients**, *[S. l.]*, v. 12, n. 5, p. 1406, 2020. DOI: 10.3390/nu12051406. Disponível em: https://www.mdpi.com/2072-6643/12/5/1406.

HE, Yue; SHIM, Youn Young; MUSTAFA, Rana; MEDA, Venkatesh; REANEY, Martin J. T. Chickpea Cultivar Selection to Produce Aquafaba with Superior Emulsion Properties. **Foods**, *[S. l.]*, v. 8, n. 12, p. 685, 2019. DOI: 10.3390/foods8120685. Disponível em: https://www.mdpi.com/2304-8158/8/12/685.

HENCHION, Maeve; MCCARTHY, Mary; RESCONI, Virginia C.; TROY, Declan. Meat consumption: trends and quality matters. **Meat science**, *[S. l.]*, v. 98, n. 3, p. 561–568, 2014. DOI: 10.1016/J.MEATSCI.2014.06.007. Disponível em: https://pubmed.ncbi.nlm.nih.gov/25060586/. Acesso em: 26 jul. 2022.

HINDERLITER, Alan L.; BABYAK, Michael A.; SHERWOOD, Andrew; BLUMENTHAL, James A. The DASH Diet and Insulin Sensitivity. **Current Hypertension Reports 2010 13:1**, *[S. l.]*, v. 13, n. 1, p. 67–73, 2010. DOI: 10.1007/S11906-010-0168-5. Disponível em: https://link.springer.com/article/10.1007/s11906-010-0168-5. Acesso em: 31 jul. 2022.

IBOPE. **Pesquisa de Opinião Pública sobre Vegetarianismo**. [s.l: s.n.]. Disponível em: https://www.svb.org.br/images/Documentos/JOB_0416_VEGETARIANISMO.pdf.

ILAK, Anita Silvana; PERŠURI´C, Peršuri´c; TEŽAK, Ana; DAMIJANI´C, Damijani´c. Connections between Healthy Behaviour, Perception of Olive Oil Health Benefits, and Olive Oil Consumption Motives. **Sustainability 2021, Vol. 13, Page 7630**, *[S. l.]*, v. 13, n. 14, p. 7630, 2021. DOI: 10.3390/SU13147630. Disponível em: https://www.mdpi.com/2071-1050/13/14/7630/htm. Acesso em: 26 jul. 2022.

JESKE, Stephanie; ZANNINI, Emanuele; ARENDT, Elke K. Evaluation of Physicochemical and Glycaemic Properties of Commercial Plant-Based Milk Substitutes. **Plant Foods for Human Nutrition**, *[S. l.]*, v. 72, n. 1, p. 26–33, 2017. DOI: 10.1007/S11130-016-0583-0. Acesso em: 1 maio. 2022.

KAHLEOVA, Hana; DORT, Sara; HOLUBKOV, Richard; BARNARD, Neal D. A Plant-Based High-Carbohydrate, Low-Fat Diet in Overweight Individuals in a 16-Week Randomized Clinical Trial: The Role of Carbohydrates. **Nutrients**, *[S. l.]*, v. 10, n. 9, 2018. DOI: 10.3390/NU10091302. Disponível em: https://pubmed.ncbi.nlm.nih.gov/30223451/. Acesso em: 26 jul. 2022.

KAHLEOVA, Hana; LEVIN, Susan; BARNARD, Neal. Cardio-Metabolic Benefits of Plant-Based Diets. **Nutrients 2017, Vol. 9, Page 848**, *[S. l.]*, v. 9, n. 8, p. 848, 2017. DOI: 10.3390/NU9080848. Disponível em: https://www.mdpi.com/2072-6643/9/8/848/htm. Acesso em: 1 ago. 2022.

KAHLEOVA, Hana; TURA, Andrea; KLEMENTOVA, Marta; THIEME, Lenka; HALUZIK, Martin; PAVLOVICOVA, Renata; HILL, Martin; PELIKANOVA, Terezie. A Plant-Based Meal Stimulates Incretin and Insulin Secretion More Than an Energy- and Macronutrient-Matched Standard Meal in Type 2 Diabetes: A Randomized Crossover Study. **Nutrients**, *[S. l.]*, v. 11, n. 3, 2019. DOI: 10.3390/NU11030486. Disponível em: https://pubmed.ncbi.nlm.nih.gov/30813546/. Acesso em: 26 jul. 2022.

KARIMIDASTJERD, Atefeh; KILIC-AKYILMAZ, Meral. Formulation of a low-protein rice drink fortified with caseinomacropeptide concentrate. **Food and Bioproducts Processing**, *[S. l.]*, v. 125, p. 161–169, 2021. DOI: 10.1016/J.FBP.2020.11.004. Acesso em: 1 maio. 2022.

LAFARGA, Tomás; VILLARÓ, Silvia; BOBO, Gloria; AGUILÓ-AGUAYO, Ingrid. Optimisation of the pH and boiling conditions needed to obtain improved foaming and emulsifying properties of chickpea aquafaba using a response surface methodology. **International Journal of Gastronomy and Food Science**, *[S. l.]*, v. 18, p. 100177, 2019. DOI: 10.1016/j.ijgfs.2019.100177. Disponível em: https://linkinghub.elsevier.com/retrieve/pii/S1878450X19300691.

LE, Lap T.; SABATÉ, Joan; SINGH, Pramil N.; JACELDO-SIEGL, Karen. The design, development and evaluation of the vegetarian lifestyle index on dietary patterns among vegetarians and non-vegetarians. **Nutrients**, *[S. l.]*, v. 10, n. 5, p. 25–27, 2018. DOI: 10.3390/nu10050542.

LOUZADA, Maria Laura da Costa et al. Consumption of ultra-processed foods and obesity in Brazilian adolescents and adults. **Preventive Medicine**, *[S. l.]*, v. 81, p. 9–15, 2015. DOI: 10.1016/J.YPMED.2015.07.018. Acesso em: 11 dez. 2021.

LYNCH, Heidi; JOHNSTON, Carol; WHARTON, Christopher. Plant-based diets: Considerations for environmental impact, protein quality, and exercise performance. **Nutrients**, *[S. l.]*, v. 10, n. 12, p. 1–16, 2018. DOI: 10.3390/nu10121841.

MALIK, Reena; JINDAL, Tanvi. Customers' Attitude Towards Vegan Products Consumption and Its Impact on Purchase Intension: An Indian Perspective: **https://doi.org/10.1177/09722629221087361**, *[S. l.]*, 2022. DOI: 10.1177/09722629221087361. Disponível em: https://journals.sagepub.com/doi/abs/10.1177/09722629221087361. Acesso em: 7 ago. 2022.

MARCUS, N.; KLINK-LEHMANN, J.; HARTMANN, M. Exploring factors determining German consumers' intention to eat meat alternatives. **Food Quality and Preference**, *[S. l.]*, v. 100, p. 104610, 2022. DOI: 10.1016/J.FOODQUAL.2022.104610. Acesso em: 7 ago. 2022.

MARIOTTI, François; GARDNER, Christopher D. Dietary protein and amino acids in vegetarian diets—A review. **Nutrients**, *[S. l.]*, v. 11, n. 11, p. 1–19, 2019. DOI: 10.3390/nu11112661.

MARISEVA, Alla; BEITANE, Ilze. Assessment of ingredients and nutritional value of vegan products in Latvian market. *Em*: 2020, **Anais** [...]. [s.l: s.n.] p. 118–124. DOI: 10.22616/RRD.26.2020.018. Disponível em: https://llufb.llu.lv/conference/Research-for-Rural-Development/2020/LatviaResRuralDev_26th_2020-118-124.pdf.

MARTINELLI, Elisa; DE CANIO, Francesca. Non-vegan consumers buying vegan food: the moderating role of conformity. **British Food Journal**, *[S. l.]*, v. 124, n. 1, p. 14–30, 2021. DOI: 10.1108/BFJ-01-2021-0023/FULL/XML. Acesso em: 7 ago. 2022.

MARTÍNEZ-PADILLA, Eliana; LI, Kexin; FRANDSEN, Heidi Blok; JOEHNKE, Marcel Skejovic; VARGAS-BELLO-PÉREZ, Einar; PETERSEN, Iben Lykke. In Vitro Protein Digestibility and Fatty Acid Profile of Commercial Plant-Based Milk Alternatives. **Foods (Basel, Switzerland)**, *[S. l.]*, v. 9, n. 12, 2020. DOI: 10.3390/FOODS9121784. Disponível em: https://pubmed.ncbi.nlm.nih.gov/33271952/. Acesso em: 9 ago. 2022.

MCCARTHY, Niall. **Where Meat Consumption Is Highest & Lowest**. 2019. Disponível em: https://www.statista.com/chart/16889/total-per-capita-meat-consumption-worldwide/. Acesso em: 26 jul. 2022.

MIGUEL, Isabel; COELHO, Arnaldo; BAIRRADA, Cristela Maia. Modelling Attitude towards Consumption of Vegan Products. **Sustainability 2021, Vol. 13, Page 9**, *[S. l.]*,

v. 13, n. 1, p. 9, 2020. a. DOI: 10.3390/SU13010009. Disponível em: https://www.mdpi.com/2071-1050/13/1/9/htm. Acesso em: 26 jul. 2022.

MIGUEL, Isabel; COELHO, Arnaldo; BAIRRADA, Cristela Maia. Modelling Attitude towards Consumption of Vegan Products. **Sustainability 2021, Vol. 13, Page 9**, *[S. l.]*, v. 13, n. 1, p. 9, 2020. b. DOI: 10.3390/SU13010009. Disponível em: https://www.mdpi.com/2071-1050/13/1/9/htm. Acesso em: 1 ago. 2022.

MOHER, David; LIBERATI, Alessandro; TETZLAFF, Jennifer; ALTMAN, Douglas G.; PRISMA GROUP. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. **PLoS Medicine**, *[S. l.]*, v. 6, n. 7, p. e1000097, 2009. DOI: 10.1371/journal.pmed.1000097.

MONTEIRO, Carlos A. et al. Commentary Ultra-processed foods: what they are and how to identify them. *[S. l.]*, 2021. DOI: 10.1017/S1368980018003762. Disponível em: https://www.cambridge.org/core.

MOUBARAC, Jean Claude; BATAL, M.; LOUZADA, M. L.; MARTINEZ STEELE, E.; MONTEIRO, C. A. Consumption of ultra-processed foods predicts diet quality in Canada. **Appetite**, *[S. l.]*, v. 108, p. 512–520, 2017. DOI: 10.1016/J.APPET.2016.11.006. Acesso em: 11 dez. 2021.

MURARO, Maria Antonella; GIAMPIETRO, Paolo G.; GALLI, Elena. Soy formulas and nonbovine milk. **Annals of Allergy, Asthma & Immunology**, *[S. l.]*, v. 89, n. 6, p. 97–101, 2002. DOI: 10.1016/S1081-1206(10)62132-1. Acesso em: 18 maio. 2022.

MUSTAFA, Rana; HE, Yue; SHIM, Youn Young; REANEY, Martin J. T. Aquafaba, wastewater from chickpea canning, functions as an egg replacer in sponge cake. **International Journal of Food Science and Technology**, *[S. l.]*, v. 53, n. 10, p. 2247–2255, 2018. a. DOI: 10.1111/ijfs.13813.

MUSTAFA, Rana; HE, Yue; SHIM, Youn Young; REANEY, Martin J. T. Aquafaba, wastewater from chickpea canning, functions as an egg replacer in sponge cake. **International Journal of Food Science & Technology**, *[S. l.]*, v. 53, n. 10, p. 2247–2255, 2018. b. DOI: 10.1111/ijfs.13813. Disponível em: https://onlinelibrary.wiley.com/doi/10.1111/ijfs.13813. Acesso em: 2 maio. 2022.

NAJJAR, Rami S.; FERESIN, Rafaela G. Plant-based diets in the reduction of body fat: Physiological effects and biochemical insights. **Nutrients**, *[S. l.]*, v. 11, n. 11, 2019. DOI: 10.3390/nu11112712.

NAJJAR, Rami S.; MOORE, Carolyn E.; MONTGOMERY, Baxter D. Consumption of a defined, plant-based diet reduces lipoprotein(a), inflammation, and other atherogenic lipoproteins and particles within 4 weeks. **Clinical cardiology**, *[S. l.]*, v. 41, n. 8, p. 1062–1068, 2018. DOI: 10.1002/CLC.23027. Disponível em: https://pubmed.ncbi.nlm.nih.gov/30014498/. Acesso em: 26 jul. 2022.

NOGUEROL, Ana Teresa; PAGÁN, M. Jesús; GARCÍA-SEGOVIA, Purificación; VARELA, Paula. Green or clean? Perception of clean label plant-based products by omnivorous, vegan, vegetarian and flexitarian consumers. **Food Research International**, *[S. l.]*, v. 149, p. 110652, 2021. DOI: 10.1016/J.FOODRES.2021.110652. Acesso em: 7 ago. 2022.

ONWEZEN, M. C.; BOUWMAN, E. P.; REINDERS, M. J.; DAGEVOS, H. A systematic review on consumer acceptance of alternative proteins: Pulses, algae, insects, plant-based meat alternatives, and cultured meat. **Appetite**, *[S. l.]*, v. 159, 2021. DOI: 10.1016/J.APPET.2020.105058. Disponível em: https://pubmed.ncbi.nlm.nih.gov/33276014/. Acesso em: 26 jul. 2022.

PAUL, Anna Aleena; KUMAR, Satish; KUMAR, Vikas; SHARMA, Rakesh. Milk Analog: Plant based alternatives to conventional milk, production, potential and health concerns. **Critical Reviews in Food Science and Nutrition**, *[S. l.]*, v. 60, n. 18, p. 3005–3023, 2020. DOI: 10.1080/10408398.2019.1674243. Acesso em: 1 maio. 2022.

RABÈS, Anaëlle et al. Greenhouse gas emissions, energy demand and land use associated with omnivorous, pesco-vegetarian, vegetarian, and vegan diets accounting for farming practices. **Sustainable Production and Consumption**, *[S. l.]*, v. 22, p. 138–146, 2020. DOI: 10.1016/J.SPC.2020.02.010. Acesso em: 30 jul. 2022.

RAGGIOTTO, Francesco; MASON, Michela Cesarina; MORETTI, Andrea. Religiosity, materialism, consumer environmental predisposition. Some insights on vegan purchasing intentions in Italy. **International Journal of Consumer Studies**, *[S. l.]*, v. 42, n. 6, p. 613–626, 2018. DOI: 10.1111/IJCS.12478. Disponível em: https://onlinelibrary.wiley.com/doi/full/10.1111/ijcs.12478. Acesso em: 7 ago. 2022.

RAIKOS, Vassilios; HAYES, Helen; NI, He. Aquafaba from commercially canned chickpeas as potential egg replacer for the development of vegan mayonnaise: recipe optimisation and storage stability. **International Journal of Food Science & Technology**, *[S. l.]*, v. 55, n. 5, p. 1935–1942, 2020. DOI: 10.1111/IJFS.14427. Disponível em: https://onlinelibrary.wiley.com/doi/full/10.1111/ijfs.14427. Acesso em: 2 maio. 2022.

RAPHAELY, Talia; MARINOVA, Dora. Flexitarianism: A More Moral Dietary Option. **International Journal of Sustainable Society**, *[S. l.]*, v. 6, n. 1/2, p. 189–211, 2013.

DOI: 10.1504/IJSSOC.2014.057846. Disponível em: https://espace.curtin.edu.au/bitstream/20.500.11937/34012/2/191902.pdf. Acesso em: 31 jul. 2022.

RASZAP SKORBIANSKY, Sharon; SAAVOSS, Monica; STEWART, Hayden. Cow's milk still leads in the United States: The case of cow's, almond, and soy milk. **Agricultural Economics**, *[S. l.]*, v. 53, n. 2, p. 204–214, 2022. DOI: 10.1111/AGEC.12700. Disponível em: https://onlinelibrary.wiley.com/doi/full/10.1111/agec.12700. Acesso em: 14 maio. 2022.

RAVINDRAN, Sangami; RADHAISRI, S. Probiotic oats milk drink with microencapsulated Lactobacillus plantarum – an alternative to dairy products. **Nutrition and Food Science**, *[S. l.]*, v. 51, n. 3, p. 471–482, 2020. DOI: 10.1108/NFS-03-2020-0073. Acesso em: 1 maio. 2022.

ROMA, Júlio César. Os objetivos de desenvolvimento do milênio e sua transição para os objetivos de desenvolvimento sustentável. **Ciência e Cultura**, *[S. l.]*, v. 71, n. 1, p. 33–39, 2019. DOI: 10.21800/2317-66602019000100011. Disponível em: http://cienciaecultura.bvs.br/scielo.php?script=sci_arttext&pid=S0009-67252019000100011&lng=pt&tlng=pt.

ROSELL, Magdalena; APPLEBY, Paul; KEY, Tim. Height, age at menarche, body weight and body mass index in life-long vegetarians. **Public Health Nutrition**, *[S. l.]*, v. 8, n. 7, p. 870–875, 2005. DOI: 10.1079/PHN2005730. Disponível em: https://www.cambridge.org/core/journals/public-health-nutrition/article/height-age-at-menarche-body-weight-and-body-mass-index-in-lifelong-vegetarians/DE4EA939708A38D1E40D665DBCB4BA55. Acesso em: 30 jul. 2022.

SABATÉ, J.; BLIX, G. Vegetarian diets and obesity prevention. *Em*: **Vegetarian Nutrition**. [s.l.] : CRC Press Inc, 2001. p. 99–107. Disponível em: https://www.cabdirect.org/cabdirect/abstract/20033115888.

SABATÉ, Joan; WIEN, Michelle. Vegetarian diets and childhood obesity prevention. **The American Journal of Clinical Nutrition**, *[S. l.]*, v. 91, n. 5, p. 1525S-1529S, 2010. DOI: 10.3945/AJCN.2010.28701F. Disponível em: https://academic.oup.com/ajcn/article/91/5/1525S/4597472. Acesso em: 30 jul. 2022.

SAMARD, Sasimaporn; RYU, Gi Hyung. Physicochemical and functional characteristics of plant protein-based meat analogs. **Journal of Food Processing and Preservation**, *[S. l.]*, v. 43, n. 10, p. e14123, 2019. DOI: 10.1111/jfpp.14123. Disponível em: https://onlinelibrary.wiley.com/doi/full/10.1111/jfpp.14123. Acesso em: 14 fev. 2022.

SARTORELLI, Daniela Saes; FRANCO, Laércio Joel. Tendências do diabetes mellitus no Brasil: o papel da transição nutricional. **Cadernos de Saúde Pública**, *[S. l.]*, v. 19, n. suppl 1, p. S29–S36, 2003. DOI: 10.1590/S0102-311X2003000700004. Disponível em: http://www.scielo.br/j/csp/a/PpGSSkRrnM3pcKb6ymzqSKP/abstract/?lang=pt. Acesso em: 1 ago. 2022.

SCHIANO, A. N.; HARWOOD, W. S.; GERARD, P. D.; DRAKE, M. A. Consumer perception of the sustainability of dairy products and plant-based dairy alternatives. **Journal of Dairy Science**, *[S. l.]*, v. 103, n. 12, p. 11228–11243, 2020. DOI: 10.3168/JDS.2020-18406. Acesso em: 14 maio. 2022.

SHORT, Erin C.; KINCHLA, Amanda J.; NOLDEN, Alissa A. Plant-Based Cheeses: A Systematic Review of Sensory Evaluation Studies and Strategies to Increase Consumer Acceptance. **Foods 2021, Vol. 10, Page 725**, *[S. l.]*, v. 10, n. 4, p. 725, 2021. DOI: 10.3390/FOODS10040725. Disponível em: https://www.mdpi.com/2304-8158/10/4/725/htm. Acesso em: 14 maio. 2022.

SHRIDHAR, Krithiga; DHILLON, Preet Kaur; BOWEN, Liza; KINRA, Sanjay; BHARATHI, Ankalmadugu Venkatsubbareddy; PRABHAKARAN, Dorairaj; REDDY, Kolli Srinath; EBRAHIM, Shah. The association between a vegetarian diet and cardiovascular disease (cvd) risk factors in india: The indian migration study. **PLoS ONE**, *[S. l.]*, v. 9, n. 10, p. 1–8, 2014. DOI: 10.1371/journal.pone.0110586.

SILVA, Aline R. A.; SILVA, Marselle M. N.; RIBEIRO, Bernardo D. Health issues and technological aspects of plant-based alternative milk. **Food Research International**, *[S. l.]*, v. 131, n. June 2019, p. 108972, 2020. a. DOI: 10.1016/j.foodres.2019.108972. Disponível em: https://doi.org/10.1016/j.foodres.2019.108972.

SILVA, Aline R. A.; SILVA, Marselle M. N.; RIBEIRO, Bernardo D. Health issues and technological aspects of plant-based alternative milk. **Food Research International**, *[S. l.]*, v. 131, 2020. b. DOI: 10.1016/J.FOODRES.2019.108972. Acesso em: 1 maio. 2022.

SINGHAL, Sarita; BAKER, Robert D.; BAKER, Susan S. A Comparison of the Nutritional Value of Cow's Milk and Nondairy Beverages. **Journal of Pediatric Gastroenterology and Nutrition**, *[S. l.]*, v. 64, n. 5, p. 799–805, 2017. DOI: 10.1097/MPG.0000000000001380. Disponível em: https://journals.lww.com/jpgn/Fulltext/2017/05000/A_Comparison_of_the_Nutritional_Value_of_Cow_s.28.aspx. Acesso em: 9 ago. 2022.

SLYWITCH, Eric. **Guia alimentar de dietas vegetarianas para adultos**. **Sociedade Vegetariana Brasileira**, 2012.

SÖDERBERG, Johanna. **Functional properties of legume proteins compared to egg proteins and their potential as egg replacers in vegan food - Epsilon Archive for Student Projects**. 2013. Swedish University of Agricultural Sciences, *[S. l.]*, 2013. Disponível em: https://stud.epsilon.slu.se/6240/. Acesso em: 2 maio. 2022.

SPENCER, E. A.; APPLEBY, P. N.; DAVEY, G. K.; KEY, T. J. Diet and body mass index in 38 000 EPIC-Oxford meat-eaters, fish-eaters, vegetarians and vegans. **International Journal of Obesity 2003 27:6**, *[S. l.]*, v. 27, n. 6, p. 728–734, 2003. DOI: 10.1038/sj.ijo.0802300. Disponível em: https://www.nature.com/articles/0802300. Acesso em: 30 jul. 2022.

STATISTA. **Share of people who follow a vegetarian diet worldwide as of 2016, by region**. 2016. Disponível em: https://www.statista.com/statistics/597408/vegetarian-diet-followers-worldwide-by-region/. Acesso em: 26 jun. 2020.

STATISTA. **Veganism and vegetarianism worldwide - statistics & facts**. [s.l: s.n.]. Disponível em: https://www.statista.com/topics/8771/veganism-and-vegetarianism-worldwide/#topicHeader__wrapper. Acesso em: 27 jul. 2022.

STATISTA. **• Global consumption of milk per year by country 2021 | Statista**. 2022. Disponível em: https://www.statista.com/statistics/272003/global-annual-consumption-of-milk-by-region/. Acesso em: 1 maio. 2022.

STREMMEL, Gesa; ELSHIEWY, Ossama; BOZTUG, Yasemin; CARNEIRO-OTTO, Fernanda. Vegan labeling for what is already vegan: Product perceptions and consumption intentions. **Appetite**, *[S. l.]*, v. 175, p. 106048, 2022. DOI: 10.1016/J.APPET.2022.106048. Acesso em: 7 ago. 2022.

THE GOOD FOOD INSTITUTE. Indústria de Proteínas Alternativas - 2020. **The Good Food Institute Brazil**, *[S. l.]*, v. 1, n. 1, p. 1–32, 2020.

TOBEY, James A. Milk and Milk Products. **American Journal of Public Health and the Nations Health**, *[S. l.]*, v. 20, n. 5, p. 564–564, 1930. DOI: 10.2105/ajph.20.5.564-a.

TONHEIM, Live Edvardsen; AUSTAD, Elisabeth; TORHEIM, Liv Elin; HENJUM, Sigrun. Plant-based meat and dairy substitutes on the Norwegian market: comparing macronutrient content in substitutes with equivalent meat and dairy products. **Journal of Nutritional Science**, *[S. l.]*, p. 1–8, 2022. DOI: 10.1017/JNS.2022.6. Disponível em: https://www.cambridge.org/core/journals/journal-of-nutritional-science/article/plantbased-meat-and-dairy-substitutes-on-the-norwegian-market-comparing-macronutrient-content-in-substitutes-with-equivalent-meat-and-dairy-products/542D087A73A860277815E01840B. Acesso em: 11 fev. 2022.

TZIVA, M.; NEGRO, S. O.; KALFAGIANNI, A.; HEKKERT, M. P. Understanding the protein transition: The rise of plant-based meat substitutes. **Environmental Innovation and Societal Transitions**, *[S. l.]*, n. April, p. 1–15, 2019. DOI: 10.1016/j.eist.2019.09.004. Disponível em: https://doi.org/10.1016/j.eist.2019.09.004.

VANGA, Sai Kranthi; RAGHAVAN, Vijaya. How well do plant based alternatives fare nutritionally compared to cow's milk? **Journal of Food Science and Technology**, *[S. l.]*, v. 55, n. 1, p. 10–20, 2018. DOI: 10.1007/S13197-017-2915-Y. Acesso em: 1 maio. 2022.

WILLETT, Walter C. The Mediterranean diet: science and practice. **Public Health Nutrition**, *[S. l.]*, v. 9, n. 1a, p. 105–110, 2006. DOI: 10.1079/PHN2005931. Disponível em: https://www.cambridge.org/core/journals/public-health-nutrition/article/mediterranean-diet-science-and-practice/C383082DF00DDFE6475D0B8614EB0BE9. Acesso em: 31 jul. 2022.

YOKOYAMA, Yoko; BARNARD, Neal D.; LEVIN, Susan M.; WATANABE, Mitsuhiro. Vegetarian diets and glycemic control in diabetes: a systematic review and meta-analysis. **Cardiovascular Diagnosis and Therapy**, *[S. l.]*, v. 4, n. 5, p. 373, 2014. DOI: 10.3978/J.ISSN.2223-3652.2014.10.04. Disponível em: /pmc/articles/PMC4221319/. Acesso em: 30 jul. 2022.

ZHANG, Yianna Y.; HUGHES, Jaimee; GRAFENAUER, Sara. Got mylk? The emerging role of australian plant-based milk alternatives as a cow's milk substitute. **Nutrients**, *[S. l.]*, v. 12, n. 5, 2020. DOI: 10.3390/nu12051254.