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VOLUME FÍSICO E VALOR MONETÁRIO DAS PERDAS E DESPERDÍCIO DE ALIMENTOS NO BRASIL

TESE DE DOUTORADO

Glenio Piran Dal' Magro

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Glenio Piran Dal' Magro

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Tese de doutorado apresentada ao Programa de Pós-Graduação em Agronegócios do Centro de Estudos e Pesquisas em Agronegócios da Universidade Federal do Rio Grande do Sul, como requisito parcial para obtenção do título de Doutor em Agronegócios.

BANCA EXAMINADORA

Profª. Drª. Angélica Margarete Magalhães – UFGD

Drº. Gustavo Porpino de Araújo – EMBRAPA

Profº. Drº. Homero Dewes – UFRGS

Orientador: Profº. Drº. Edson Talamini – UFRGS

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Centro de Estudos e Pesquisas em Agronegócios
Programa de Pós-Graduação em Agronegócios

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VOLUME FÍSICO E VALOR MONETÁRIO DAS PERDAS E DESPERDÍCIO DE ALIMENTOS NO BRASIL

elaborada por
Glenio Piran Dal' Magro

como requisito parcial para obtenção do grau de **Doutor em Agronegócios**

COMISSÃO EXAMINADORA

Edson Talamini, Drº.
(Presidente/Orientador - UFRGS)

Angélica Margarete Magalhães, Drª (UFGD)

Gustavo Porpino de Araújo, Drº. (EMBRAPA)

Homero Dewes, Drº. (UFRGS)

Porto Alegre, 14 de junho de 2019.

Dedico esta tese a minha amada família.
Obrigado pelo incentivo, entendimento, carinho e ensinamentos,
que formaram os alicerces da minha história.
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“Toda a existência humana decorre do binômio Estômago e Sexo. A Fome e o Amor governam o mundo, afirmava Schiller. Os artifícios da astúcia, disciplina da força, oportunidade da observação aplicada, são formas aquisitivas para a satisfação das duas necessidades onipotentes. O sexo pronuncia-se em época adiantada apesar das generalidades delirantes de Freud. O estômago é contemporâneo, funcional ao primeiro momento extrauterino. Acompanha a vida, mantendo-a na sua permanência fisiológica. O sexo pode ser adiado, transferido, sublimado noutras atividades absorventes e compensadoras. O estômago não. É dominador, imperioso, inadiável.”

História da Alimentação no Brasil - Luís da Câmara Cascudo

RESUMO

Tese de Doutorado
Programa de Pós-Graduação em Agronegócios
Universidade Federal do Rio Grande do Sul

VOLUME FÍSICO E VALOR MONETÁRIO DAS PERDAS E DESPERDÍCIO DE ALIMENTOS NO BRASIL

AUTOR: Glenio Piran Dal' Magro
ORIENTADOR: Edson Talamini
Data e Local da Defesa: Porto Alegre, 14 de junho de 2019.

O Brasil está entre os principais produtores mundiais de alimentos, abastecendo populações locais e globais. Por outro lado, existe uma grande quantidade de perdas e desperdícios de alimentos geradas entre as etapas da cadeia de abastecimento alimentar. Neste sentido, o objetivo principal deste estudo é estimar quantitativamente a geração de perdas e desperdício de alimentos no Brasil. Os resultados estão apresentados em três capítulos que, combinados, fornecem uma melhor compreensão sobre a temática. O primeiro, refere-se a busca de diferentes abordagens, estruturas e estratégicas para estimar perdas e desperdícios de alimentos. O capítulo objetiva discutir o estado da arte das perdas e desperdícios de alimentos a partir de uma revisão sistemática de estimativas quantitativas. Por meio de protocolo metodológico foram identificados diferentes estudos realizados pelo mundo, verificando que existem mais estudos em países desenvolvidos. As metodologias utilizadas para estimar as perdas e desperdícios de alimentos são heterogêneas (diretas, indiretas e mistas) e variam de acordo com o objetivo do estudo. O segundo capítulo se refere à disponibilidade de alimentos no Brasil e a estimativa das perdas e desperdícios de alimentos gerado nas etapas que compõem a cadeia de abastecimento alimentar. Nesse sentido, realizou-se um exercício de estimação de perdas e desperdícios de alimentos usando dados da produção agrícola, armazenamento, processamento, distribuição e consumo de alimentos, para diferentes grupos de commodities. Para tanto, utilizou-se dados disponibilizados pela FAOSTAT. Identificou-se uma média anual de perdas e desperdícios de 82.2 milhões de toneladas, entre os anos de 2007 e 2013. Esse montante representou 42% da oferta média nacional de alimentos para o período. O terceiro capítulo tem como objetivo estimar valores de desperdício alimentar domiciliar para o Brasil. Para tanto, utilizou-se dados populacionais da aquisição de alimentos (em quilogramas) e valores monetários (em Real) coletados da Pesquisa de Orçamento Familiar (POF) de 2008-2009 e as estimativas de desperdício domiciliar identificados em estudo amostral, no ano de 2018,para todas as regiões brasileiras. O percentual médio de desperdício de alimento no domicílio brasileiro, foi de 12,88%, representando o valor monetário médio de R$ 56,89 por domicílio para o ano de 2008. Isto denota um montante nacional de R$ 3,282 bilhões em alimentos desperdiçados no país. Em suma, apesar de que pesquisas adicionais são necessárias para melhorar a exatidão e precisão das estimativas das perdas e desperdícios de alimentos, os resultados podem ser utilizados para nortear ações ou políticas voltadas à mitigação de perdas e desperdício de alimentos.

Palavras-chave: Agronegócios, Alimento, Aquisição, Cadeia de abastecimento alimentar, Consumo, Estimativa, Quantificação

ABSTRACT

Doctoral Thesis
Graduate Program in Agribusiness
Federal University of Rio Grande do Sul

PHYSICAL VOLUME AND THE MONETARY VALUE OF FOOD LOSS AND WASTE IN BRAZIL

AUTHOR: Glenio Piran Dal' Magro
ADVISER: Edson Talamini
Date and Place of Defense: Porto Alegre, 14 June 2019.

Brazil is among the world's leading food producers, supplying local and global populations. On the other hand, there is a large amount of food loss and waste generated between the stages of the food supply chain. In this sense, the main goal of this study is to quantitatively estimate the generation of food loss and waste in Brazil. The results of this thesis are presented in three chapters that, combined, provide a better understanding of food loss and waste in Brazil. The first refers to the search for different approaches, structures and strategies to estimate food losses and waste. The chapter aims to discuss the state of the art of food loss and waste from a systematic review of quantitative estimates. Were identified, through methodological protocol, different studies conducted around the world and there are more studies in developed countries. The methodologies used to estimate food losses and waste are heterogeneous (direct, indirect and mixed) and vary according to the objective of the study. The second chapter refers to the availability of food in Brazil and the estimation of food losses and waste generated in the stages that make up the food supply chain. In this sense, a food loss and waste estimation exercise was performed using data from agricultural production, storage, processing, distribution and food consumption for different commodity groups. To this end, data provided by FAOSTAT were used. An annual average loss and waste of 82.2 million tons were identified between 2007 and 2013. This amount represented 42% of the national average food supply for the period. The third chapter aims to estimate household food waste values for Brazil. For this, we used population data of food acquisition (in kilograms) and monetary values (in Real) collected from the 2008-2009 Family Budget Survey (POF) and the household waste estimates identified in a sample study for the year of 2018, for all Brazilian regions. The average percentage of food waste in the Brazilian household was of 12.88%, representing the average monetary value of R$ 56.89 per household for 2008. This denotes a national amount of R$ 3.282 billion in wasted food. in the country. In sum, while additional research is needed to improve the accuracy and precision of food loss and waste estimates, the results can be used to guide actions or policies aimed at mitigating food loss and waste.

Keywords: Agribusiness, Food, Acquisition, Food supply chain, Consumption, Estimation, Quantification

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CAPÍTULO 1

Introdução

A temática de perdas e desperdícios de alimentos (FLW – *Food Loss and Waste*) é conduzida por dois sensos internacionais de interlocução, um voltado à perspectiva social, e outro, à ambiental. Essas linhas são norteadas por organizações distintas que desenvolvem ações voltadas aos seus respectivos objetivos e formas de entendimento quanto a definições, mensuração, destinação, eficiência de recursos naturais, aspectos comestíveis e valores nutricionais dos alimentos. Nesse sentido, apresentar-se-á, na contextualização, distintas iniciativas promovidas por diferentes setores da sociedade engajados com a temática.

A primeira organização é a *Food and Agriculture Organization (FAO)* das *United Nations (UN)*, que desenvolve a perspectiva social na busca da erradicação da fome e da extrema pobreza. A FAO obteve maior visibilidade e destaque nos últimos anos e tem desenvolvido ações voltadas para a segurança alimentar a fim de cumprir com os direitos fundamentais do ser humano. Baseado no desenvolvimento de iniciativas político-institucionais, essa perspectiva se desenvolve em consonância com as ações da UN, que conduzem esforços coletivos comuns voltados para todas as pessoas, para o planeta e para a prosperidade (UN, 2010).

Dentre os esforços para este século, contempla a erradicação da pobreza extrema e da fome, que estão entre os objetivos de Desenvolvimento do Milênio, na Agenda 2030, elaborada em 2015 (UN, 2010). O atual plano propõe 17 objetivos com 169 metas que estimularão ações por uma década e meia. A meta de reduzir para a metade, até o ano de 2030, o percentual de pessoas com rendimento inferior de US$ 1,25 por dia, auxiliaria na redução do percentual da população mundial que sofre de fome.

Apesar de se ter alçado metas com o plano anterior, o novo plano reconhece que “a erradicação da pobreza em todas as suas formas e dimensões, incluindo a pobreza extrema, é o maior desafio global” (UN, 2015a, p.3). Aliado à agenda da UN, a FAO possui nos seus objetivos estratégicos ajudar na eliminação da fome, da insegurança alimentar e da má nutrição por meio da promoção de uma agricultura sustentável. Uma das formas de alcançar esse objetivo refere-se à mitigação de perdas e desperdício de alimentos, portanto, envolve-se na promoção ao Direito Humano à Alimentação Adequada.

Esse direito consta na Declaração Universal dos Direitos Humanos, que traz o acesso à alimentação como um direito, uma vez que a alimentação se constitui no próprio direito à vida (UN, 2015b). Direito fundamental, por ser considerada a mais relevante necessidade do ser humano (MASLOW, 1943), a alimentação deve ser a prioridade de uma nação, não apenas devido à importância do alimento para o bem-estar pessoal, mas também devido à importância deste para a estabilidade social e política de um país (SKIDELSKY, 2009). Contudo, sabe-se que esta não é uma realidade amplamente vivenciada.

A fim de atingir os objetivos de Desenvolvimento do Milênio, a FAO possui uma interlocução com demais organizações para desenvolver ações voltadas a mitigar a FLW. A União de Nações Sul-Americanas possui em seus objetivos específicos o desenvolvimento social e humano, estabelecido com a finalidade de erradicar a pobreza e superar as desigualdades na região (UNASUR, 2016). Ademais, a Comissão Econômica para América Latina e Caribe contribui com mecanismos regionais de discussão e implementação da Agenda 2030, com ênfase na erradicação da pobreza e no fomento de um crescimento inclusivo, equitativo e duradouro, incluindo padrões de consumo e produção sustentáveis (LEÓN, 2016).

Cabe salientar que a FAO faz uma distinção entre perda e desperdício alimentar. A perda refere-se à diminuição da massa de alimentos durante o processo produtivo, ou seja, nas etapas de produção, colheita, processamento e distribuição, seja destinado diretamente para o consumo humano ou para a alimentação animal, ou outros fins, como biocombustíveis (BELIK; CUNHA; COSTA, 2012). Procedimentos inadequados ou pouco eficientes causam perdas ou danos aos produtos nos processos de manipulação, transformação, estocagem, transporte e embalagem (GUSTAVSSON et al., 2011).

Já o desperdício refere-se à redução do volume de alimentos destinados exclusivamente à alimentação humana e que ocorre nas etapas finais da cadeia de abastecimento alimentar, ou seja, nas etapas de varejo e consumo. Entretanto, o desperdício nessas etapas também pode ser decorrente de problemas originários nas etapas anteriores, tais como, o uso de embalagens inapropriadas que encurtam o tempo de vida de frutas e hortaliças. Portanto, é um fenômeno associado à ineficiência do processo de distribuição – atacado e varejo – e de consumo (BELIK; CUNHA; COSTA, 2012). Suas causas procedem da perda de valor comercial do produto ofertado e não necessariamente do seu valor nutricional, decorrente do excesso de produção, de danos na aparência dos alimentos ou mesmo do consumo não realizado após a compra. Para os mesmos autores, embora haja relação causal entre perdas e subsequente desperdício – por exemplo, produtos danificados que se deterioram biologicamente –, o desperdício é essencialmente um fenômeno decorrente da não realização do consumo dos produtos cuja oferta chegou até a esfera da distribuição (atacado e varejo) ou aquisição domiciliar.

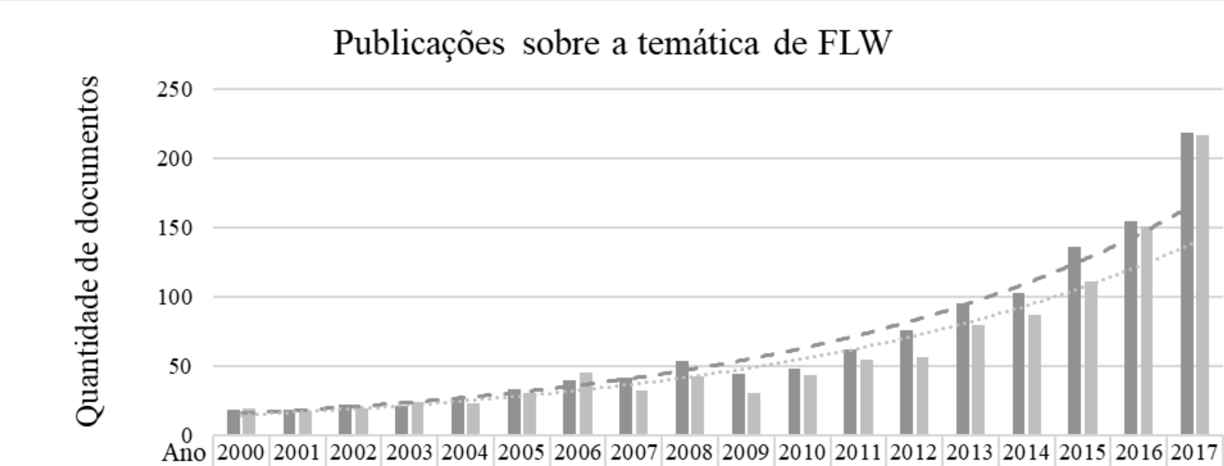
Por outro lado, a *European Union* (EU) concentra suas ações na eficiência dos recursos utilizados na cadeia de abastecimento alimentar (FSC – *Food Supply Chain*), visando uma perspectiva ambiental. O projeto *Fusions*, financiado pela EU, aplica o termo FLW como sendo todo o excedente de alimentos, nas etapas da FSC, que não é utilizado (ÖSTERGREN *et al*., 2014). Ademais, diferentemente da FAO, a EU não diferencia perdas alimentares de desperdício alimentar, não distingue partes comestíveis e não comestíveis de produtos alimentares, nem considera como alimentação a porção de FLW redirecionada para alimentar animais ou utilizada em novos processos de produção na bioeconomia. Essa escolha é explicada por um plano de ação que a EU adotou em 2012, voltado para o uso sustentável dos recursos dentro de uma economia de origem biológica (CHABOUD; DAVIRON, 2017).

Nesse sentido, a EU defende em suas políticas, além da prevenção da FLW (EUROPEAN COMMISSION, 2011), a reutilização de alimentos e novos destinos, o uso de recursos já empregados e a redução das emissões de gases de efeito estufa (NAHMAN et al., 2012; CHABOUD; DAVIRON, 2017). A prevenção de resíduos também deve ser uma prioridade, pois reduz o fluxo de geração de FLW (GENTIL, GALLO; CHRISTENSEN, 2011; UNGER et al., 2016).

Outra questão que promove relevância ao tema e remete à pertinência de sua discussão são os fóruns internacionais, promovido por distintas entidades sociais. Como exemplos de congressos importantes que promovem o diálogo sobre o tema de perdas e desperdício alimentar, têm-se o *Save Food*, que em 2014 foi realizado na Suíça, a conferência *No More Food To Waste*, realizada em 2015 nos Países Baixos e, englobado no campo do agronegócio, a *International Food and Agribusiness Management Association*, que, na conferência de 2016, realizada na Dinamarca, inseriu a temática de *Food Loss & Waste* entre os tópicos de abordagem do evento. Há ainda o grupo *Champions 12.3*, que realiza encontros anuais em Nova York, Estados Unidos, discutindo especificamente a temática. Portanto, representantes de diferentes países, institutos e fundações se reuniram para um evento de avaliação dos progressos globais em direção da meta 12.3 (reduzir pela metade o desperdício de alimentos per capita mundial), registros dos avanços desenvolvidos e o estabelecimento de novos caminhos de sucesso.

A FLW compreende uma temática complexa, com múltiplas dimensões, inclusive abordada pela ciência. Ao realizar uma análise bibliométrica, verifica-se um panorama das publicações científicas sobre o tema. A partir da busca na plataforma *Scopus*, usando o termo "*food loss*" (perda de alimento) e "*food waste*" (desperdício de alimento) identificados no título, resumo e/ou palavras-chave, foram obtidos 1211 registros de documentos entre os anos de 2000 a 2017 (Figura 1). A mesma busca foi realizada na plataforma *Web of Science*, e foram obtidos 1078 registros para o respectivo período, conforme Figura 1.

Figura 1 – Número de publicações por ano em diferentes plataformas.



Ano	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Scopus	18	18	22	21	27	33	40	41	53	44	48	62	76	95	103	136	155	219
Web of Science	19	16	19	24	23	30	45	32	42	30	43	54	56	79	87	111	151	217

Nota: elaborado pelo autor (2019).

Desde o ano 2000 observou-se um crescimento relativo das publicações sobre a temática. A partir de 2010 esse crescimento se torna mais acentuado, dobrando a produção científica, nas plataformas pesquisadas, em quatro anos (Figura 1), o que, portanto, assinala a importância e pertinência da temática abordada. As áreas que apresentam a maior quantidade de registros na *Scopus* são *Environmental Science* (23,2%) e *Agricultural and Biological Sciences* (21%). Ainda cabe salientar que os cinco principais países ou territórios que mais possuem documentos sobre a temática são os Estados Unidos (258), China (127), Reino Unido (103), Itália (92) e Índia (75), respectivamente, cabendo ao Brasil 56 documentos. Na *Web of Science*, as principais áreas foram *Environmental Sciences* (26,22%), *Engineering Environmental* (14,98%) e *Food Science Technology* (13,48%). Os principais países ou territórios que mais possuem documentos sobre a temática são os Estados Unidos (234), China (104), Itália (101), Inglaterra (93) e Alemanha (93), respectivamente, cabendo ao Brasil 40 registros.

Corrobora com essa questão Chaboud e Daviron (2017), que identificaram distintas inconsistências na apresentação e análise da temática mundial de FLW. A complexidade da definição de FLW está relacionada com a origem da definição utilizada e as questões que serão levantadas a partir da análise proposta, ou seja, do problema-alvo da pesquisa. Essas inconsistências revelam ambiguidade na utilização de definições. O descompasso entre metodologias utilizadas e o problema-alvo expõe a quantificação de FLW como um processo desafiador e caro (PARFITT; BARTHEL; MACNAUGHTON, 2010). A variação do método utilizado na quantificação e as respectivas limitações, geralmente, não conseguem diferenciar os reais impactos da redução de FLW para diferentes produtos e recursos empregados durante o processo produtivo (GRIZZETTI et al., 2013; KOESTER, 2014). As incongruências entre problema-alvo e dados obtidos apontam dados insuficientes ou inadequados para tirar conclusões científicas, seja com objetivo de avaliar possíveis impactos na disponibilidade de alimentos quanto à segurança alimentar, seja com o de identificar uma maior eficiência no uso de recursos.

Desde 1960 houve crescimento acentuado na produção de alimentos, o que, apesar da duplicação da população mundial, ainda permitiu a redução do número de pessoas no mundo em estado de fome (GODFRAY et al., 2010). A partir do início dos anos 1970, o consumo per capita de leite, produtos lácteos e óleos vegetais quase dobrou, enquanto o consumo de carne quase triplicou (ALEXANDRATOS; BRUINSMA, 2012). Após uma década de desaceleração do crescimento nos anos 1990, a despesa global em pesquisa e desenvolvimento agrícola aumentou em média 3,1% ao ano durante o período 2000-2009 (FAO, 2017a). Os gastos da China e da Índia foram responsáveis por quase metade do aumento. A Argentina, o Brasil, o Irã, a Nigéria e Rússia também aumentaram significativamente seus investimentos em pesquisa e desenvolvimento agrícola, representando coletivamente um quinto do aumento total de gastos em todo o mundo. Por outro lado, apesar dos esforços, o número de pessoas subnutridas no mundo cresceu desde 2014, chegando a 821 milhões em 2017 (FAO, 2018).

Em meio ao conjunto de desafios existentes, o cenário alimentar permanece inquietante. Embora tenha havido um aumento na produção de alimentos de forma constante e proporcionalmente superior ao crescimento populacional, a agricultura precisará produzir quase 50% a mais de alimentos, rações e biocombustíveis do que em 2012 para atender a demanda projetada para 2050 (FAO, 2017a) – isso ante a projeção do crescimento populacional mundial para mais de 9 bilhões de pessoas (FAO, 2009a; SANTANA; CONTINI; MARTHA JUNIOR, 2011). A demanda global por produtos agrícolas está aumentando e pode continuar assim ao longo de décadas, devido ao aumento de 2,3 bilhões de pessoas na população mundial até 2050 e à previsão de maior renda per capita para o mesmo período (GODFRAY et al., 2010; TILMAN et al., 2011).

O Brasil é considerado um dos maiores produtores de alimentos do mundo (OCDE/FAO, 2015) e o terceiro maior exportador agrícola, com 6% das exportações agrícolas globais (WTO, 2017). A produção agrícola brasileira obteve um crescimento médio anual de 4,3% entre 1970 e 2017, equivalente a um aumento de seis vezes na produção agrícola bruta e a um quarto da produção global de alimentos (FAO, 2017b). O abundante suprimento de alimentos foi alcançado pelo Brasil a partir da Revolução Verde por meio do investimento em pesquisa e desenvolvimento para a produção agrícola (BUAINAIN et al., 2014). As projeções de produção de grãos para o biênio 2029/2030 correspondem a um acréscimo de 33% sobre a safra 2016/17, e a um aumento de 9,4 milhões de toneladas de proteína animal na próxima década (GASQUES; SOUZA; BASTOS, 2018). Nesse sentido, o Brasil deverá aumentar sua contribuição na oferta global de alimentos a fim de atender a dietas mais diversificadas e ao aumento de renda da população, especialmente nos países asiáticos em desenvolvimento (OCDE-FAO, 2015).

Portanto, a temática de FLW tornou-se uma questão paradoxal: a) alimentar, em razão de o alimento, ainda em condições de consumo, ser desperdiçado (OELOFSE; NAHMAN, 2013); b) econômica, já que os custos com desperdício alimentar tendem a ser subvalorizados, particularmente em países onde os alimentos representam uma pequena proporção nos orçamentos dos consumidores (GUNDERS, 2012); c) ambiental, por demandar consumo de recursos ambientais utilizados para a produção de alimentos, como água e combustíveis fósseis, contribuindo para as alterações climáticas globais

(HALL et al., 2009; FAO, 2011); d) política, por implicar em custos no descarte adequado de alimentos potencialmente comestíveis, representando valores comumente ignorados pelos decisores políticos (NAHMAN; LANGE, 2013); e, e) social, devido à fome e ao desperdício representarem um contrassenso moral e ético na sociedade.

A redução do FLW representa uma das formas de aumentar a disponibilidade de alimentos a fim de atender às necessidades futuras (DUBBELING et al., 2016). Minimizá-lo está diretamente relacionado com a possibilidade de proporcionar benefícios econômicos, melhorar a eficiência do uso dos recursos naturais, reduzir os impactos ambientais e diminuir a insegurança alimentar e nutricional (FLW, 2016).

Problematização e justificativa da pesquisa

O desperdício de alimentos no mundo é caracterizado por números expressivos. Anualmente, 1,3 bilhão de toneladas de alimentos tornam-se FLW ao longo da FSC, o que significa que esses alimentos não consumidos utilizam um volume de água equivalente ao fluxo anual do rio Volga, na Rússia (FAO, 2013). Ou seja, o FLW consome um quarto de toda a água utilizada pela agricultura anualmente (HANSON; MITCHELL, 2017). Isso causa perdas econômicas, um custo mundial de US$ 940 bilhões ao ano, e representa uma área cultivada do tamanho da China (HANSON; MITCHELL, 2017). Ainda, respondem pela emissão de 3,3 bilhões de toneladas de gases de efeito estufa na atmosfera do planeta (FAO, 2013), equivalente a 8% das estimativas de emissões globais totais desses gases (HANSON; MITCHELL, 2017).

O FLW ocorre em todas as etapas da FSC, ou seja, desde a pré-produção até o pós-consumo, estimado em cerca de 25-40% da produção total de alimentos (GODFRAY et al., 2010; KUMMU et al., 2012). Outro estudo mostra que cerca de um terço dos alimentos produzidos para consumo humano são perdidos ou desperdiçados globalmente (GUSTAVSSON et al., 2011). Finalmente, o pior cenário indica que metade de todos os alimentos produzidos é perdida ou desperdiçada antes e depois de chegar ao consumidor (LUNDQVIST; FRAITURE; MODELN, 2008).

A rápida urbanização, o crescimento populacional e o FLW tornaram-se tendência e questão de preocupação não só para países desenvolvidos, mas também para os países em desenvolvimento. Problemas alimentares voltaram a receber atenção mundialmente após a recente volatilidade de preços dos produtos agrícolas no mercado mundial

(GERMAN; HERNANDEZ; MORENO, 2009; PIESSE; THIRTLE, 2009), conjuntamente com o crescimento de renda nos países chamados emergentes e mudanças na dieta alimentar e seus efeitos para a saúde da população (GERMAN; HERNANDEZ; MORENO, 2009). Portanto, o aumento da renda dos consumidores em diversos lugares do mundo também ocorreu nos países em desenvolvimento (GODFRAY et al., 2010). No Brasil, por exemplo, conduziu a um maior poder de compra da população de baixa renda e à sua inserção no mercado de consumo (IPEA, 2012). Com essa realidade desafiadora, mudanças na forma de produção, armazenamento, processamento, distribuição e acesso dos alimentos tornam-se necessárias (GODFRAY et al., 2010).

A mitigação do FLW é um fator potencialmente importante nos esforços para combater a fome, melhorar a segurança alimentar nos países pobres e atender às necessidades futuras (GUSTAVSSON et al., 2011; DUBBELING et al., 2016). Além disso, a eficiência do sistema alimentar também está intimamente relacionada com a questão da segurança alimentar (BENDER, 1994). Ademais, o FLW é responsável por subtrair dos esforços produtivos uma parcela considerável da produção alimentar, o que agrava a disponibilidade mundial de alimentos (BELIK; CUNHA; COSTA, 2012). A redução do FLW é um fator potencialmente importante nos esforços para combater a fome, a desnutrição e, consequentemente, a insegurança alimentar dos países pobres e em desenvolvimento (BROWN UNIVERSITY FACULTY, 1990; LUNDQVIST, FRAITURE; MODELN, 2008; GUSTAVSSON et al. 2011; CHABOUD; DAVIRON, 2017).

Aliada a essas questões, a expectativa global de crescimento populacional para 9,3 bilhões de pessoas, em 2050, traz em voga a necessidade de alimentar essa população (UN, 2011). Esse desafio torna-se uma responsabilidade global à medida que é um problema global. A resolução de grandes problemas necessita da máxima concentração de distintos esforços por meio de diferentes tipos de habilidades e conhecimentos, ou seja, de empenho interdisciplinar (LEDFORD, 2015).

Entretanto, antes da implementação de novas iniciativas de prevenção, otimização de recursos ou vias distributivas, se faz necessário conhecer como e onde ocorre o FLW, e o que ele representa em quantidade e valores monetários. Essas informações se tornam fundamentais para o desenvolvimento de estratégias de redução do FLW a fim de monitorar o progresso ao longo do tempo, aumentar a eficiência dos elos na FSC e auxiliar na prosperidade do planeta.

A FAO publicou em 2013 o primeiro estudo relacionado à FLW, destacando algumas regiões críticas, relacionando-as com produtos, consequências para o clima, uso da água e do solo e biodiversidade. Na Ásia o FLW de cereais tornou-se um grave problema devido ao impacto sobre as emissões de carbono e o uso da água e do solo, principalmente na cultura do arroz, particularmente relacionada com elevadas emissões de metano (FAO, 2013). Em relação à carne, apesar do volume de FLW ser considerado baixo globalmente, tem-se que essa indústria gera um impacto considerável sobre o meio ambiente em termos de uso da terra e da pegada de carbono, especialmente nos países de elevado rendimento e na América Latina, que juntos respondem por 80% do total de FLW (FAO, 2013). No referente às frutas, o nível de FLW contribui na utilização desnecessária de água na Ásia, Europa e América Latina, e em relação aos produtos hortícolas, o FLW se encontra nos países industrializados do Sul e Sudeste da Ásia e na Europa, resultando em uma pegada de carbono para o setor (FAO, 2013). Nos países em desenvolvimento, o desperdício de alimentos surge principalmente devido a limitações financeiras, gerenciais e técnicas (compreendem desde a colheita, armazenamento, instalações, infraestrutura, processamento, embalagens e sistemas de marketing), podendo perder mais de 40% dos alimentos pós-colheita (PARFITT; BARTHEL; MACNAUGHTON, 2010).

Independente da etapa na cadeia produtiva, segundo a FAO (2011), 54% do FLW no mundo ocorre na fase inicial da produção, que compreende a manipulação pós-colheita e armazenagem, e 46% ocorre nas etapas de processamento, distribuição e consumo. Quando se separa o globo por regiões, os países em desenvolvimento sofrem mais com as perdas durante a produção agrícola, enquanto nas regiões de renda média e elevada, o desperdício na distribuição e consumo tende a ser maior (FAO, 2011). A melhor gestão e distribuição dos recursos alimentares em nível mundial, regional, nacional e local poderia proporcionar benefícios para a sociedade menos privilegiada (FAO, 2011; FAO, 2014).

Nesse sentido, pode-se citar que uma substancial proporção de alimentos desperdiçados ainda é considerada comestível, ou seja, um alimento melhor gerido e distribuído pode ser aproveitado por todos, principalmente por pessoas necessitadas (NAHMAN et al, 2012; OELOFSE; NAHMAN, 2013). Essa realidade retrata a necessidade de repensar as relações entre a alimentação e o ambiente como forma da sociedade obter saúde e qualidade de vida. Portanto, tem-se a necessidade de apontar caminhos para uma melhor gestão política alimentar em níveis nacionais e internacionais.

A literatura internacional sobre o problema e os impactos ambientais e econômicos relacionados ao FLW tornou-se abundante, mas dados confiáveis ao longo das FSC continuam escassos (FINE et al., 2015). Chaboud e Daviron (2017) analisaram as inconsistências sobre a temática de FLW e destacaram que uma delas está relacionada com as metodologias utilizadas em relação ao problema-alvo de pesquisa. De modo específico, muitos artigos enfocam a quantificação de FLW, apesar do fato de que este é um processo desafiador e caro (PARFITT; BARTHEL; MACNAUGHTON, 2010). Os autores ressaltam que países que estão crescendo e evoluindo rapidamente, como Brasil, Rússia, Índia e China, não têm dados sobre FLW. De modo específico, o Brasil não possui estudos que quantifiquem FLW em cadeias produtivas, menos ainda estudos em toda a FSC brasileira. Porpino (2015), Henz (2017) e Henz e Porpino (2017) relatam que existem estudos pontuais, realizados em diferentes etapas da FSC e em diferentes cadeias produtivas, geralmente focados em determinados produtos.

Ademais, bases de dados para estimar a quantidade e a qualidade de FLW são bastante escassas para a maioria dos produtos agrícolas (KRANERT et al., 2012). Por exemplo, o projeto *Fusions* da EU revelou discrepância na disponibilidade de dados para as diferentes etapas da FSC entre os Estados membros Europeus (ÖSTERGREN *et al*., 2014). De acordo com os autores do projeto, a falta de dados foi particularmente aguda para o setor de transformação, bem como para o setor de produção primária, e há poucas medidas de FLW na agricultura, horticultura, aquicultura, pesca ou outras atividades de produção primária e grandes diferenças na definição de FLW nestes setores (STENMARCK et al., 2016). Alguns países iniciaram medidas de escalas de FLW, descritas nos estudos de Gooch, Felfel e Marenick (2010); Nahman et al. (2012); Liu, Liu e Cheng (2013); Beretta, Stoessel e Baier (2013); Pearson, Minehan e Wakefield-Rann (2013); Garrone et al. (2012). No caso brasileiro, se faz necessário o desenvolvimento de pesquisas básicas para quantificar FLW.

Tentativas globais de quantificar FLW são motivadas pela necessidade de avaliar a sua escala de geração, estabelecer uma linha de conduta baseada em metas de redução, medir a eficiência das iniciativas desenvolvidas e seus reais impactos na sociedade atual. A falta de um protocolo padronizado de mensuração (WRI, 2014) associado à escassez de dados leva a estimativas de FLW que variam amplamente na literatura internacional (PARFITT; BARTHEL; MACNAUGHTON, 2010; XUE et al., 2017), causando incertezas nas quantidades estimadas. Até mesmo a avaliação da própria eficiência da

FSC brasileira, verificada por meio de estudos futuros de estimativas de FLW, desde a produção até o consumo, em diferentes cadeias produtivas, torna-se cada vez mais necessária. Ademais, a necessidade do desenvolvimento de um aparato estatístico sobre o tema que possa medir, com certa periodicidade, o volume de FLW anualmente (BELIK, 2018) refletiria na maior eficácia de ações pontuais que precisam ser desenvolvidas na FSC brasileira.

Nesse sentido, existem distintas razões para a importância da temática de FLW. A primeira diz respeito à expectativa de crescimento populacional mundial para 9,3 bilhões de pessoas em 2050 e a respectiva necessidade alimentar (UN, 2011). A segunda razão se dá por cerca de 821 milhões de pessoas encontrarem-se sem as devidas condições de se alimentarem ao menos três vezes ao dia, em 2017 (FAO, 2018). A terceira razão corresponde ao FLW representar quantias monetárias significativas, além de recursos investidos ao longo do ciclo de vida dos alimentos, desde a produção, armazenagem, transporte, e por não cumprir com a sua finalidade fundamental de alimentar as pessoas (BUZBY et al., 2011). Por fim, a quarta razão refere-se às externalidades negativas que podem surgir ao longo do ciclo de vida dos alimentos, produzindo impactos adversos na sociedade e áreas necessárias para urbanização, no meio ambiente, na utilização de recursos como água, solo, florestas, biodiversidade e vida selvagem (LUNDQVIST; FRAITURE; MOLDEN, 2008; BUZBY; HYMAN, 2012).

Nesse âmbito, se faz necessário o desenvolvimento de estudos que otimizem os elos ao longo da FSC, que impeçam e/ou minimizem a ocorrência de FLW e, até mesmo, promovam a reutilização ou a reciclagem de alimentos ou resíduos com características organoléptico/nutricionais adequadas para o consumo. Atualmente não se dispõem de compreensão suficiente sobre o quanto, o porquê e onde os alimentos ou suas partes comestíveis são removidos da FSC (FLW, 2016). Para tal, torna-se imprescindível a utilização de métodos de quantificação para determinadas regiões ou respectivas etapas da FSC a fim de identificar informações consistentes para a geração de relatórios e definir ações de planejamento.

Assim as contribuições almejadas por esta tese baseiam-se em diferentes estudos que aportam *gaps* na literatura científica brasileira. Os estudos fornecerão valores de FLW baseados em diferentes métodos de quantificação para auxiliar na produção científica nacional e inserir o país como referência em pesquisas sobre a temática. Portanto, torna-se importante entender a magnitude de FLW localmente, regionalmente e globalmente.

Nesse sentido, há a necessidade de lançar luz sobre essa conjuntura no Brasil, e os resultados podem refletir em uma nova agenda para o sistema produtivo de alimentos. As estimativas de FLW podem auxiliar os decisores políticos e a própria FSC na definição de metas, no desenvolvimento de iniciativas, legislações ou políticas públicas para minimizar a FLW, conservar recursos e melhorar a saúde humana. Sendo um dos principais produtores mundiais de alimentos, o Brasil pode ser alçado, por informações sobre esta temática, a líder em políticas para a redução de FLW. Posteriormente, novas pesquisas podem ter como objetivo restringir e melhorar metodologias utilizáveis nas estimativas, adicionando outros dados e fontes que possam produzir um modelo nacional mais realista.

A redução de FLW representa distintos benefícios (HANSON; MITCHELL, 2017): (i) traz economia de dinheiro para os agricultores, para as empresas e famílias; (ii) o menor desperdício se torna uma oportunidade para alimentar mais pessoas; e, (iii) reduz as pressões existentes sobre a água, a terra, e o clima. Esses benefícios podem trazer segurança alimentar, econômica, ambiental e nutricional, auxiliando nas metas que contemplam os objetivos do milênio.

A alimentação e a nutrição constituem elementos fundamentais na garantia da sobrevivência e saúde dos indivíduos e contribuem para uma existência digna no contexto do desenvolvimento integral da pessoa humana. Portanto, tendo a fome como problemática, não devido a um déficit da produção de alimentos, mas sim da inacessibilidade de milhões de pessoas a alimentação adequada, dentre as quais uma das causas é a distribuição precária, torna-se importante desenvolver novos meios distributivos. Nesse contexto, observa-se um paradoxo entre a fome e o desperdício, que implica inclusive em uma questão moral e ética. Dentre as principais razões do desperdício podem-se encontrar os excessos de normas e regras relacionados a preocupações sanitárias ou estéticas nos países desenvolvidos, e reduzidas capacidades de armazenamento e de acesso ao mercado nos países em desenvolvimento (ONU..., 2013). Todavia, qualquer perda ou desperdício se torna injustificável, ainda mais quando parte da população mundial passa fome.

Diante do exposto por meio da temática norteadora, questiona-se: Quais os volumes físicos e o valor monetário das perdas e desperdícios de alimentos no Brasil?

Objetivos

Objetivo geral

Destaca-se como objetivo geral estimar o volume físico e o valor monetário correspondente à geração de perdas e desperdício de alimentos no Brasil.

Objetivos específicos

- Identificar métodos quantitativos utilizados para mensurar perdas e desperdícios de alimentos;
- Estimar os volumes físicos das perdas e desperdícios de alimentos nas diferentes etapas da cadeia alimentar de abastecimento brasileira;
- Estimar o volume físico e o valor monetário do desperdício de alimentos nos domicílios brasileiros.

Estrutura da tese

A tese está composta por pesquisas complementares entre si, em consonância com a temática de FLW. Assim sendo, cada pesquisa apresenta metodologias, método e dados específicos, de acordo com os objetivos propostos para os respectivos manuscritos desenvolvidos. O presente trabalho se estrutura por capítulos, que estão brevemente resumidos a seguir.

O capítulo 1 faz a introdução da temática de FLW, bem como apresenta a problematização e a justificativa para esta tese. A FLW é tida como uma problemática multidimensional por envolver questões sociais, econômicas e ambientais. Portanto, emprega-se uma abordagem multidisciplinar contemporânea que endossa essas questões. Ademais, a tese é construída sob a ótica da mensuração quantitativa de FLW, abordando a importância de definir adequadamente o objetivo almejado.

O capítulo 2 discute o estado da arte de FLW a partir de um protocolo de revisão sistemática. Realizou-se a revisão de documentos da literatura científica mundial, publicados em periódicos, que possuíam como objetivo quantificar FLW. Os documentos que cumpriam com este requisito foram minuciosamente avaliados e representam as diferentes estruturadas e abordagens estratégicas para a mensuração de FLW.

Uma grande variedade de metodologias aplicadas para estimar e/ou quantificar FLW foram identificadas. A mensuração disponível na literatura internacional pode ocorrer de forma direta, indireta ou mista. Realizou-se a extração, compilação e análise dessas estimativas quantitativas identificadas nos diferentes documentos. Analisou-se as mensurações de FLW para todas as etapas da cadeia de abastecimento alimentar, desde a produção agrícola até o consumo. As estimativas identificadas nos estudos foram classificadas em valores percentuais, em quilogramas ou quilocalorias. Ademais, o capítulo está constituído em formato de artigo científico.

O capítulo 3 consiste em um exercício de estimativa de FLW ao longo da FSC brasileira. A falta de dados e informações sobre a temática levou a utilização de uma metodologia baseada em Oelofse e Nahman (2013), fundamentada em Gustavsson et al. (2011). Os dados de produção, variação de estoques, quantidade exportada e importada, durante os anos de 2007 até 2013, foram extraídos da FAOSTAT. Considerou-se a análise de diferentes grupos de *commodities*, tais como: cereais, raízes e tubérculos, leguminosas, frutas e vegetais, carne, peixes e frutos do mar, e leite. Como referência de FLW para cada grupo de *commodity* e para cada etapa da FSC, utilizou-se os dados de Gustavsson et al. (2011) para a América Latina.

Estimou-se FLW para o ano de 2007 e para o período total de dados disponíveis. Os valores foram transformados em quantidades per capita por ano (kg/pessoa/ano), para cada grupo de *commodity* e em cada etapa da cadeia. Por fim, um diagrama de Sankey apresenta o fluxo total da quantidade de oferta interna de alimentos no Brasil. Esse exercício de estimativa constitui-se em formato de artigo.

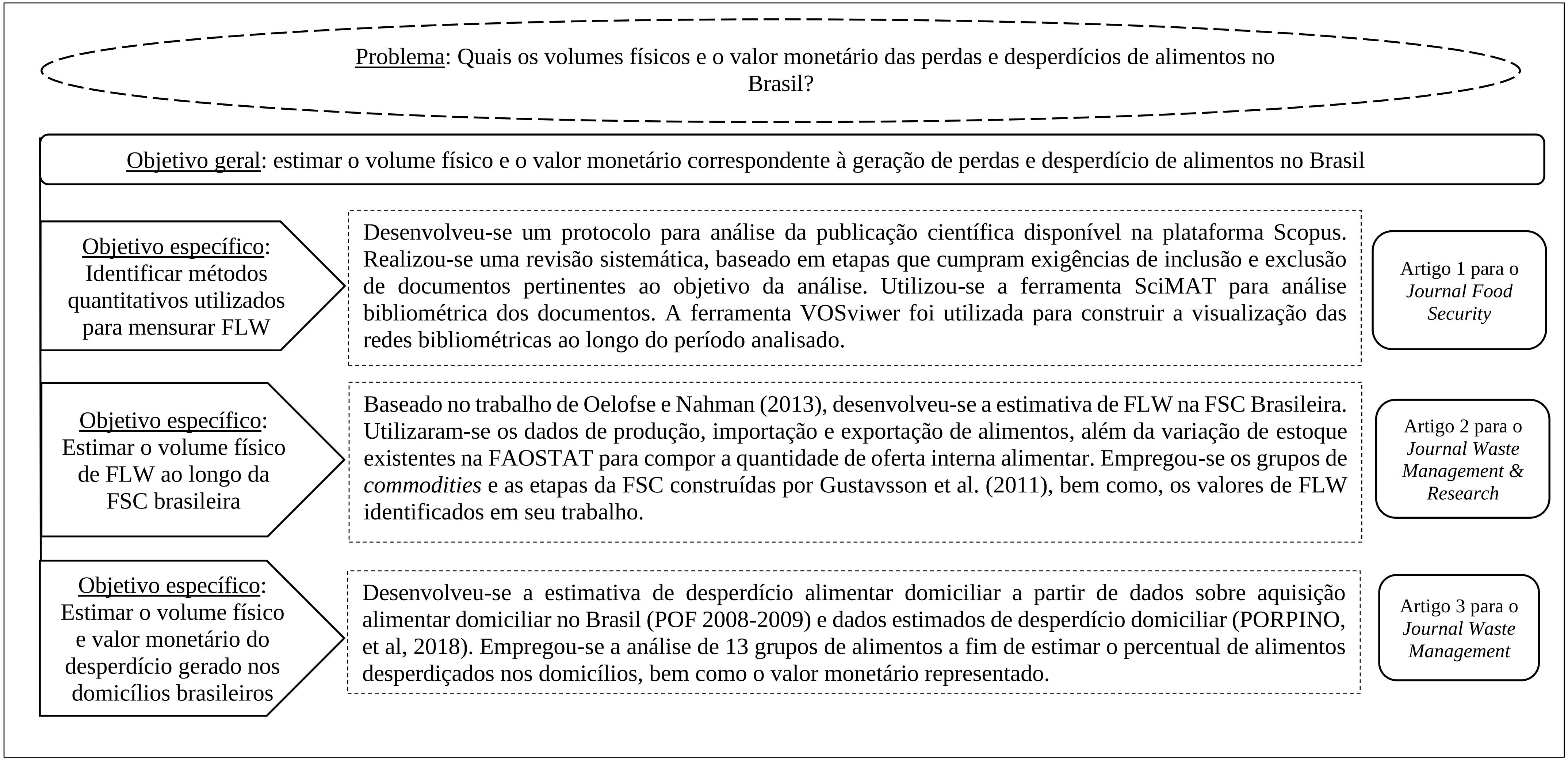
O capítulo 4 aborda a estimativa de FLW nos domicílios brasileiros. Inicia-se por meio de uma abordagem da origem do desperdício de alimentos na etapa de consumo. Uma descrição sobre fatores econômicos, sociais e comportamentais relacionados à temática e identificados pela literatura internacional foi desenvolvida a fim de estruturar a contextualização.

Utilizou-se dados de aquisição de alimentos da Pesquisa de Orçamento Familiar (POF) de 2008-2009 para cada região brasileira. As quantidades de desperdício identificadas por Porpino et al. (2018), para determinados grupos de alimentos, foram utilizadas para cada região. Extraíram-se da POF os mesmos grupos de alimentos utilizados por Porpino et al. (2018) a fim de estimar o percentual e o valor monetário representado pela geração de FLW para cada grupo. Do mesmo modo que os capítulos anteriores, o capítulo 4 constitui-se em formato de artigo.

O capítulo 5 apresenta as considerações finais da tese. Expressa as conclusões obtidas por meio das leituras, análises dos dados e escritas desenvolvidas e discutidas ao longo dos textos aqui apresentados. Aborda-se uma recapitulação de cada capítulo desenvolvido, com considerações pertinentes ao capítulo e à tese.

A contribuição para a conscientização sobre a temática de FLW torna-se um passo importante. Porém conhecer sua magnitude e o que representa é a chave que impulsiona o primeiro passo. Abaixo apresenta-se um resumo da problemática abordada nesta tese, abrangendo o problema, objetivos, síntese metodológica e produto resultante (Figura 2).

Figura 2 – Síntese estrutural da problemática desenvolvida na tese.



CAPITULO 2

Food loss and waste generation in the World: mapping the science[1]

Abstract:
Food loss and waste (FLW) has been widely discussed in society, academia, and civil and government organizations. Among the concerns is the search for different structured and strategic approaches to estimation, prevention, and mitigation of FLW. In this sense, the article aims to discuss the state of the art of FLW from a systematic review of quantitative estimates identified by different studies. From the recognition of some key terms, we identified 2085 files on the Scopus platform. After performing different screening processes, 37 files that had the objective of quantifying FLW were selected. Extraction, compilation, and analysis of the FLW estimates of these files were performed. The estimate in kilos was performed by 19 studies, in percentage by 17 and in kilocalories by one. The FLW in agricultural production ranged from 15 to 33%, depending on the culture and purpose of the idealized study. In the processing, different groups of fruits and vegetables were studied in different cities of the globe, estimating FLW between 4.19 and 4.7%. At the consumption step, the studies diverge between products and data collection sites. There are more studies in developed countries, with the United States and South Africa being the most analyzed countries. The methodologies used to estimate FLW are heterogeneous (direct, indirect and mixed) and vary according to the purpose of the study. Additional research is needed, to improve the accuracy and accuracy of FLW estimates especially in developing countries.
Keywords: consumption, food, food supply chain, quantification, systematic review.

1 Introduction

A food supply chain (FSC) is only efficient when the food produced from it is used effectively. World food production has increased substantially over the last century, as did per capita caloric intake (Nellemann et al., 2009). However, the food supply needs to increase by 60% (based on 2005 food production levels) to meet food demand by 2050 (Alexandratos and Bruinsma, 2012). On the other hand, food produced and not consumed generate environmental, social and economic impacts (Testa et al., 2014). This phenomenon is known as Food Loss and Waste (FLW) and is at the center of academic debates, civil society initiatives, and policy agendas.

The FLW has become a global problem due to the environmental, social and economic impact. However, despite growing attention, concern and awareness have intensified (Smil, 2004), an international review of the literature has found a shortage of data on FLW (Langley et al., 2009; Parfitt, Barthel and MacNaughton, 2010; Kranert et al., 2012). Global estimates suggest different FLW situations. Godfray et al. (2010) and Kummu et al. (2012) estimated a loss of 25-40% of total food production. Another study shows that about one-third of food produced for human consumption is lost or wasted globally (Gustavsson et al., 2011). The worst case scenario indicates that half of all food produced is lost or wasted before and after reaching the consumer (Lundqvist, Fraiture and Modeln, 2008).

The FLW causes rise to several interrelated problems. The first problem concerns the disposal of waste. The FLW is responsible for a problematic waste stream destined

[1] This manuscript was submitted for evaluation in the Journal Food Security. The text was written in British English and follows the author guidelines of the journal. Appendix A complements the manuscript.

for landfills, where it contributes to greenhouse gas emissions (Hartman and Ahring, 2006), and its prevention reduces the flow of waste generation (Gentil, Gallo and Christensen 2011; Unger et al., 2016). The second problem concerns the emissions of greenhouse gases throughout the FSC. On average, greenhouse gas emissions across the food supply chain range between 2.8 and 4.14 tonnes of carbon dioxide equivalent (tCO2e) per tonne of food (Bakas, 2010). Besides, between 20% and 30% of the environmental impact of the products is caused by food consumption (Tukker et al., 2006). The third problem relates to the FLW representing a significant loss of resources invested in the production, transport, processing, and storage of food. Since resources (land, energy, water, and agricultural inputs) are limited, they must be applied efficiently and sustainably (Engström and Carlsson-Kanyama, 2004; Lundqvist, Fraiture and Molden, 2008; Buzby et al., 2014). Also, it can contribute to food insecurity as economically avoidable FLW is important in efforts to combat hunger (Forbes, 2012) and to improve food security not only in developing but also in developed countries.

The quantification of FLW is being used to draw attention to the misuse of food resources. Estimating FLW is a challenging process where your approach can be approached in different ways. More objectively, FLW is facilitated from production to consumption (Beretta et al., 2013; Nahman and Lange, 2013; Katajajuuri et al., 2014) or in one or more phases of FSC (Monier et al. (1998), where FLW is more likely to occur (Hodges, Buzby, et al., 2010; Nahrman et al., 2012; Kaminski, Christiaensen and Bennett, 2011).

The FLW can be quantified in different units depending on the available data or the proposed objective. For example, it can be measured in terms of quantity and/or quality. The quantity FLW occurs when the actual amount of food, often measured in kilograms or calories, reduces over time and space (FAO, 2014; Sheahan and Barrett, 2017). Quality FLW occurs by losing important nutrients or food contamination (FAO, 2014; Sheahan and Barrett, 2017).

The FLW measurement is described in the literature by different methodologies ranging from pre-harvest to post-consumption. As a form of measurement in the pre-harvest, quantifications of FLW originating from the productive process occur before the harvest of a given crop. However, the non-yield of pre-harvest steps are not considered FLW (FAO, 2014; Östergren *et al*., 2014).

Post-harvest measurement is widely used to estimate FLW at FSC or to measure FLW at different steps of FSC. The analysis can be performed using secondary data (Abdulla et al., 2013, Buzby et al., 2014) as mass flow data on the food balance (Gustavsson et al., 2011; Brautigam et al., 2014). Case studies are also used as a methodology to estimate FLW in certain production chains or steps of a given chain (Griffin, Sobal and Lyson, 2009; Garrone et al., 2014).

Different methodologies can perform the post-consumption FLW measurement. The analysis can be performed from a small number of FLW-weighted families, or even the use of a kitchen diary to record the FLW generation and composition, involving thousands of families (WRAP 2009; Langley et al., 2010). Contemporary archaeological excavations carried out in landfills, identifying the proportions of organic and inorganic material, is another methodology that can determine the historical levels of FLW (Rathje, 1991; Jones, 2006). Using an FLW coefficient, based on existing research, can be a methodology to indirectly estimate home FLW (Sibrián et al., 2006). Using statistical models relating to population metabolism and body weight can also be used to estimate FLW (Hall et al., 2009). Finally, a more extreme methodology used to estimate FLW can be made by the positive difference between the number of calories ingested and the recommended caloric intake, the perception of excess consumption as a form of FLW (Smil, 2004).

Therefore, the methodologies vary between modelling, simulations, and quantifications for the direct and indirect measurement of FLW. Indirect measurement is often used to develop global, continental, or country-wide estimates, while direct measurements are used for smaller geographic units, such as consumption units (households, households, people), city, or a particular region. Generally, studies quantitatively estimating FLW are based on a percentage, caloric, or mass value of food (Loke and Leung, 2015). All have their place when used properly, but can be misused and misinterpreted, resulting in difficult comparisons and replications of studies. It should be noted that the inadequate definition of FLW inflates estimates and impairs the development of actions that can improve the efficiency of resource use and policies that can contribute to FLW mitigation (Koester, 2014; Chaboud and Daviron, 2017).

Chaboud and Daviron (2017) report the inconsistencies in the way the FLW problem has been presented and analyzed. One of the reported inconsistencies in the use of methodologies focused on the target problem. As seen, quantification can be done by multiple methodologies. However, it seems limited by time and resources. In addition, the authors report that research does not show how FLW reductions can effectively influence food safety and the environment. The lack of data and knowledge on quantities of FLW becomes an obstacle to any progress to reduce this problem (Nahman et al., 2012; Affognon et al., 2015). Therefore, quantification approaches using specifically related methods, such as modelling, life cycle assessment, and even econometric models, can provide a more effective measure of this impact (Chaboud and Daviron, 2017).

One of the first FLW reduction initiatives was promoted by the FAO in 1976 through the Special Action Program for Food Prevention to halve post-harvest FLW. The first initiative for the methodological structuring of FLW was developed in 2013 by the World Resources Institute (WRI). Through a multiparty process, a standardized FLW measurement protocol was developed that forms a global standard of FLW accounting and reporting, and unrelated parties (WRI, 2014).

In this sense, through a systematic review of the literature, we aim to compile the different methodologies used to quantify and/or estimate FLW. The article: i) provides the first analysis of studies of global FLW estimates; ii) identify the regions that have the most studies and information on FLW; iii) lists the methodologies used; and iv) quantifies FLW (kilograms, percentage, and kilocalories) in each step of the FSC.

This review also assists in guiding society, governments and the scientific community on efforts to identify and estimate FLW. Section 2 describes the method, scope, and procedures used in this study. Section 3 presents the results of the FLW estimates. Section 4 discusses these findings and the limits of the research. The conclusions are presented in section 5.

2 Materials and Methods

A systematic review of the literature was performed by the adaptation of the PRISMA protocol (Liberati et al., 2009). As it is a protocol used in the social sciences and medical sciences, it was applied for this review to give additional rigor to the literature review process. Developing research terms, the identification of the database used and determining the criteria for inclusion and exclusion of documents were carried out jointly before starting the review.

2.1 Research strategy

A pre-review was conducted on the subject, to identify the key terms in the FLW theme. Using the terms food waste and food loss on the Scopus platform, 127 files were identified for the review document type, from 1974 to 2017. By reading the abstracts of these reviews, 20 files corresponded to the desired theme. The choice of the Scopus platform is justified by the bibliographic database being multidisciplinary, bringing together a large set of scientific journals from different publishers and having the largest number of indexed journals.

Using SciMAT Software, we identified 87 keywords used in the 20 selected review files. The words that were repeated at least twice were: *food loss, food waste, food security, fruit, waste minimization, vegetables, storage, animal feed, food wastes and losses, food supply chain, shelf life, review*. For the identification of methodological studies pertinent to this research, the key terms used were: “food loss*” and “food wast*” to guarantee the breadth of files that examined the amount of FLW generated throughout the FSC. In this work, both terms are used synonymously and refer to all food losses along the FSC.

The inclusion and exclusion criteria for the study comprise: (a) detailing the research between 1939 and 2017; (b) deletion of review files; (c) archives in English and Portuguese; (d) research conducted in any country of the globe; and (e) studies that aim to quantify FLW.

Two thousand eighty-five files were identified, remaining 1,807 after excluding document review and conference review. The first screening was performed through the tracking of titles consistent with the review theme. The reading of the abstracts to identify the documents consistent with the purpose of this review includes the second screening. Files that remained after screening by summary were subject to full reading, as available on the platform. After the text screening, we identified the files that had the objective of quantifying FLW.

Figure 1 shows the flowchart of the systematic review. As described, after using the inclusion/exclusion criteria, 37 files were identified consistent with the purpose of this review. The authors have reserved the right regarding the final decision on the relevance of the file for insertion in the review, based on the quantities of FLW that could be extracted and used in a database.

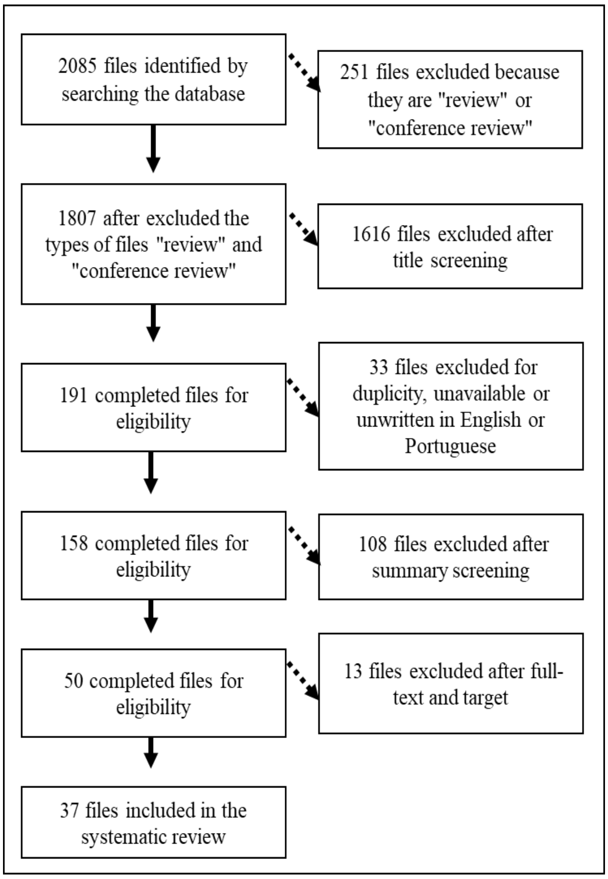


Figure 1. Flow diagram of the systematic review.

The data of the selected files were extracted and catalogued in Excel (Microsoft). The cataloguing was divided into two parts. The first one corresponds to the identification of the type of document, authors, year of study, keywords used, identification of the objective and journal in which the document was published. The second part reports on the geographic detail of the research, the methodology of the study (direct or indirect measurement), details of the methodology, type of data used, sector, chain or product studied, identification of FLW in each FSC step and pertinent observations. According to the proposal developed in each study that quantified the FLW, the data were grouped by the respective steps that make up the FSC and correspond to percentages, kilograms or calories (Table S1).

In addition, the VOSviewer Software was used for better visualization of the key terms, in the pre-processing and after the selection of the files that make up this revision. The clusters were formed from the analysis of the bibliographic data for co-occurrence of the key terms. The analysis was performed after the extraction of the 20 revision files (pre-processing) and the 37 files (which make up the systematic review), in CVS format, of Scopus.

3 Results

Figure 2 shows the pre-processing of the key terms and key terms found in this review. Figure 2 (a) presents the main key terms in the FLW theme and the direct link between the words identified in the 20 revision files, forming the cluster network. A cluster is a set of items included in a map. In the map view, items with a larger weight are shown more prominently (Van Eck and Waltman, 2010). The authors also point out that the weight of the item determines the size of the label and the circle of an item. Therefore, the larger the weight of an item, the larger the label and the circle of the item. The color of an item is determined by the cluster to which the item belongs. The main clusters of key terms identified were "food loss" and "food waste."

Figure 2 (b) presents the chronological occurrence of the key terms, an evolutionary map of the terms used in the subject studied. Colors range from blue (lower score) to green and yellow (higher score). Temporal slicing is represented between 2010 and 2018. The key clusters of key terms identified in 2010 have gone from "waste minimization" to "food loss" and "food waste" between 2014 and 2016.

In relation to the key terms found in this review, these are in Figure 2 (c, d), Figure 2 (c) presents the main key terms identified in the 36 files used as results of the systematic review. The main clusters of key terms identified were "food waste," "food loss" and "food security." Figure 2 (d) shows the chronological occurrence of the key terms identified in the documents that make up the review. Time slicing is represented between 2012 and 2018. Key clusters of key terms identified in 2012 have shifted from food losses to food security in 2014 to food loss and food waste in 2016.

Each sphere that makes up Figure 2 represents a node, and its associated files lie within. Thus, clusters were detected and categorized, where an evolutionary map of the terms can be developed (Cobo et al., 2012). The lines between the spheres represent links, where the stronger the link of the item, the larger the sphere.

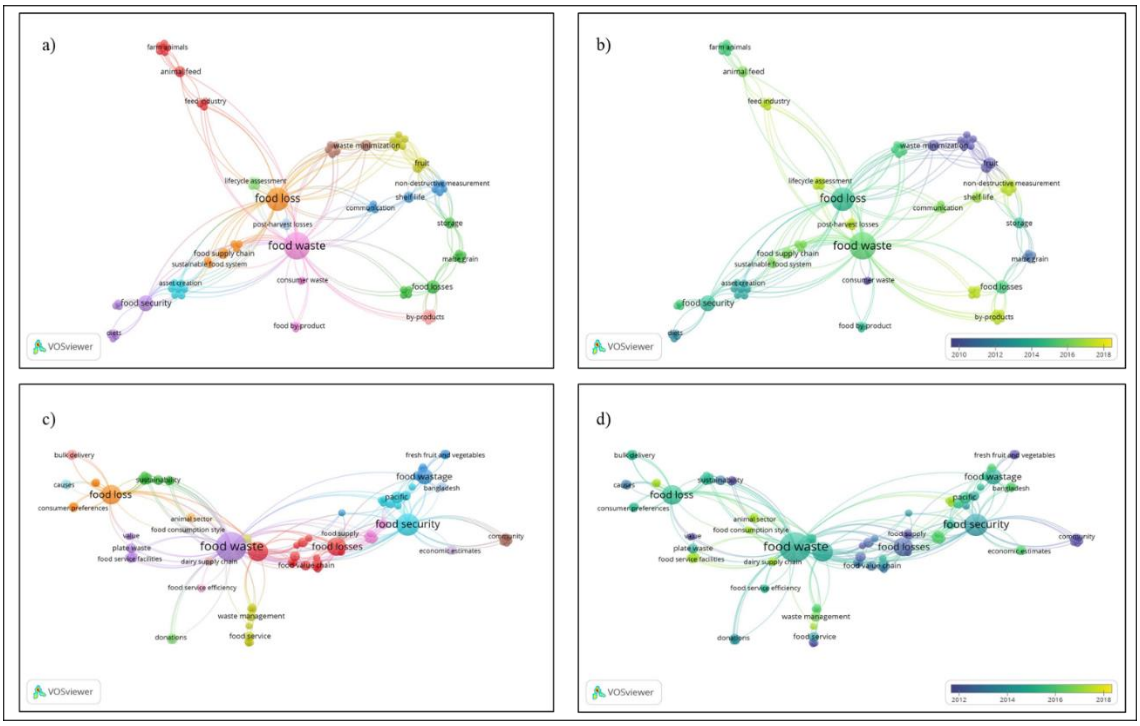


Figure 2. Visualization of key terms of the search.

From the key terms identified in the 37 files, which comprise the systematic review, were organized in the SciMAT Software to detect duplicate words, incorrect words or that have the same meaning, coupling to the same terminology. The main terms "food losses" and "food loss" were coupled and identified in 20 files. The term "food security" was identified in 12 files and "food waste in 26. Other key terms that stood out were:" food supply chain" (coupling "food supply", "supply chain", “waste management" and "fruits and vegetables" (coupling "fruit", "vegetable", and "fruits and vegetables”) with respectively 16, 14, and nine files each.

3.1 General outcomes and characteristics of the study

Table S1 summarizes each of the selected studies. Its composition organizes the study information associated with the FLW estimate at each step of the FSC. Of the 37 files selected for review, one file is classified as "article in press," one as a "conference paper", one as "book chapter" and 34 as "article."

In Figure 3 the studies by country and regions of the globe were classified. The countries with the most studies on FLW estimation were the USA and South Africa followed by Italy, Japan and Switzerland, with four and three studies respectively (Figure 3, a and b). There were 23 studies conducted in developed regions of the globe, 12 in developing regions (Figure 3, a) and two in the global food system. It can be seen. Therefore, those developed regions have more studies of FLW estimates than developing regions.

All studies were published after 2004, achieving a greater concentration of publications as of 2011. Most of the studies were developed between 2009 and 2011. The studies included: regional estimates (e.g. Europe, North America and Oceania - Kummu et al. al., 2012); estimates across the country (e.g. South Africa - Nahman and Lange, 2013, Portugal - Dias-Ferreira, Santos and Oliveira, 2015, USA - Buzby and Hyman, 2012); state estimates (e.g. Hawaii - Loke and Leung, 2015); municipality estimates (for example, Verona-Falasconi et al., 2015; Kyoto-Yamada et al., 2017); energy estimates (e.g., Alexander et al., 2017).

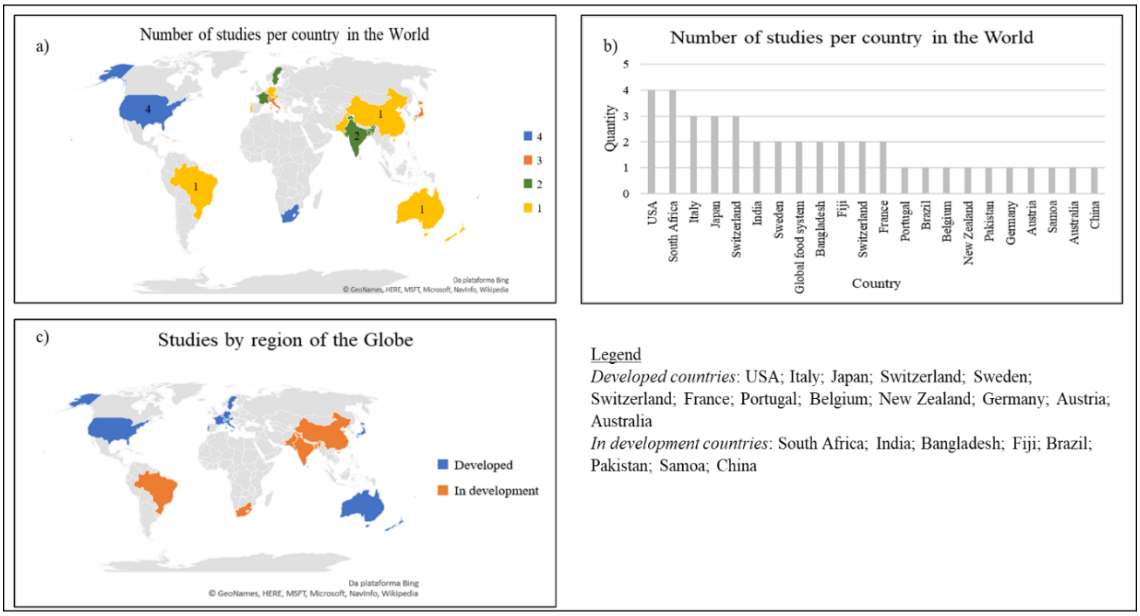


Figure 3. The number of studies per country and region of the globe.

Figure 4 presents more details about the reviewed studies. After the publication of Gustavsson et al. (2011), the scientific community allocated more effort to estimate FLW in different products and chains. In addition, it can be said that this study became a reference in the theme and the percentage of FLW identified, guided new research. Therefore, an increase in publications, which aim to quantify FLW after 2011, reaching eight publications in 2015 (Figure 4, a). In the review, we identified 17 studies that estimated FLW in kilograms and 19 that estimated in percentage and one in calories, according to Figure 4 (b).

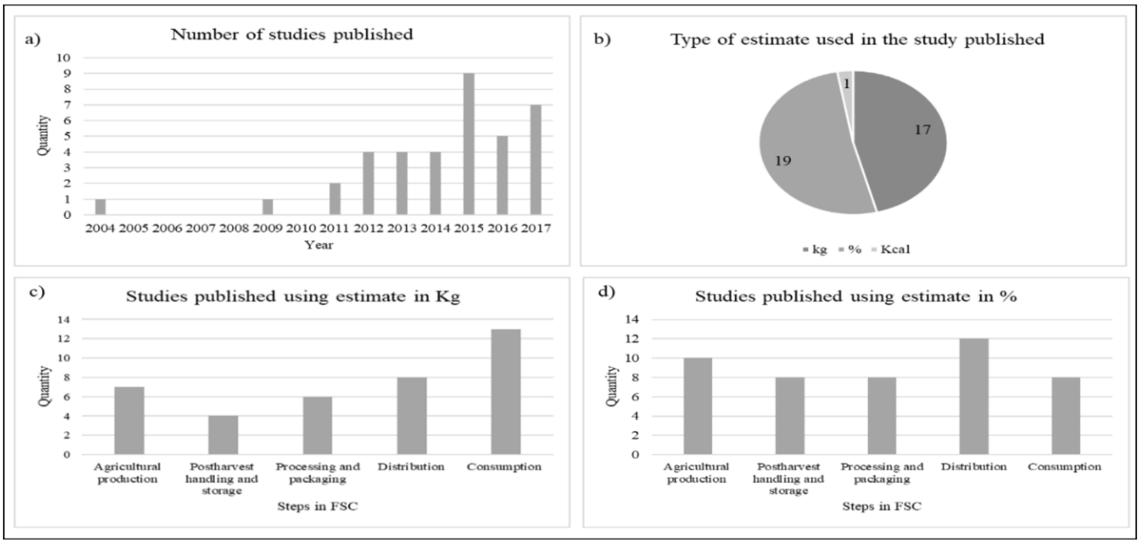


Figure 4. Information on the studies used in the review.

Only six studies provided estimates of FLW at all steps of FSC. It should be noted that not all studies were aimed at estimating FLW at all steps of the chain. However, for greater detail of the studies, the number of estimates for each FSC step was identified. In studies published using the kilogram estimate, the steps with the greatest amount of information are distribution and consumption. On the other hand, using the percentage estimate, the distribution and agricultural production steps were the ones with the greatest amount of information. Although the latter steps were less difficult to estimate FLW, not all studies had information in these steps. However, the scarcity of information between the post-harvest handling and storage steps and processing and packaging were observed in most studies. The difficulty of estimating FLW in these steps may be related to the concentration of retail corporations that dominate the FSC organization (Cicatiello et al., 2017). However, estimating FLW in these steps becomes complex because the way discarded foods are recorded depends on the retailer's internal organization, product return agreements with the supplier, and even local policy influences (Parfitt et al. 2010). However, currently, there are insufficient amounts of data to estimate FLW in the pre-consumption steps of FSC (Nahman et al., 2012; Affognon et al., 2015).

3.2 Review of results by position in FSC

Analyzing all the studies that estimate FLW, it was noticed that not all steps of the FSC had data. Most of these studies were focused on estimating at the consumption step. Other studies aimed at estimating FLW in the processing or distribution.

The heterogeneity of the products studied can be verified in Table S1. Estimates based on product groups, such as cereals, milk and dairy products, fruits, vegetables, and meat, were identified in ten studies. Specific FLW studies for certain products have been identified for tomato, banana, potato cabbage and seafood. Fruits and vegetables were the most studied products, either in individualized or grouped items. There is a high degree of variability in the FLW estimates in all steps of the FSC.

3.2.1 Agricultural production and post-harvest handling/storage

There were 17 studies that which estimated FLW in agricultural production and 12 in post-harvest handling/storage. Some of these studies have estimated FLW for several product groups (e.g., Nahman and Lange, 2013; Olofse and Nahman, 2013; Redlingshöfer et al., 2017). On the other hand, there are some estimations of FLW corresponding to the study of a particular product or step of the FSC. For example, Willersinn et al. (2015) studied the potato chain in Switzerland, estimating FLW between 17 and 33% in production and between 7-23% in post-harvest handling. Underhill and Kumar (2015) estimated FLW for tomatoes in Viti Levu (one of the Fijian islands). The authors estimated 25.5% FLW in the production and 1% in the post-harvest handling. In Queensland (Australia) the FLW of banana production was estimated at 15% (White et al., 2011).

3.2.2 Processing/packaging and distribution

Estimates in the processing/packaging step were carried out by 14 studies. However, the distribution has 20 FLW estimation studies. In the same way as the previous steps, some studies performed estimates for several groups (Nahman and Lange, 2013; Olofse and Nahman, 2013; Redlingshöfer et al., 2017), while other studies were performed using a particular product (Rahman et al. 2014; Love et al., 2015; Willersinn et al., 2015). We would like to highlight that among the pre-consumption steps, the distribution was the most studied, and some studies were performed to estimate FLW, specifically, in this step of the FSC. Lanfranchi et al. (2014) estimated FLW of 100 thousand kilograms per year for a particular group of vegetables in 13 sales outlets in the city of Sicily (Italy). Fruits and vegetables were also estimated by Eriksson et al. (2012) in Stockholm, Sweden, at 4.3%. In the city of Apia (Samoa) the FLW estimate for fruits and vegetables was 4.7% (Underhill et al., 2017). Finally, Lebersorger and Schneider (2014) estimated FLW for fruits and vegetables, milk and confectionery in 612 retail stores throughout Austria, estimating FLW of 4.19%, 1.14%, 3.99%, respectively.

3.2.3 Consumption

Regardless of the type of estimation (kilogram, percentile or calories) consumption is the FSC step with the most FLW estimates. We hypothesized that nine studies were developed to estimate FLW exclusively at the consumption step, eight of which were directly and indirectly. Besides, four studies were carried out in controlled environments, such as schools, restaurants, and hospitals, from meals (Betz et al., 2015, Dias-Ferreira, Santos and Oliveria, 2015). For example, the estimate of FLW in the restaurant of two companies was estimated by Betz et al. (2015). The authors included an FLW of 10.73% and 7.69% of the total food supplied in each company. Nevertheless, other four studies estimated from household residues (Soares et al., 2011; Nahman et al., 2012; Yamada et al., 2017; Amato and Musella, 2017). In the city of Kyoto (Japan) domestic and commercial organic waste was estimated by Yamada et al. (2017). The authors estimated 30 tonnes of domestic FLW and 34 tonnes of commercial FLW.

3.3 Methodological issues

FLW estimates are derived directly or indirectly, producing results difficult to compare (Van der Werf and Gilliland, 2017). The methodology used in the identified studies is divided into direct, indirect and mixed. The understanding of the direct and indirect methodologies are shown in Table 1, and the mixed methodology contains characteristics of both methodologies. The direct methodology was used in 22 studies. Ten studies used indirect and four mixed methodologies. Generally, indirect methodologies were used to estimate FLW in food groups, while direct methodologies focused on particular products or a certain step of FSC.

Chart 1. Comparison of indirect and direct measurement of FLW		
	Indirect measurement	Direct measurement
General approach	Mass flows model used to estimate FLW at a specific FSC position(s)	Direct collection of waste samples to estimate FLW at a specific FSC
Steps to calculate FLW	FLW estimated using five-step process: - Estimate production volumes (typically national or transnational), per commodity - Estimate food loss coefficient, per commodity - Calculate the product of the production volume and food loss coefficient, per commodity - Allocate FLW across the FSC, per commodity - Sum per commodity FLW to develop total per FSC position FLW	FLW estimated using six-step process: - Scope by position on FSC, where waste samples will be collected - Scope by geography (e.g. city) - Scope by FLW sorting categories (e.g. edible and inedible) - Collect representative samples of FLW - Manually sort and weigh FLW into selected categories - Extrapolate FLW by scoped position(s) on the FSC, geography and sorting categories
Output	Results in general national and transnational FLW estimates	Results in specific and geographically scoped local FLW
Using data	Identifies and estimates extent of FLW but offers little 'empirical' evidence on where to possibly implement interventions	Identifies and estimates extent of local FLW and offers 'empirical' evidence on where to possibly implement interventions

Note: Elaborate by Van der Werf and Gilliland (2017)

Quantitative research includes studies combining existing data sets to develop estimates. Griffin's study, Sobal, and Lyson (2009) conducted interviews and collected information in public databases to compose the methodology and study a city in the state of New York / USA. Another example is the study by Redlingshöfer et al. (2017), where food data came from various sources, mainly from technical reports and interviews with academics, practitioners, and specialists.

Measures of the composition of residues based on weight was another methodology used to estimate FLW. Nahman et al. (2012) used data from household waste produced in South Africa to compose the estimates of their study. Amato and Musella (2017) used a questionnaire for respondents to estimate the quantities of FLW produced. Yamada et al. (2017) used garbage bags collected in households and industries of different districts of the city of Kyoto, classified and estimated FLW.

The studies developed for specific products have greater methodological detail. For example, Munhuweyi et al. (2015) developed a study aimed at quantifying and qualifying cabbage losses at three outlets in Stellenbosch, South Africa. The authors estimated global losses, insect damage, mechanical damage and cabbage rot on days 0, three days of storage and seven days of storage. Being that on three days and seven the cabbage was stored in environments with a temperature of 0ºC and between 22-25ºC.

The methods that estimate FLW and their respective data sources can be observed in Table S1. The different methods and data may comprise pros and cons depending on the purpose that is developed from this study. The different data scales used, ranging from the study conducted in a neighborhood (Amato and Musella, 2017), even the estimation for large regions of the globe (Kummu et al., 2012). Both are relevant in the debate on the subject. However, most studies that estimate FLW have focused on consumption and distribution, and to a lesser extent on other steps. Additional FLW estimates are required for the agricultural production step, and especially for post-harvest handling/storage and processing/packaging. Although more studies are using direct rather than indirect methodologies, there is still a need to expand studies that focus on direct FLW estimates for all steps of the FSC.

4 Discussion

The FLW theme is criticized for not having a unification of concepts, because it is difficult to measure, to standardize the data and to have multiple possibilities of applicable methodologies (Abdulla et al., 2013; Gustavsson et al., 2011; Langley et al., Parfitt, Barthel and MacNaughton, 2010; Xue et al., 2017; Creus, 2018). However, the data limitations and resource constraints for FLW estimates restrict the interest of researchers, the community, and policymakers to developing studies focused on those steps of the chain of a less complex intervention and mitigation of FLW or of higher cost-benefit (Hodges, Buzby and Bennett, 2011).

It was contributed to this theme in different ways. First, the case studies estimating FLW in different FSC sectors are conducted in both developed and developing countries. Differently from the argument of Minten et al. (2016), where the authors state that case study research is heavily dominated in developing countries. In addition, developed regions have more studies of FLW estimates than developing regions. The literature reports two different types of FLW (Partiff et al., 2010). The first type is the loss of food during post-harvest production and processing and occurs mainly in the Global South. The second type is the waste of consumers and retailers and is primarily a problem in the Global North, coupled with food standards.

Developing FLW studies, structured in the current perspective, originates first in developed countries. The Global North inserts this discussion in two ways. The European Community has focused on the conservation and efficient use of natural resources, focusing mainly on the relationship between FLW and its efficient re-use in food systems (Chaboud and Daviron, 2017). Conversely, the FAO focuses on FLW as a problem of food security, due to a problem of food accessibility rather than availability (Chaboud and Daviron, 2017).

In the Global South, post-harvest food loss minimization, which includes the current FLW approach, is considered timely to expand food supply, conserve resources, and improve human well-being. Based on this argument, the reduction of FLW in developing countries becomes an opportunity to promote more sustainable development (Thi, Kumar and Lin, 2015).

The heterogeneity of the methodologies, products, and chains studied became noticeable in this review. The size of each study (characterized in Table S1) is related to the objective and comprehensiveness in estimating FLW. Results from different studies cannot be accurately compared due to the different definitions, methodologies, and baselines (Lebersorger and Schneider, 2014; Fine et al., 2015). Obviously, by exploring only one product or a production chain, more detail is needed, using a more sophisticated methodology and more complex calculations that satisfy the issues addressed. Each method has its challenges. Hall et al. (2009) argue that cumulative errors in inferential methods can arise if incorrect factors of food waste are applied in the early steps of food system calculations. However, the more complex a more difficult to use, standardized, compared and replicated. The FLW in the least developed countries is relatively unknown, and most are estimates derived from questionnaires, rather than actual measurements (Hodges, Buzby and Bennett, 2011). Therefore, several financial resources, destined to estimate FLW, can generate a difficult comparison and control estimate over time.

Among the many other antagonisms that compose this theme, from production to food consumption, the less complex the ways of estimating FLW, the faster the ways to mitigate it. Indirect estimates, to that end, are often used to develop global, continental or country-wide estimates, while direct estimates are used for smaller geographic units, such as consumption units (households, households, people), city or region. However, indirect estimates are criticized for applying conversion factors for the studied food, food group, or step of the chain. For this, inferences based on estimates of FLW calculated or identified in regions similar or available in the literature are inferred. Extrapolating the data obtained from only a small sample can produce biased results (Lebersorger and Schneider, 2014). Moreover, its use becomes relevant to developing a general picture of the current situation, given the challenges described for using indirect estimation (Van der Werf and Gilliland, 2017). Therefore, potential future research may aim to restrict and improve estimates by using additional data from other sources to produce a more realistic model.

Direct estimates are made where it is possible to collect, classify and control the samples or population studied. Usually, it is employed at a certain step of the FSC, or, when estimating FLW for a particular product. It is also widely used to estimate FLW in the consumption step, being the analysis of the composition of residues and use of cookery diaries the most used methodologies. Direct FLW estimates are more accurate and better represent the area studied, resulting in the development of more meaningful interventions (Van der Werf and Gilliland, 2017).

Another contribution concerns the initial and final steps of FSC (agricultural production and consumption) to have greater studies when compared to the other steps. Due to the need for developing countries to return to the inefficiency of post-harvest production systems to maximize efforts to reduce FLW and contribute to the availability of food for consumption, sale or exchange and improvement of the means of production. Subsistence and food security (Hodges, Buzby and Bennett, 2011). Conversely, the developed countries have more studies of FLW for consumption, which is consistent with the large quantities of FLW produced in this step, originating from the large supply of food, leftovers from meals or due to the expiration of the expiration date for consumption of food (Hodges, Buzby and Bennett, 2011).

It corroborates with this question that the steps of agricultural production and consumption, become less complex to estimate FLW, since the products or foods are clearly identifiable, be it in nature (apple, tomato) or ultra-processed (pizza, lasagne, bread). Besides, foods or products that do not go through processes of transformation, modification or are not used as ingredients in other food and products, are less complex to estimate FLW. Therefore, when one has a specific food and estimates FLW from it, it becomes more accurate to estimate. It is also worth noting that estimating FLW in steps of storage, processing, and distribution is a complex task because it involves the internal organization of each production chain and its links.

The fourth contribution is related to this study reinforces the findings of Van der Werf and Gilliland (2017). The authors noted the existence of considerable variability in the data; there is a greater tendency to estimate FLW immediately before reaching the consumer. In addition, the consumption step and indirect measures usually result in higher FLW estimates.

Finally, the academic literature, which estimates FLW, has been developed in different regions of the globe, and in all regions, there is at least one published archive on the subject. In previous work, Underhill et al. (2017) stated that much of the current academic literature that estimates post-harvest FLW was concentrated in sub-Saharan Africa and the Asian region. Therefore, the interest in the subject is perceived due to the dissemination of studies carried out and published on the same. However, it should be noted that Latin America needs to develop further studies on the subject.

In addition, some considerations must be observed, such as using a precise date to estimate the FLW at a given step. Lebersorger and Schneider (2014) defend the reliable date for estimating the FLW at each step of the FSC (e.g. agriculture, production and processing, retail, consumers). In addition, in studies that investigate more than one step of the FSC, observe the possible overlaps between the links of each step. One should also consider the limitations of inferential methodologies. In addition, any methodology used becomes a static portrait of FLW at a given moment (Griffin, Sobal and Lyson, 2009). Therefore, it is necessary to avoid possible generalizations and applications that deviate from the studied reality. To develop effective interventions to reduce FLW and measure its impact, it is essential to understand its generation accurately. To improve the efficiency of food consumption, the FLW, its identification, evaluation, planning and prevention measures should be estimated at the regional, national and global levels.

4.1 Limitations

This review only looked at the FLW estimates of files intended to quantify them. First, this was the simplest and the first FLW estimation approach performed across the globe. Second, the estimates were listed in metric kilograms, percentages, and calories, making comparability between studies difficult. The comparability of the estimates was considered of limited value.

5 Conclusions

Based on this systematic review of the literature, a considerable variability was identified between the FLW estimates. So that the methodology and the data used, in particular, whether the data were collected directly or indirectly. In understanding the relevance of the debate on the definitions of FLW, it is important to point out, although indirect measures can provide an overview of the current situation, direct measures are necessary to develop more accurate estimates of FLW, and their composition, comparison, and studies in different geographic contexts.

National FLW estimates are becoming more important in developed countries. These estimates will direct resources to mitigate FLW efficiently. On the other hand, developing countries lack more data and information to estimate FLW. Targeting priority areas for research, addressing key chains, products and/or food will assist in estimating approaches and formulating FLW mitigation policies and resource efficiency.

Although the analysis is based on scientific production, there are FLW surveys made by organizations, private companies and other institutions that can use methodologies, data, and more rigor than those described in this research, obtaining more reliable results. However, this information is for personal use or is characterized as gray literature, having little or no impact on public policy. In this sense, the funding of public research with greater methodological rigor becomes necessary to provide more reliable data for the promotion of policies that result in FLW mitigating practices.

We know the specificities involved in estimating FLW, so it is necessary to develop more studies that test methodologies and metrics found that can directly measure the FLW. However, among the pros and cons of different methods that estimate FLW and using data sources, one must observe the methodology that best fits the desired objective, food or estimated product, FSC step and scale sought in the study.

Although studies of FLW estimates using indirect data collection in the different regions of the globe are interesting parameters, only estimates developed from the study of each production chain will provide improved data. From this data, specific actions can be developed and mitigated to FLW in different contexts, focusing on the consumer society, where human well-being is erroneously based on the unlimited consumption of resources.

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CAPÍTULO 3

Estimating the magnitude of the food loss and waste generated in Brazil[2]

Abstract:
The current global food production is enough to meet the caloric needs of the 7 billion individuals. On the other hand, 821 million people are currently malnourished. Living on a planet with this conjuncture should catenate more effective actions in combating food insecurity. Food losses and wastes contribute to this scenario, both in the economic sphere and in the use of inputs such as water, energy and work for the production process, and emits greenhouse gases. The lack of data and a precise method of quantification should not prevent the producing countries and food suppliers, such as Brazil, from quantifying their food losses and waste. Through a methodology used by Oelofse and Nahman (2013), we performed an exercise in quantifying food losses and wastes in the Brazilian food supply chains. Thus, it can be initiated and improved understanding on this topic. An annual average of losses and waste of 82,1 million tons was identified between the years 2007 and 2013. It represents 42% of the average national food supply for the period. The average amount of losses and wastes was 427 Kg/inhabitant/year. The edible portion corresponds to 327kg/inhabitant/year. Specific studies that quantify and detail the losses and waste of food by productive chain are necessary to assist in the resolutions of this problem.
Keywords: commodity, developing country, domestic supply, estimation, food supply chain, quantity, provisions, resources.

1 Introduction

Rapid urbanization, population growth and food waste have become a trend and concern issues in developed and developing countries alike. The awareness of food losses and wastes (FLW) became prominent after the publication of Gustavsson et al. (2011), which addressed the losses occurring along the global food supply chain (FSC). The study suggests that about one third of the food produced for human consumption is lost or wasted annually.

The negative externalities resulting from the food production process cause adverse impacts on the society and local environmental quality. On the one hand, the produced food, which is not used for consumption, characterizes poor management of natural resources such as water, soil, forests, biodiversity and wildlife (Engström & Carlsson-Kanyama, 2004, Lundqvist et al., 2008, Buzby & Hyman, 2012). The reduction of the FLW associated with a better use of natural and productive resources brings productive efficiency and reduces the negative externalities produced by agriculture, reducing even the demand for land (Bender, 1994, Scott Kantor et al., 1997, SMIL, 2000, Wirsenius, 2000, Garnett, 2011, Lanfranchi et al., 2014, Alexander et al., 2017, Notarnicola et al., 2017).

The prevention of FLW should also be a priority, since it reduces its own flow of generation (Gentil et al., 2011, Unger et al., 2016). Preventive actions can be considered as: avoiding overproduction or surplus of food originating from production and consumption; prevent the generation of avoidable waste by means of the food value chain;

[2] The manuscript was accepted in its current form for publication in the Waste Management & Research Journal, https://doi.org/10.1177/0734242X19836710. The text was written in British English and follows the guidelines of the author of the journal. Appendix B complements the manuscript.

allocate the productive surplus to people who are in food insecurity, through redistribution networks, institutions and food banks (Creus et al., 2018).

On the other hand, the FLW is responsible for a problematic flow of waste destined to landfills, which contributes to greenhouse gas emissions (Hartman & Ahring, 2006). In this sense, in addition to the prevention of FLW, the European Union (2008) defends in its policies new destinations and the reuse of food, using the resources already employed and the reduction of greenhouse gas emissions developed throughout the FSC (Nahman et al. 2012, Chaboud & Daviron, 2017).

The reuse of FLW can be accomplished in both edible and non-edible food fractions-which can result in environmental and social impacts (Nahman & Lange, 2013), therefore, the disposal implies in the generation of a quantity of FLW that requires a suitable destination. Non-edible FLW fractions may compose potentially valuable resources in the composition of diets for animal nutrition (European Commission, 2010, Liu et al. 2016), generation of energy or production of composting (Nahman & Lange, 2013). The recycling of FLW in new production chains, such as bioenergy, for instance, was revised and discussed by Dahiya et al. (2018). The authors advocate the valorization of FLW as a potential raw material in new biological processes for the generation of products in other production chains, which would result in biofuels, chemicals, bioelectricity, biomaterial, biofertilizers, animal food, among others.

Finally, the FLW represents a significant amount of money and resources invested throughout the life cycle of food. Therefore production, storage, processing and transportation are FSC steps that add financial value to the developed product, while the original purpose, that is to feed people, is not entirely fulfilled (Bender, 1994, Buzby et al., 2011).

Global attempts to quantify FLW are motivated for the following reasons: (1) to evaluate the scale of food waste production, (2) to be able to establish a line based on reduction targets, and (3) to measure the efficiency of the developed FLW prevention initiatives and their impacts on the current society. The lack of a standardized measurement protocol (WRI, 2014) associated with data scarcity, leads to estimates of FLW that vary widely in the international literature (Parfitt et al., 2010, Xue et al., 2017), causing uncertainties in the estimated quantities. The goal of this article is to quantify the magnitude of the FLW in different commodity groups (CGS) in the different steps of the Brazilian FSC and its per capita representativeness.

A review of the literature on the FLW approach in Brazil is provided in section 2. The method of the research performed is described in detail in section 3. Subsequently, the results of this study are presented and discussed. In the last section of this article, a conclusion is provided.

2 Food loss and waste along the supply chain in Brazil

Since 1960 there has been a sharp growth in world food production that allowed the decrease in the number of starving people in the world, even though the world's population grew twofold (Godfray et al., 2010). Although the achievement of these efforts for productive growth, one in seven people does not have enough access to protein and energy in their diet (FAO, 2009). Additionally, studies conducted in the global FSC suggest different serious situations of FLW. In each step of the FSC this situation is noticeable, that is, from pre-production to post-consumption, being estimated at about 25-40% FLW of total food production (Godfray et al., 2010, Kummu et al., 2012). Another study reports that about one third of the food produced for human consumption is lost or wasted globally (Gustavsson et al., 2011). Finally, the worst-case scenario indicates that half of all food produced is lost or wasted before and after reaching the consumer (Lundqvist et al., 2008).

This high global standard of FLW associated with a precarious supply and poor food distribution worsens the worldwide availability of food (Belik et al., 2012). Therefore, a global strategy consisting of multiple initiatives is necessary to ensure food security in a sustainable and equitable way. Affirmative actions that minimize losses and fight against food waste are highlighted. Among these actions, the prevention and reduction of the FLW become the ways to increase the availability of food in order to meet these needs (Dubbeling et al., 2016).

Among the main reasons for waste, there are the excesses of norms and rules related to sanitary or aesthetic concerns in developed countries and the lack of storage capacities and reduced market access in developing countries (UN, 2013). Financial, managerial and technical limitations ranging from harvesting, storage, installations, infrastructure, processing, packaging and marketing systems also influence the FLW in developing countries and there may be higher losses, around 40%, in post-harvest food (Parfitt et al., 2010). However, any FLW becomes unjustifiable, even more so when part of the world's population is starving: the number of undernourished people in the world has grown since 2014, reaching 821 million in 2017 (FAO, 2018).

The FLW is a potentially important factor in the efforts to combat hunger and improve food security in poor countries (Gustavsson et al., 2011). Moreover, the efficiency of the food system is also closely related to the issue of food security (Bender, 1994).

Food security consists of when all people, always, have physical and economic access to safe, nutritious and enough food that meets with their dietary needs and preferences to perform an active and healthy life (FAO, 2006). This definition originates from the World Food Summit of 1996 and its inexistence leads to food insecurity.

In Brazil, the food insecurity situation was first researched in 2004, by the National Household Sample Survey (PNAD) – Food Security. The most recent data on Brazilian food security corresponds to the survey carried out in 2013 by the Brazilian Institute of Geography and Statistics (IBGE). The report shows that 52 million Brazilians go through food insecurity, which represents 22.6% of households (IBGE, 2014).

The reduction of the FLW is a path towards the shrinkage of hunger, malnutrition and, consequently, food security in countries that still struggle with this situation (Brown University Faculty, 1990, Lundqvist et al., 2008, Gustavsson et al., 2011, Chaboud & Daviron, 2017). This situation is even more dramatic considering that the global expectation of population growth for 2050 is of 9.3 billion people, which bears in mind the need to feed this upcoming population (UN, 2011a).

The decrease in the mass of food during the production process, that is, in the steps of producing, harvesting, storing, processing and distribution, may be due to inadequate or inefficient procedures that cause loss or damage to the products in the processes of manipulation, transformation, storage, transport and packaging (Gustavsson et al., 2011). The reduction in the amount of food destined exclusively to human food, which occurs in the final step of the food supply chain, is associated with the inefficiency of the distribution process – wholesale and retail – and consumption (Belik et al., 2012). Its causes result from the loss of commercial value of the product offered and not necessarily of its nutritional value, due to the excess of production, damage to the appearance of the food or even the consumption not made after the purchase.

In relation to the step in the production chain, according to the FAO (2013), 54% of the food losses in the world occurs in the initial phase of manufacturing, comprising the postharvest manipulation and storage, and 46% of the waste occurs in the processing, distribution and consumption. When taking in consideration the separation of countries in terms of development, developing countries suffer more from losses during agricultural production, while in the middle and high-income regions the waste in distribution and consumption tends to be higher (FAO, 2013).

Following the same dynamics, Brazil is composed of different socio-economic contexts, which transforms food habits or food patterns and their consumer markets. Mores et al. (2017), who studied the recent evolution of the Brazilian food standard, suggested that the main drivers of changes in the food patterns in different regions are associated with changes in the regional agricultural base, to the availability of new foods and new cultures and to the change in the income of the population, which caused new dietary habits. These factors lead to a new FSC, which results in a greater supply of food and, consequently, to distinct behaviors of FLW in different Brazilian regions. With this challenging reality, changes in the form of production, storage, processing, distribution and access of food become of main importance (Godfray et al., 2010). Before the implementation of new initiatives for prevention, optimization of resources or distributive pathways, it is necessary to know in which steps of the FSC occur the FLW. Better understanding where food is wasted, where it goes, its quantifications and which monetary values it represents becomes an important information. The estimation of the quantities and monetary values of FLW is relevant to raise awareness among producers, industry and consumers and to assist policymakers and formulators to tackle the issue. The definition of goals and the development of initiatives, legislations or public policies to minimize waste, conserve resources and improve human health is convincing. Thus, better management and distribution of food resources at the global, regional, national and local levels would provide benefits for less privileged societies (FAO, 2011, FAO, 2014).

As an important player in the global food market, the first publications on post-harvest losses of perishable products in Brazil began in the 1970's (Henz, 2017). The author reviewed the publications on this subject for perishable vegetables and observed three distinct periods: (1) from 1970 to 1990, there was an agronomic and economical emphasis on publications, aiming at understanding the effect of losses on the price of products, determining percentages of losses and preliminarily identifying the causes; (2) from the 1990's onwards, the focus turned to the application of post-harvest technologies (such as packaging and refrigeration), with the objective of reducing the qualitative and quantitative losses of vegetables, in addition to losses caused by diseases or mechanical damage; and (3) in the 2000's, the efforts turned to study the distribution and management channels, due to the changes in the commercialization of fresh fruits and vegetables in Brazil.

On the food waste matter, the interest for scientific research aroused from the 1980's onwards, being the issue studied with attention to household waste (Henz & Porpino, 2017). It is perceived a division between the understandings of losses and food waste between the FSC steps, based on studies guided by the United Nations Food and Agriculture Organization. However, these publications (books or chapters available, reviewing articles, reports, case studies and technical publications) have had little practical effect, because they are studies of segmented steps of the FSC generally focused on specific products (Henz, 2017). Most of them comprise estimates that were obtained through questionnaires and/or interviews, with little potential capacity to modify the situation they describe. There are relatively few scientific studies published in Brazil, being the largest part in Portuguese, considered as gray literature, since they are not reviewed in pairs, indexed in journals or easily accessible (Henz & Porpino, 2017).

3 Research method

This article is based on the application performed by Oelofse and Nahman (2013), which calculates the amount, in kilograms, of FLW in the FSC in South Africa, from the food production data of FAO. For Brazil, we used the FAO food balance data (FAOSTAT, 2018). The food balance comprises the domestic production, the imported and exported quantity of food, as well as the stocks variation for each commodity group (CG) analyzed. These data are summarized in table S1. It is worth noting that for oil seeds and CG pulses, only pulses were considered due to the lack of complete data for oil seeds. Moreover, no primary data collection was performed for this research. The reason to use the food balance data is because Brazil has a high flow of international food trade with several countries, thus it is necessary to analyze and quantify the FLW on the optics of the internal supply of food. Therefore, the quantities of food mass that comprise the calculations of each step of the FSC differ.

The FLW proportion estimates that occur at each step is based on the results reported by the United Nations Food and Agriculture Organization (FAO) for Latin American countries (Gustavsson et al., 2011, Creus et al., 2018). Table S2 shows the estimates of the FLW at each step of the chain in Latin America, as a percentage of the weight of the food that enters in each step. The steps are organized into five columns comprising agricultural production, post-harvest handling and storage, processing and packaging, distribution and family consumption. The percentage of FLW was estimated for different product groups (table S3), denominated as CG (cereals, roots and tubers, seeds of oleaginous and legumes, fruits and vegetables, meat, fish and seafood and milk), according to Gustavsson et al. (2011). The same percentage of FLW was considered for all analyzed years.

Figure 1 (a) explains what amounts of mass that comprise each step of the chain, from production to consumption. It is assumed that the quantity produced represents the agricultural production step of FSC. It is summed up the quantity produced, the quantity of food in stock from the step of handling and post-harvest storage. The quantity of imported food is inserted in the calculations from the processing and packaging step. This occurs due to part of the imported foods entering as input in the processing step of the Brazilian FSC. From the distribution step onwards, the quantity of exported food is withdrawn from the calculations. Both the distribution and consumption steps represent the domestic supply of food in Brazil. For instance, the tons that enter the agricultural production must be A (production quantity) and the ones that leave the agricultural production should be X = A - percentage of FLW in this step (and so on, until the final step), as shown in Figure 1 (b). It is worth noting that the percentage of FLW corresponding to each commodity group should be observed.

The same CGs used by Gustavsson et al. (2011) were used for this study. The data that represent the flow of the domestic supply of food, by CG in Brazil, are presented in table S4. As the internal supply data for different commodities varies year by year, it was used the average quantities over the period analyzed (2007-2013), as indicated in the last column of table S4.

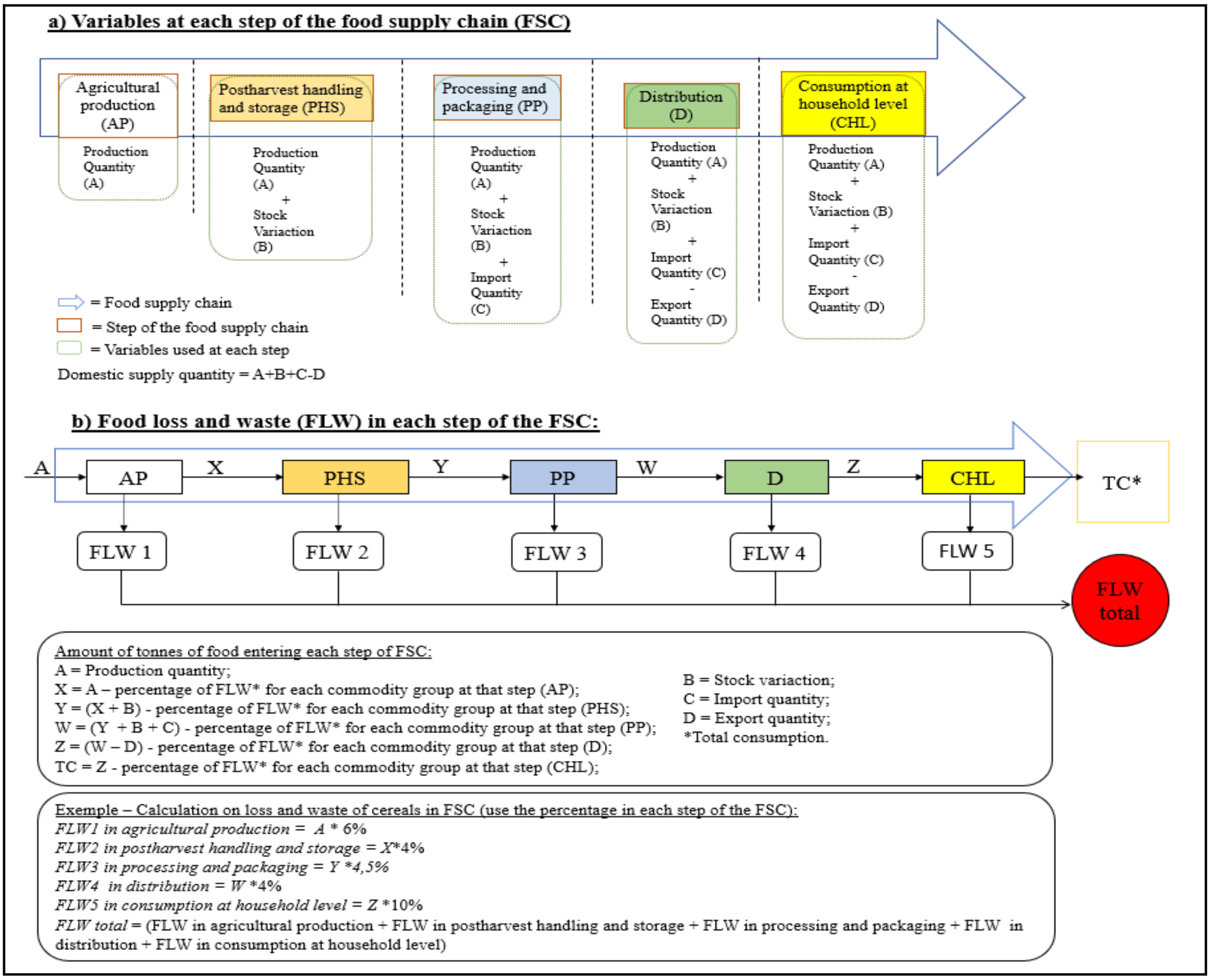

Figure 1. Flowchart of the calculation model used in the methodology.

In Figure 1 (b), it is explained how the FLW was quantified at each stage of the chain. The percentages of FLW of Gustavsson et al. (2011) refer to the percentages (per mass) of food that enters each step of the FSC. Likewise, the percentages described in table S2 were used. The FLW calculated at each step of the FSC was, therefore, subtracted from the calculation of quantity produced in the previous step. For instance, the amount of agricultural production for the cereal group, minus the losses during the agricultural production step of this group, was equal to the input value for the subsequent calculation. Adding the post-harvest handling and storage step, the existing quantity in stock (if there is any) to the cereal group, minus the losses generated during this step and so on. Figure 1 (b) shows the calculation schemes, being these the same for any other CG. Only the percentage of losses or waste of each step in the FSC for each CG changes.

To quantify the edible parts, the conversion factors were used according to Gustavsson et al. (2011), after the quantification of FLW for each stage of the FSC. Because of the international estimates of FLW presented by Gustavsson et al. (2011) were based on data from 2007, this study analyzed data from 2007 to 2013. This period also covers the most recent available data. Furthermore, this period is justified due to the possibility of comparison with international estimates of other researches. Thus, to present estimates of FLW for Brazil in terms of per capita values (useful for comparison with other countries), it was necessary to use data from the food balance and the population from 2007. These population statistics were obtained from the Brazilian Institute of Geography and Statistics (IBGE, 2013).

4 Results and discussions

Using the described method, the results of the analysis are presented in table S5. It is observed that the lines comprise the commodity groups analyzed between the years 2007 and 2013. The average amounts of FLW were identified according to the steps of the Brazilian FSC and are presented in the last column. It is observed in the steps of agricultural production, handling and postharvest storage, as well as in the processing step, that the larger quantities of FLW are composed by the groups of fruits and vegetables, roots and tubers and cereals. In the distribution step, there are the groups of (1) fruits and vegetables; and (2) cereals and milk that make up the largest amounts of FLW. In the consumption, the quantities of FLW are mainly composed by the groups of (1) fruits and vegetables; (2) roots and tubers; and (3) cereals and milk.

In table 1, the quantities of FLW for the year 2007 (a) and for the period analyzed (b) are organized. In 2007, there were totalized 77.7 million tons, being that the steps of agricultural production and processing and packaging contributed the largest share of the FLW, with values of 20.4 and 19.2 million of tons, respectively. Between 2007 and 2013, the total amount of FLW generated was 21.1 million tons in the agricultural production, 14.3 million of tons in the handling and storage postharvest, 19.8 million tons in the processing and packaging, 12 million tons in the distribution and 14.7 million tons in household consumption.

On average, the FLW in the Brazilian FSC for the analyzed period was 82.1 million tons per year. This equates to 42.25% of the average value of domestic food supply between 2007 and 2013 (194,360,000 tons).

Table 1. Calculated food loss and waste by commodity groups.

A. Calculated food loss and waste in different commodity groups for Brazil (2007).

Commodity groups	*Production average of FLW for the year(1000 tonnes and %)*													
	Agricultural production		Postharvest handling and storage		Processing and Packaging		Distribution		Pre-consumer FLW		Consumption		Total FLW per commodity group	
Cereals	3945.48	*19.32*	2610.32	*18.89*	3411.81	*17.78*	2564.84	*23.43*	12532.5	*19.47*	6412.1	*47.84*	18944.6	*24.36*
Roots and tubers	4321.94	*21.16*	4321.94	*31.28*	3740.64	*19.50*	932.46	*8.52*	13317	*20.69*	1243.28	*9.28*	14560.3	*18.72*
Pulses (only)	191.34	*0.94*	98.67	*0.71*	274.64	*1.43*	68.04	*0.62*	632.69	*0.98*	68.04	*0.51*	700.73	*0.90*
Fruits and vegetables	9827.4	*48.12*	4913.9	*35.56*	10000.2	*52.12*	4399.32	*40.19*	29140.8	*45.27*	3666.1	*27.35*	32806.9	*42.18*
Meat	1156.2	*5.66*	239.965	*1.74*	1092.6	*5.70*	765.1	*6.99*	3253.86	*5.05*	918.12	*6.85*	4171.98	*5.36*
Fish and seafood	61.104	*0.30*	53.6	*0.39*	133.11	*0.69*	137.6	*1.26*	385.414	*0.60*	55.04	*0.41*	440.454	*0.57*
Milk	919.59	*4.50*	1579.74	*11.43*	532.08	*2.77*	2079.36	*19.00*	5110.77	*7.94*	1039.68	*7.76*	6150.45	*7.91*
FLW total	**20423**	*100.00*	**13818.1**	*100.00*	**19185.1**	*100.00*	**10946.7**	*100.00*	**64373**	*100.00*	**13402.4**	*100.00*	**77775.3**	*100.00*

B. Calculated average food loss and waste in different commodity groups for Brazil (2007–2013).

Commodity groups	*Production average of FLW for the period (1000 tonnes and %)*													
	Agricultural production		Postharvest handling and storage		Processing and Packaging		Distribution		Pre-consumer FLW		Consumption		Total FLW per commodity group	
Cereals	4593.69	*21.75*	3085.94	*21.53*	3923.22	*19.78*	2875.29	*23.78*	14478.15	*21.49*	7188.23	*48.77*	21666.38	*26.38*
Roots and tubers	4058.58	*19.21*	4058.58	*28.32*	3533.43	*17.81*	881.62	*7.29*	12532.21	*18.60*	1175.49	*7.97*	13707.70	*16.69*
Pulses (only)	193.43	*0.92*	97.10	*0.68*	279.75	*1.41*	69.46	*0.57*	639.74	*0.95*	69.46	*0.47*	709.20	*0.86*
Fruits and vegetables	9883.60	*46.79*	4941.83	*34.48*	10116.29	*51.00*	4746.79	*39.26*	29688.50	*44.06*	3955.66	*26.84*	33644.16	*40.97*
Meat	1257.36	*5.95*	260.96	*1.82*	1188.64	*5.99*	873.02	*7.22*	3579.98	*5.31*	1047.63	*7.11*	4627.61	*5.63*
Fish and seafood	75.43	*0.36*	66.16	*0.46*	173.48	*0.87*	185.70	*1.54*	500.77	*0.74*	74.28	*0.50*	575.05	*0.70*
Milk	1061.50	*5.03*	1820.22	*12.70*	622.17	*3.14*	2459.33	*20.34*	5963.21	*8.85*	1229.66	*8.34*	7192.87	*8.76*
FLW total	**21123.60**	*100.00*	**14330.80**	*100.00*	**19836.97**	*100.00*	**12091.20**	*100.00*	**67382.57**	*100.00*	**14740.40**	*100.00*	**82122.98**	*100.00*

The percentage contribution to the total of FLW in each step of the FSC in 2007 is illustrated in Figure 2 (a). The division identified that the steps of agricultural production (26.26%), processing and packaging (24.67%) contributed with the largest quantities in the generation of FLW within the Brazilian FSC. The majority of FLW produced in 2007 (64.3 million tons per year or 82.77%) was generated during the pre-consumption steps and accounted for 43.71% of the Brazilian food supply.

The same analysis for the period that composes the research (2007-2013) shows that the FSC steps that contributed to the highest amounts of FLW were: agricultural production (25.72%) and processing, and packaging (24.16%) (Figure 2, B). Considering the average values, the majority of the FLW produced during the period (82.1 million tons per year or 82.05%) was generated during the pre-consumption steps and accounted for 42.25% of the Brazilian food supply.

One of the few studies in the scientific literature conducted in Brazil refers to fruits and vegetables. Between August of 1989 and March of 1990, the dynamic of FLW for fruits and vegetables was studied in some steps of the chain in the city of Uberlândia in Minas Gerais (Fehr & Romão, 2001). The authors identified FLW estimates of fruits and vegetables of 6.28% in the wholesale market, 11% in retail, 11.67% in street markets, 12.56% in food stores and 8.76% in supermarkets.

Analyzing the studied period, almost 18% (14.7 million tons) of the total FLW was generated in the consumption step. This amount represents 7.58% of the average domestic food supply. During the consumption step, the CGs that contribute with the largest amounts ~~for~~ to the FLW were: cereals (48.77%) and fruits and vegetables (26.84%). It is worth noting that to analyze the step of food consumption in Brazil, one should take into consideration the great social heterogeneity that characterizes the country, due to the high-income inequality, which inserts a different weight in the household expenditure associated with the food expenses of different income strata (Maluf, 1999).

The contribution of each CG to the FLW is illustrated in Figure 2 (c), for the year of 2007, and the averages of the period are in Figure 2 (d). The group of fruits and vegetables, combined with cereals, contributed with 66.54% of the total FLW flow. Tthe groups of legumes, meats, fish, seafood and milk totaled 14.74%, and the group of roots and tubers represented 18.72% of FLW in the FSC for the measured year. When analyzing the contribution of each CG for the period (2007-2013), the fruits and vegetables, together with cereals, accounted for 67.35% of the FLW in the chain. The FLW from the roots and tubers group accounted for 16.69% of the total, with a quantity close to the sum of the other groups (legumes, meats, fish, seafood and milk), which together accounted for 15.68% of the average amount of FLW in the analyzed period. Efforts focused on reducing losses and waste in the fruit and vegetable groups, especially in the harvesting and processing steps, and the cereal group, can cause a significant direct impact on the overall FLW rates of the Brazilian FSC.

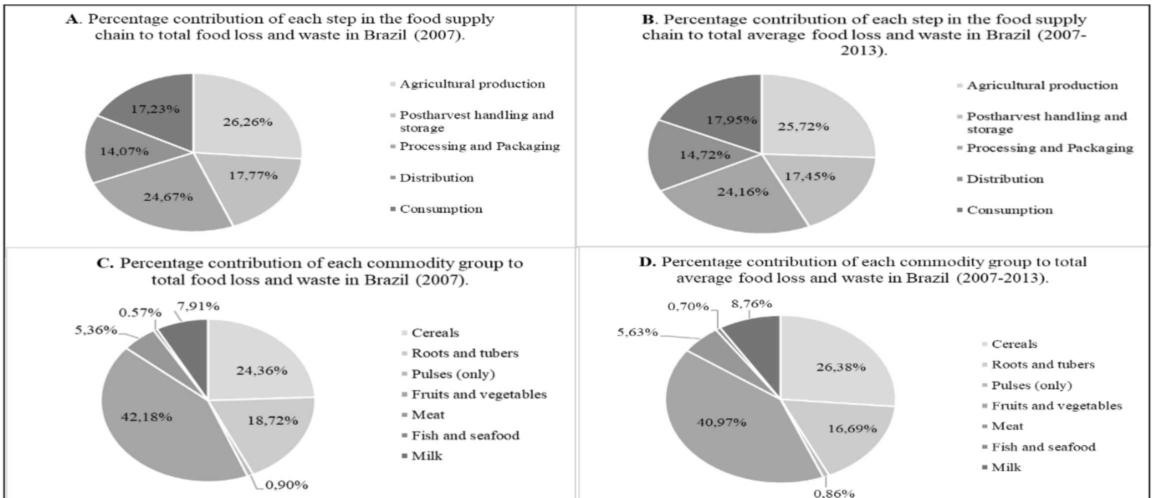

Figure 2. Percentages of food loss and waste by commodity groups and by step of the food supply chain.

In the same context, experiences of civil society and the state in order to handle FLW during distribution and consumption of food in Brazil compose different initiatives (Griza & Fornazier, 2018). The food banks are intended to put to good use food that, still in conditions to be consumed, would be thrown away or wasted. The Brazilian Program for the Modernization of the Hortigranjeiro[3] Market (Prohort - Ordinance 171 of 2005) was created with the purpose of fostering the development of the sector in interaction with all the Brazilian states, municipalities and agents that are part of the production and distribution chain, modernizing supply centers in order to mitigate losses due to infrastructure constraints. The development of research related to pest management, agroindustrialization and food processing, post-harvest practices, packaging, logistics and waste disposal, among other topics, includes other practices addressed by researchers from the Brazilian Agricultural Research Corporation (EMBRAPA). Public purchases of food from family farming, such as the Food Acquisition Program (PAA) and the National School Feeding Program (PNAE), are mechanisms that indirectly contribute to the reduction of food losses and waste in Brazil.

By associating the mass quantities that comprise each step of the chain and the FLW quantities calculated for the period (2007-2013), a Sankey diagram was created, using data from tables 1, S1, S4 and S5. This represents the Brazilian FSC and can be visualized in Figure 3. The different CGs (cereals, roots and tubers, pulses, fruits and vegetables, meat, fish and seafood and milk) are organized by lines. The size of the stream is indicated by the width of the line. The first five nodes represent agricultural production (AP), postharvest handling and storage (PHS), processing and packaging (PP), distribution (D) and family consumption (CHL), respectively. The insertion of the stock occurs for some CGs (cereals, legumes, fruits and vegetables and, milk), in the post-harvest handling and storage step; the insert of imports occurs in the processing and packaging step; and the withdrawal of exports from the flow occurs in the distribution step. In all steps, the mass quantities representing the FLW were taken. The last node represents the total average consumed and the total average of FLW in the Brazilian FSC.

Performing the same methodological approach as Oelofse and Nahman (2013), it was identified that the steps of agricultural production, post-harvest handling and storage and processing and packaging were the ones that generated the largest amounts of FLW both in South Africa and Brazil. However, unlike Brazil, the estimates for South Africa were more similar between the steps of the chain. Nevertheless, this is not something new once it is known that developing countries have greater FLW in the pre-consumption steps (Gustavsson et al., 2011). In addition, countries in Africa, Asia and Latin America face difficulties at the beginning of their FSC, with different challenges, such as inadequate harvesting techniques, poor post-harvest management, lack of infrastructure needed for production (storage and transport), inefficient processing, defective packaging and even a market that can cope inefficiently with product pricing information and consumer preferences (Global, 2014).

When evaluating the estimates of FLW by CG analyzed, it is observed that the groups of fruits and vegetables, cereals and roots and tubers are the ones that contribute the most to the values of FLW. In Brazil, mechanical damage linked to inappropriate practices of postharvest handling; such as rough handling, inadequate packaging, uncooled transport blankets associated with poorly preserved roads, as well as diseases and high temperatures in most of the country; are associated with the high amounts of fruit and vegetable FLW (Henz, 2017).

To compare the results of this study with the findings of the literature – such as Gustavsson et al. (2011) and Oelofse and Nahman (2013) – we calculated the generation of FLW, per capita, for each step of FSC in Brazil and the quantity referring to the edible proportion. In 2007, 77.7 million tons of FLW were generated in Brazil by a population of around 184 million inhabitants (IBGE, 2013). The per capita generation was of 422kg,

[3] Relative the activities that are exercised in vegetable gardens and small farms.

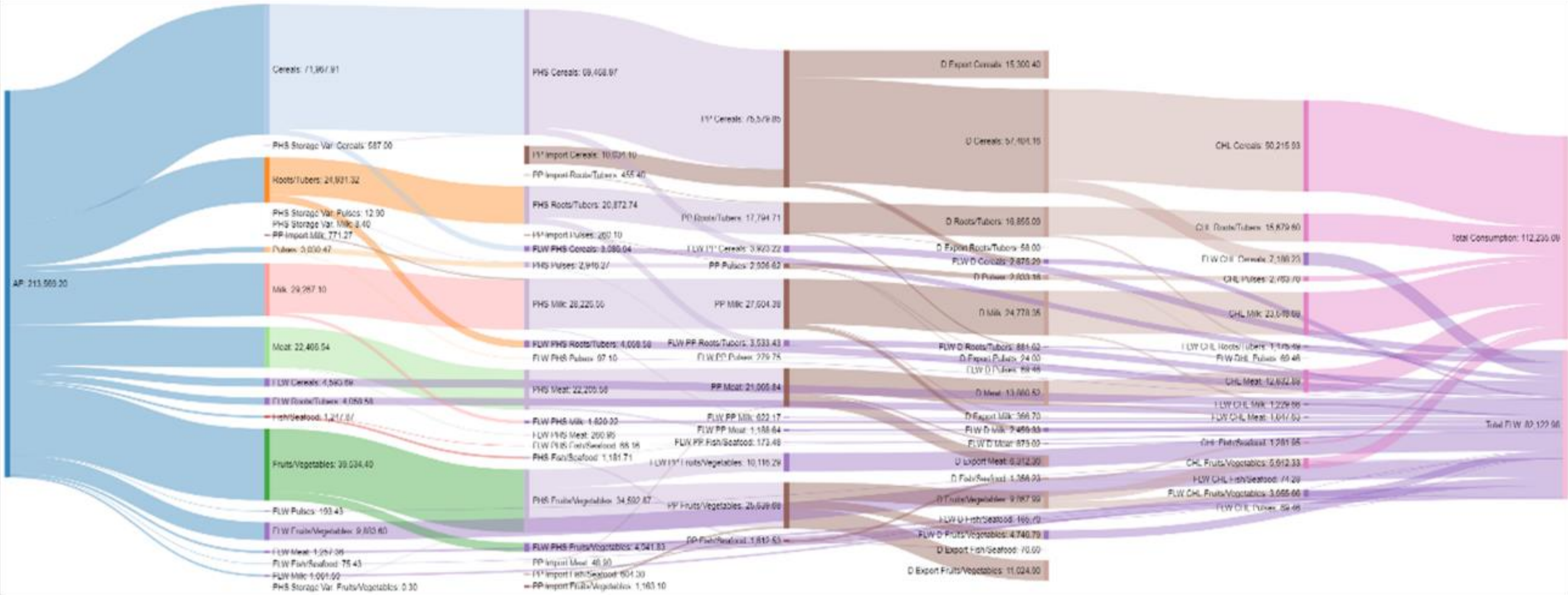

Figure 3. Sankey diagram of the Brazilian food supply chain (2007-2013).

being the proportion of the edible part of 323kg, as observed in table 2. Gustavsson et al. (2011) calculated, for Latin America, 225 kg per capita for the same year. The estimated calculated for Brazil was almost 100 kg higher than the value calculated in the edible proportion and almost 200_kg in the total generation of FLW. Oelofse and Nahman (2013) estimated the value of 177 kg per capita of FLW along the FSC of South Africa in 2007, being close to the one calculated by Gustavsson et al. (2011) of 170 kg year per capita; however, they did not identify the edible portion of FLW.

A higher per capita number is expected for Brazil compared to other Latin American countries, once the country has the highest gross domestic product (GDP) among the countries of this region (WB, 2017) and there are indications of a strong correlation between GDP of a country and its generation of FLW (UN, 2011b). For South Africa, Oelofse and Nahman (2013) warn that a higher per capita number of FLW is expected for South Africa, as the country has the highest GDP of all sub-Saharan African countries (WB, 2017).

In terms of GDP per capita, Brazil went from went from position 68 in 2007 to position 64 in 2013 (IFM, 2018). Although it has improved, when the country's GDP is verified with its GDP per capita, there is a scenario of income inequality and socio-economic disparity, which can influence the quantities of FLW regionally.

Table 2 also presents that the average per capita value of FLW between 2007 and 2013 is 427 kg per inhabitant/year. Moreover, analyzing the internal supply of food, the daily supply of food for the population of Brazil was 0.967 grams per capita in 2007, and the daily supply of food was 1.012 grams per inhabitant/year during 2007 and 2013.

Table 2. Estimates of total and per capita food loss and waste in Brazil.

Steps in the food supply chain	Food loss and waste (1000 Tonnes)		Food loss and waste (kg/habitante)		FLW edible proportion¹ (1000 Tonnes)		FLW edible proportion (kg/habitante)	
	Total (2007)	Total (2007-2013 Avarage)	2007*	2007-2013**	Total (2007)	Total (2007-2013 Avarage)	2007*	2007-2013**
Agricultural production	20423.05	21123.60	111.00	110.09	15725.75	16265.17	85.47	84.77
Postharvest handling	13818.14	14330.80	75.10	74.68	10639.96	11034.72	57.83	57.51
Processing - Packaging	19185.08	19836.97	104.27	103.38	14388.81	14877.73	78.20	77.53
Distribution	10946.72	12091.20	59.50	63.01	8428.97	9310.23	45.81	48.52
Consumption	13402.36	14740.40	72.84	76.82	10319.82	11350.11	56.09	59.15
FLW total	**77775.34**	**82122.98**	**422.72**	**427.98**	**59503.31**	**62837.95**	**323.41**	**327.48**

* Population= 183.989.711; **Population mean= 191.884.271; ¹ Edible proportion: AP:77%; PHS:77%; PP:75%; D:mean=77%; CHL:mean=77%.

Figure 4 summarizes the quantities of domestic food supply in Brazil from 2007 to 2013 and the quantities of FLW, with their respective percentages. The estimates identified for Brazil reflect a preliminary evaluation of the generation of FLW in FSC.

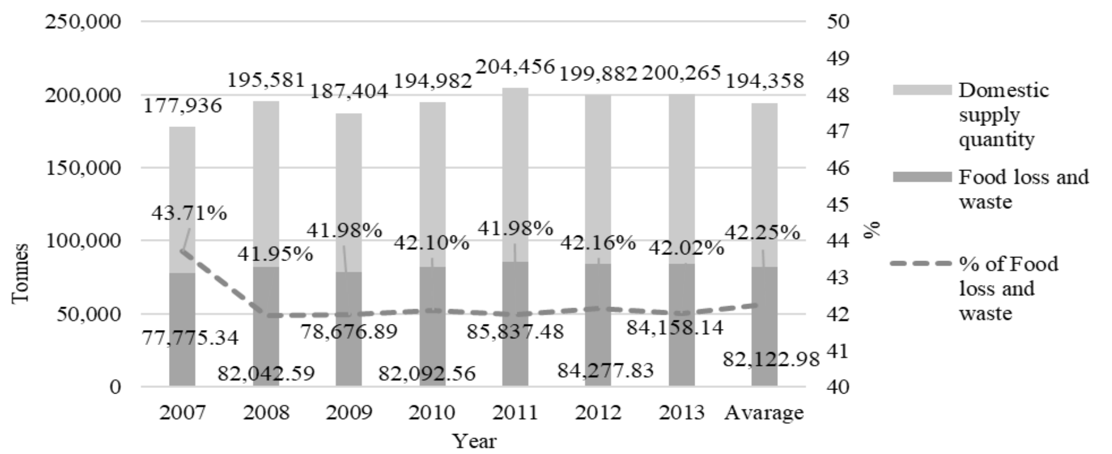

Figure 4. Representation of food loss and waste in relation to the domestic supply quantity (2007-2013).

It is worth noting that the calculations were based on official data representing some CGs, not including products originating from the informal markets. For instance, the city hall of São Paulo estimated a FLW of 160 tons of food per day, mainly of fruits and vegetables, resulting from the street markets (informal) (Secom-SP, 2017). Therefore, to provide a more realistic image, these estimates should be inserted into the calculation, which can alter the amounts of FLW in some of the steps that compose the Brazilian FSC. Furthermore, it is important to notice that the estimates of FLW calculated in this manuscript for the different stages of FSC may be underestimated or overestimated due to the proportions of Gustavsson et al. (2011) referring to Latin America and due to the limitations of this study.

In this way, the results provide a first estimate on FLW, but more detailed and specific estimates are needed to use in cost analysis to develop specific FLW mitigation initiatives. It is reinforced the need for further case studies, for example, studies in chains and productive systems. The results estimated here can also be useful to start addressing and evaluating the efficiency of the Brazilian food supply chain, verifying in other future studies the quantities of FLW from production to consumption. Moreover, the need to develop a statistical apparatus on the subject, which can measure the volume of FLW annually with a certain periodicity (Belik, 2018), would reflect on the greater efficacy of punctual actions that need to be developed in the Brazilian FSC.

5 Conclusions

Based on the proposed methodology, the calculated estimates identified greater FLW in the CGs of fruits and vegetables and cereals, when compared with the other groups. When the amounts of FLW per Brazilian FSC step were observed, the production and processing were the steps with the largest quantity.

Approximately 78 million tons of FLW in Brazil were identified in 2007, which accounted for 43.71% of the domestic food supply. The average of FLW between 2007 and 2013 represented 42.24% (82.1 million tons) of the food supply. In terms of per capita quantities, during this period the FLW was 422 kg per inhabitant in 2007 (being that 324 kg correspond to the edible portion) and 427 kg per inhabitant/year (being that 327 kg correspond to the edible portion of food). Since Brazil is one of the players in the global FSC, it is important to know the magnitude of the FLW generated. This exercise contributes to this discussion. In addition, it is recommended to verify the highly aggregated results presented herein through the gathering of primary data throughout the FSC.

The main limitation of this study is related to methodology. The use of aggregated data has made it difficult to screen the import and export data to be inserted or not, in the respective steps of the FSC in which they should be considered or not. It is also assumed that it is possible to identify FLW in the different steps of the chain considering the insertion of these aggregated data. Moreover, the lack of other scientific publications in this subject did not allow to compare results with other countries, which would have enriched the discussion.

The identification and quantification of the FLW in specific phases of the FSC is still indispensable. Understanding the amount of FLW produced as well as its value in terms of their impacts in the FSC are relevant information, which the food industry and policymakers can use to raise awareness on the issue. Furthermore, a more accurate evaluation of FLW could improve the management practices during the FSC steps. Thus, using strategies to reduce FLW in the country, its mitigation and/or its monitoring over time, can increase the efficiency of the links in the FSC in favor of the sustainability of the planet.

Finally, it becomes opportune to rethink the Brazilian FSC in a broader way, including research and discussions on production and consumption systems and their alignment with public policies on food security, reduction of greenhouse gas emissions and efficient use of food produced.

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Appendix A. Supplementary data
Please view the supplementary data below for enhancing the understanding of this article.

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CAPÍTULO 4

Total and per capita amount and monetary value of food waste in Brazilian households[4]

Abstract:
Estimated population growth in developing countries makes it necessary to seek solutions to the problem of hunger. However, increasing agricultural production without reducing food loss and waste is not the solution to mitigate it. In order to understand the values that represent this theme, the objective is to estimate the values of household food waste generated in Brazil. For this, the population data of per capita household food acquisition and per capita food waste sample data were used. The foods rice, corn, beans, vegetables, fruits, noodles/pasta, breads, meat, fish, chicken, eggs and milk were organized into food groups. The percentage of household waste and its respective monetary value were calculated for the different Brazilian regions in the period 2008-2009. The average percentage of food waste was 12.88% in Brazilian households. The Northeast Region (18.18%) presented the highest percentage of waste, while the South Region (8.18%) presented the lowest. The food groups of noodles and pasta, beans, corn, chicken and rice presented the highest percentages of waste. The milk, meat and fruit groups presented the lowest percentages of waste. The average monetary value, referring to annual food waste, was R $ 56.89 per household. The Northeast Region (R $ 80.94) presented the highest value of waste, while the South Region (R $ 44.73) presented the lowest. The average monetary value attributed to household food waste generation in Brazil corresponded to R $ 3.28 billion, or US $ 1.37 billion.
Keywords: acquisition, Brazil, consumption, food insecurity, domestic food supply

1 Introduction

Food, plays a central role in social, economic and cognitive interactions, besides providing essential nutrients for the development and maintenance of human life (Defra, 2010). However, many of the foods used in the world end up lost or wasted. It is estimated that between 30% and 50% of all uneaten foods in the human stomach (Lipinski et al., 2013; Rentizelas et al., 2014), and up to 60% of foods released into health products, are still considered food. edible (WRAP, 2011a; Mason et al., 2011).

According to FAO (2013), produces enough food worldwide for a diet of approximately 2,700 calories/person/ day. However, the amount of food available for consumption varies by country. For example, between 2007 and 2013 Brazil recorded an average domestic food supply of 112.2 million tons (Dal' Magro and Talamini, 2019). This represents 584 kg / inhabitant / year.

Food loss or waste (FLW) refers to these foods, which have been diverted from their original function, nutrients, and discarded under-consumed conditions. FLW can occur at all stages of the food supply chain (FSC), from harvesting to post-consumption (HLPE, 2014). Globally, it symbolizes the reduction of food availability (mass, calories or nutrients), but the local level has more diverse and indirect effects related to food security (Pinstrup-Andersen, Gitz, and Meyback, 2016).

FLW along the FSC directly affects food availability, affecting all stages and causing different actors to have different economic impacts. The more food is wasted, the

[4] This manuscript was submitted for evaluation in the Journal Waste Management. The text was written in British English and follows the author guidelines of the journal. Appendix C complements the manuscript.

more or more it is charged at the end of the chain, that is to say, the FLW contributes to higher food demand and subsequently, higher prices (Stuart, 2009; HLPE, 2014). According to Alexandratos and Bruinsma (2012), the accurate food supply increases by 60% (estimated 2005 food production levels) to meet the required food demand by 2050. In another prediction, Tilman et al. (2011) estimate a need for a 100% increase in global agricultural production by 2050. On the other hand, if the FLW is halved, or the necessary increase for 25% serious food production by 2050 (FAO, 2014a).

Generally, the largest amount of FLW occurs at the FSC consumption stage (Monier et al., 2010; Parfitt, Barthel and Macnaughton, 2010; Gustavsson et al., 2011; Kranert et al., 2014), is called waste. D'Silva et al. (2010) report that the waste in the consumption stage can be born in 1950, due to changes in the lifestyle of consumers, attributable to socioeconomic and cultural variables. However, the generation of FLW in the consumption stage is linked to different factors ranging from pre-consumption to post-consumption.

For Evans (2012), consumers do not plan the waste and some even feel guilty when this occurs. However, it is difficult to totally control the food waste in households, as there are several interaction activities that affect the amount of food wasted (Mondéjar-Jiménéz et al., 2016; Quested et al., 2013). Such interactions may be related to business negotiations and necessary interactions, as well as inappropriate domestic practices (Evans, 2012). Waste can occur from preparation, with some food being underused, until the time the food is served and not consumed (Pekcan et al., 2014). In addition, the short shelf life of some foods coupled with improper management of purchased samples can be delayed for further waste (Vanham et al., 2015).

Although many causes of despair are similar between developed and developing countries, such as the expiration of "validity data", other factors vary more widely, such as sociodemographic resources and cultural traditions manifested through individual behavior (Buzby and Hyman, 2012). The presence of macro and microenvironmental factors causes and influences desperate consumer behavior (Watson and Meah, 2013; Graham-Rowe et al., 2014), showing the understanding of this even more complex phenomenon.

In industrialized countries, food loss and waste occur in greater numbers (Gustavsson et al., 2011; Lipinski et al., 2013; Halloran et al., 2014; Thi et al., 2014). One possible explanation is that population growth and urbanization speed influence FLW generation (Adhikari et al., 2006). Thus, the constant increase in population in developing countries, attention and attention, pose greater challenges for FLW management in industrialized countries (Thi, Kumar and Lin, 2015).

In the case of Brazil, producing abundant food is not a problem, however, the challenges of enhancing food security and reducing LWF at different FSC stages remain (Belik, 2018; Porpino et al., 2018, Dal' Magro and Talamini, 2019). It was estimated that between 2007 and 2013, 42% of all food produced and offered were lost or wasted throughout the Brazilian FSC (Dal’ Magro and Talamini, 2019).

Therefore, to avoid waste, you need to understand the reasons for its generation and how much it represents. However, in developing countries, there is a lack of historical data making it difficult to understand and plan for FLW generation (Dyson and Chang, 2005). It is noteworthy that estimates are an important part of the planning process, as they provide guidance for decision making. In this sense, to contribute toward actions, tools, and projects facing the contextualized problem, the objective is to estimate the percentage and the corresponding monetary value of the Brazilian household food waste.

2 Quantifying household food waste in Brazil

Reconciling the existing studies with the data set necessary to achieve the objective of this research, we chose to use the mixed estimation method, defined by Van der Werf and Gilliland (2017).

2.1 Data used

This study uses population data that correspond to the food acquisition values of the Family Budget Survey (POF) of the Brazilian Institute of Geography and Statistics (IBGE), 2008-2009. The quantity purchased (in kilograms) and monetary expenditure (in Reais) were used. For each variable, a sample weight with an expansion factor was applied, which allows estimates of quantities to be obtained for the entire research universe. In this sense, it is justified to use these data, as they correspond to products purchased for consumption by the entire Brazilian population.

For the analysis of food waste, the estimates identified by Porpino et al. (2018) for food groups: rice, maize, beans, vegetables, fruits, noodles/pasta, bread, meat, fish, chicken, eggs, and milk. The authors based their research on Van Geffen (2017) and adapted it to the Brazilian food reality.

2.2 Description of the collection

The average per capita food acquisition data (kg) and the average per capita food monetary expenditure (Reais) for Brazil and Regions[5] were used. The average of residents per household and the number of households for the Regions and Brazil were extracted from the POF (IBGE, 2010a). These data correspond to the latest official survey available from IBGE. In addition, data corresponding to the average per capita household food waste (in kilograms) identified by Porpino et al. (2018) for Brazil and Regions.

After extracting the data of interest, they were organized by food groups. The delimitation of the food groups selected for this research is linked to the identification of these, in both source surveys, mentioned above. In this sense, 13 food categories were selected. Supplementary Figure 1 presents the foods that integrate each group in the respective research and the nomenclature used in the 13 food groups analyzed in this study.

2.3 Data analysis

After identifying the amount of per capita food acquisition, the per capita monetary expenditure and the amount of waste per capita, the values were transformed to households, according to the average of inhabitants by Region, indicated by the POF (IBGE, 2010a).

Thus, the estimated percentages of waste for each Region and for Brazil were calculated. Measurement of the percentage of Brazilian household food waste (bhfw, in percent) is defined by household food acquisition (hfa, in kilograms) minus household food waste (hfw, in kilograms), as (Equation 1). That is, the percentage of Brazilian household food waste was calculated from the difference between the food available for

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[5] Regions and its respective States: North (Acre – AC; Amazonas – AM; Rondônia – RO; Roraima – RR; Amapá – AP; Pará – PA; Tocantins – TO); Northeast (Maranhão – MA; Piauí – PI; Ceará – CE; Rio Grande do Norte – RN; Paraíba – PB; Pernambuco – PE; Alagoas – AL; Sergipe – SE; Bahia – BA); Midwest (Mato Grosso – MT; Goiás – GO; Distrito Federal – DF; Mato Grosso do Sul – MS); Southeast (Minas Gerais – MG; Espírito Santo – ES; Rio de Janeiro – RJ; São Paulo – SP); South (Paraná – PR; Santa Catarina – SC; Rio Grande do Sul – RS).

household consumption and the amount of food identified as wasted in households, both in kilograms. The percentages were organized by household[6].

$$\%_{bhfw} = (\bar{x}_{hfa} * 100)/\bar{x}_{hfw} \quad (1)$$

At where:
$\%_{bhfw}$= percentage of household food waste in the household food group;
$\bar{x}_{hfa}$= average annual household food acquisition by food group in kilograms;
$\bar{x}_{hfw}$= average annual household food waste per food group in kilograms.

The monetary value of household food waste (bhfw) was calculated from the estimated percentage of physical waste (Equation 2). For each food group, the average annual household food purchase expenditure (hfp, in Real – R$) was deducted from the corresponding percentage of household food waste (hfw, in %). Therefore, the estimated monetary value of waste was calculated for each Region and for the product groups analyzed. It is noteworthy that the monetary values of waste integrate the value of household food monetary expenditure, however it is not used for consumption. Monetary values were organized by household[7].

$$R\$_{bhfw} = (\bar{x}_{R\$hfp} * \%_{hfw})/100 \quad (2)$$

At where:
$R\$_{bhfw}$= monetary value of household food waste in the household food group;
$\bar{x}_{R\$hfp}$= average value of annual household food purchase expenditure for the food group, in Reais (R$);
$\%_{hfw}$= percentage of household food waste per food group.

The monetary values identified in Equation 2, corresponding to each food group, were grouped by Region. In this sense, the sum of the groups of each Region ($\bar{x}_{R\$bhfw}$) represents the monetary value of household food waste for each Brazilian Region ($\sum R\$_{bhfwR}$), according to Equation 3.

$$\sum R\$_{bhfwR} = (\bar{x}_{R\$bhfw1} + \bar{x}_{R\$bhfw2} + n \ldots + \bar{x}_{R\$bhfw13}) \quad (3)$$

At where:
$\sum R\$_{bhfwR}$= sum of the monetary value of household food waste for each Region, in Reais (R$);
$\bar{x}_{R\$bhfw(n1 \ldots n13)}$= average amount of annual household food purchases expenditure for the food group, in Reais (R$).

The total amount, representing the monetary value of household food waste in Brazil (Equation 4). It was calculated from the sum of the monetary value of household food waste for each Brazilian Region ($\sum R\$_{bhfwR}$), multiplied by the number of corresponding households in the respective region.

$$\sum R\$_{bhfwBR} = \sum R\$_{bhfwR} * NHRe \quad (4)$$

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[6] For more information see Supplementary Figure 2.
[7] For more information see Supplementary Figure 3.

At where:

$\sum R\$_{bhfwBR}$= monetary value of household food waste generated in Brazil, in Reais (R$);

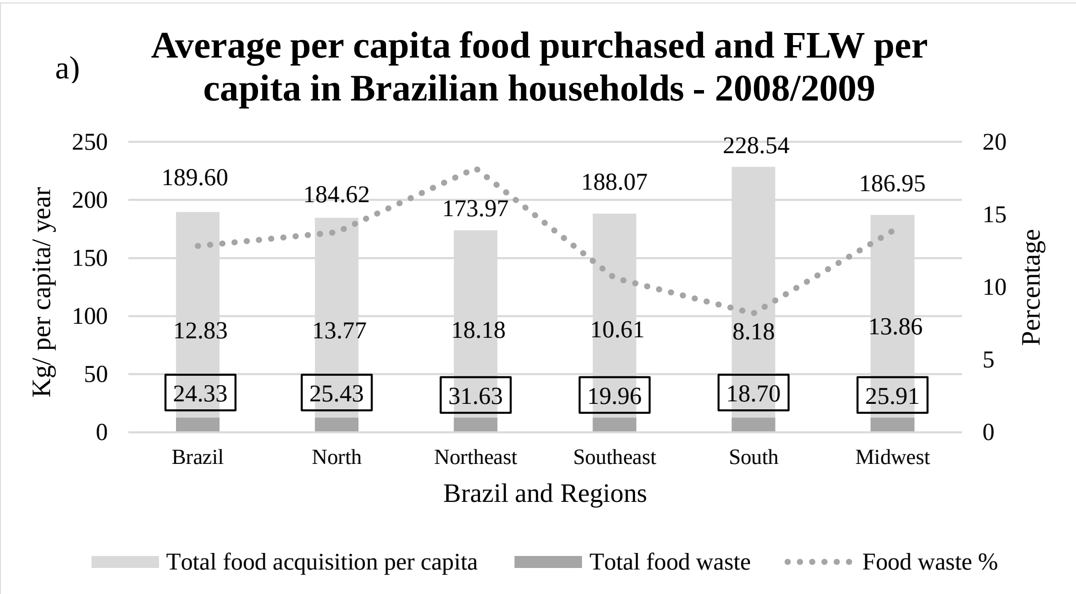
$\sum R\$_{bhfwR}$= sum of the monetary value of household food waste for each Region, in Reais (R$);

NHRe = number of households by Region (South, Southeast, Midwest, Northeast, and North).

3 Results and Discussion

3.1 Estimating the percentage of household food waste generated in Brazil and Regions

The average purchase of food and beverages for Brazilian household consumption in 2008 was 944.5 kg / per capita/year (IBGE, 2010b). The average per capita acquisition of the product groups analyzed in this research was 189.60 kg, as shown in Figure 1 (a). The value corresponds to 1/5 of all food and beverages purchased in 2008. When analysed by region, the South (228.54kg) was the one that bought the most food and the least purchased was the Northeast (173.97kg). Figure 1 (b) shows the average household acquisition for each Brazilian region. The average acquisition of food per household in Brazil was 2,833,5 kg in 2008. Among the food groups analyzed per household, the North region (720kg) was the one that bought the most food and the least purchased was the Southeast and Midwest (590kg).



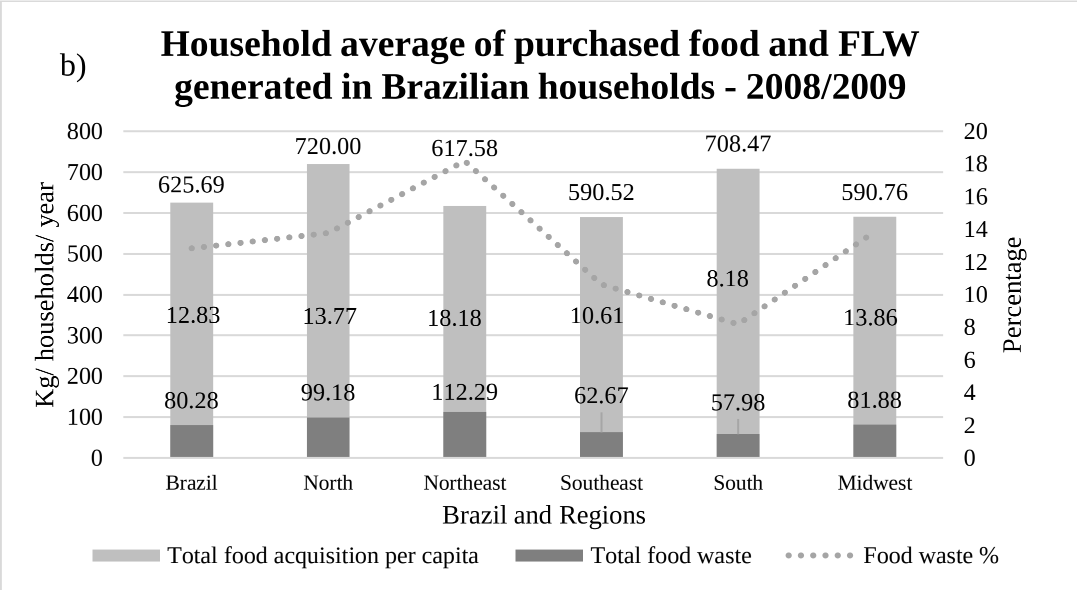


Figure 1 - Quantification of food acquisition and waste in the Brazilian Regions – 2008/2009.

FAO (2014b) estimated for Latin America that 28% of food reaching the end of FSC is wasted at the consumer level. However, considering only the food groups studied in this study, we identified for Brazil the average percentage of food waste at home of 13%. It should be noted that there is a variation between the Regions. The Northeast Region (18.18%) had the highest percentage of waste, while the South (8.18%) had the lowest.

Among the studied foods, the Brazilian Northeast Region presented the lowest food acquisition and the highest percentage of waste. This research corroborates research carried out by the Department of Nutrition of the University Center of Rio Grande do Norte, which identified the generation of 25% of food waste in families in the state of Rio Grande do Norte (TN, 2013).

Other research carried out in the Northeast Region verified the food waste in fairs, markets, supermarkets, grocery distribution center and some restaurants in the city of São Luís, capital of Maranhão. The survey was conducted by the Municipal Food Safety Council and identified that 80 tons of food is wasted per year, and of this total, 30 tons could be benefited and reused by distributing it to the needy population (Capital ..., 2013). In this sense, we can see the development of initiatives that estimate FLW in different stages of FSC and the results bring a warning to the high amounts of food wasted in the Northeast of Brazil.

On the other hand, the Southern Region had the highest amount of food purchased and the lowest percentage wasted. Therefore, it can be stated that the quantity purchased and quantity wasted are not directly related.

The coexistence of other factors that permeate FLW generation, such as behavioral, cultural and sociodemographic factors, may influence the amount of FLW generated. Falasconi et al. (2019) say that individual and social aspects should be considered in the analysis of wasteful behavior, as they form the food choices of individuals. Behavioral habits such as food preparation and eating decisions (Soyeux, 2010), or why prioritizing family preferences rather than reusing food leftovers (Cappellini and Parsons, 2012; Graham-Rowe et al., 2014) influence generation waste at home. When prepared food is not fully consumed and left for the other day or not suited to the tastes of family members, potential waste is created (Lee, 2016).

The natural appearance of the food or the design of the products may also influence eating habits. For example, the decision to peel an apple or eat a peeled potato (Halloran et al., 2014) is up to the consumer. In addition, purchasing, coordination and time planning habits influence the generation of waste (Soyeux, 2010). Difficulty in managing routine and lack of skills in dealing with food purchases and leftovers (Stancu, Haugaaard and Lahteenmaki, 2016), associated with inadequate or insufficient use of storage and freezing practices, and overeating (Cox and Downing, 2007; WRAP, 2008a; Koivupuro et al., 2012; Porpino et al., 2015), result in waste in the consumption stage. In addition, marketing techniques that encourage consumers to buy excessively on impulse or food (WRAP, 2011b; Williams et al. 2012) may also be influential in FLW generation.

Dealing specifically with Brazil, Mores, Talamini, and Dewes (2017) identified that the states that make up the Great Brazilian Regions have similarities in their dietary patterns. The authors suggest that the main drivers of changes in dietary patterns in different regions are associated with changes in the regional agricultural base, the availability of new foods and new crops, and the change in population income, leading to new eating habits. These factors can influence the organization of a new FSC, which results in higher food supply and probably distinct behaviors regarding FLW generation between Regions.

That way, Figure 2 presents the variation of the estimated FLW percentage in Brazilian households. An analysis was made for each food group comparing the Great Brazilian Regions. The foods classified in the scientific literature as carbohydrates[8] presented the highest percentages of waste. Noodles and pasta (47.6%) with beans (47.4%) were the foods with the highest average percentages of waste in Brazilian households, followed by corn (38%), chicken (29%) and rice (22.6%).

According to Figure 2, the Midwest was the Region that presented the highest percentages of noodles and pasta waste and beans. Already meat presented the highest percentages in the Northeast. This may have occurred because the Region had the second smallest number of respondent participants in the research developed by Porpino (2018), second only to the Northern Region. In this sense, the percentage of waste for the Northeast Region increased. Another explanation may be related to a large amount of food, which was wasted at the time of the research.

Additionally, when using another perspective, among the foods with the lowest percentages of waste are milk, meat, and fruits. None of these foods had a national average household waste greater than 4%. However, it should be noted that 86% of losses and waste of fruits and vegetables in Brazil occur during the exposure of the product for sale, 9% happen in transportation and 5% in storage (Melo et al., 2013).

When analyzing vegetables, a national average of 17% waste for vegetables and 9% for vegetables was identified. On the other hand, in a study by Fehr and Romão (2001), the authors found 16.6% waste of fruits and vegetables from a sample study conducted in households in a medium-sized Brazilian city. Moreover, Gustavsson et al. (2011) when analyzing the generation of FLW in Latin America, identified the percentage of 5% waste for these foods in the consumption stage.

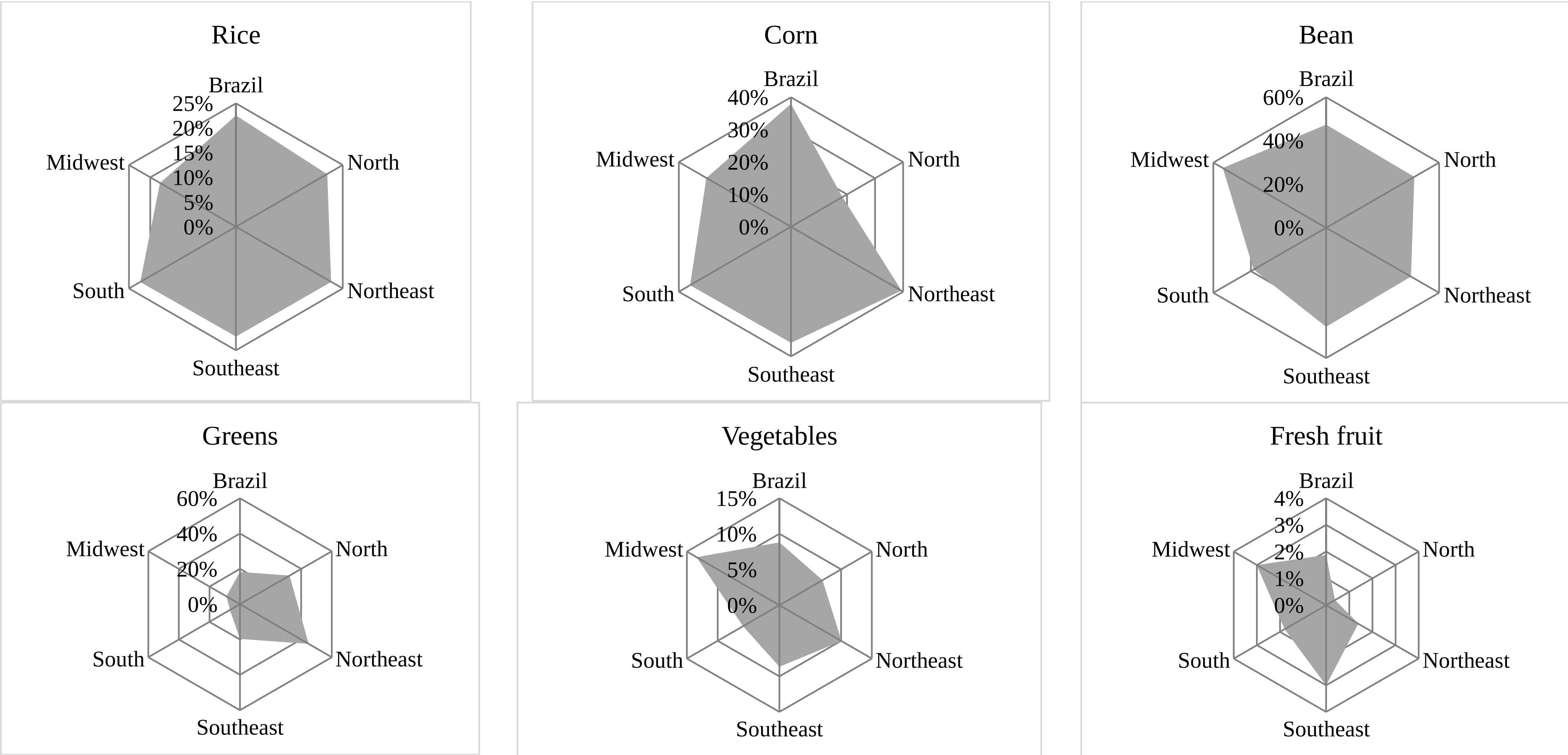
These amounts of waste vegetables, fruits and vegetables may also be related to the packaging of these products. Because it is a perishable product, it is necessary to supply these foods to the consumer through dynamic logistics, including a cold chain to minimize FLW (Jedermann et al., 2014). In this sense, the authors mention that the

[8] The designation carbohydrates derived from the general formula $(CH_2O)_n$ presented by most of these molecules (Júnior, 2008).

existence of a dynamic, cold chain logistic structure results in longer food life. Besides improving quality and efficiency, the cold chain offers high-quality perishable products, assists with accurate life forecasting, aids in stock organization and supplies and storage of perishable foods considered seasonal (Jedermann et al., 2014).

Another weighting observed corresponds to the Brazilian Regions with the highest average temperature, in which the highest percentages of waste were recorded. In this sense, this characteristic may be related to the high waste of these foods, especially the perishable ones, because the food may not have been adequately conditioned, resulting in waste. In addition, according to Porpino, Parente, and Wansink (2015), Brazilians like the freshness of products and vegetables, vegetables and fruits are foods considered abundant and of lower added value in Brazil. These characteristics may result in repeated acquisitions and increased waste generation in Brazilian households.

Although Brazil has a high generation of food losses in the postharvest stages (Soares, 2009), it also has high waste generation in the consumption stage. The high values in waste generation show that Brazil has both low-income and developed country characteristics when it comes to FLW (Porpino, Parente and Wansink, 2015).


Rice
Brazil
25%
20%
15%
10%
5%
0%
North
Northeast
Southeast
South
Midwest
Corn
Brazil
40%
30%
20%
10%
0%
North
Northeast
Southeast
South
Midwest
Bean
Brazil
60%
40%
20%
0%
North
Northeast
Southeast
South
Midwest
Greens
Brazil
60%
40%
20%
0%
North
Northeast
Southeast
South
Midwest
Vegetables
Brazil
15%
10%
5%
0%
North
Northeast
Southeast
South
Midwest
Fresh fruit
Brazil
4%
3%
2%
1%
0%
North
Northeast
Southeast
South
Midwest


Noodles/pasta
Brazil
80%
60%
40%
20%
0%
North
Northeast
Southeast
South
Midwest
Breads
Brazil
8%
6%
4%
2%
0%
North
Northeast
Southeast
South
Midwest
Beef
Brazil
4%
3%
2%
1%
0%
North
Northeast
Southeast
South
Midwest
Fish
Brazil
6%
4%
2%
0%
North
Northeast
Southeast
South
Midwest
Chicken
Brazil
60%
40%
20%
0%
North
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Northeast
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South
Midwest

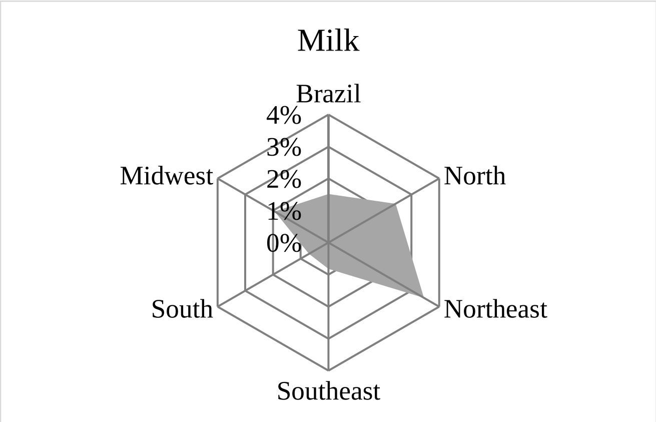

Figure 2 - Average percentage of household waste for different food groups in Brazil and Regions - 2008/2009.

This result demonstrates that household food waste is a proxy for the range of other behaviors. There are strong and positive relationships between some closely related behaviors, mainly planning: planning meals in advance; check food levels before shopping; and make a shopping list (Quested et al., 2013). It should be noted that changes in consumer behavior also become problematic, as the population tends to underestimate the amount of food they waste (Quested et al., 2011).

Household food waste generation becomes a private matter, as the results of adopting waste mitigation practices are generally less visible to friends, family, and neighbors than when compared to recycling, car use practices. and the reuse of plastic bags (Tucker and Douglas, 2006). Still, according to the authors, the ability of specific social norms to influence particular practices of mitigating household food waste may not be as effective as some more visible social behaviors.

According to the literature, waste generation may be related to sociodemographic factors. The size and composition of the household, the characteristics of the household, the gender of the person responsible for providing food, the age and income of the household members, and the existence or otherwise of practices that reduce waste (Jörissen, Priefer and Bräutigam, 2015; Lee, 2016) are associated with the amount of food wasted.

For example, studies analyzing per capita waste have identified that people living alone generate more waste (Parfitt, Barthel and MacNaughton, 2010; Koivupuro et al., 2012). On the other hand, families with large numbers of individuals tend to waste less food (WRAP, 2008a). When analyzed by gender, it can be stated that women tend to waste more food than men, especially when they are responsible for providing food at home (Bar, 2007; Secondi, Principato and Laureti, 2015). Considering age, older individuals tend to waste less food compared to younger individuals (Lyndhurst, 2007; Quested and Johnson, 2009; Principato, Secondi and Pratesi, 2015; Blichfeldt, Mikkelsen and Gram, 2015). In addition, families that have members with completed higher education generate more waste (Monier et al., 2011; Koivupuro et al., 2012).

3.2 Valuing household food waste in Brazil and Regions

Household waste can be translated into monetary values. The Brazilian disbursed the average per capita value of R$ 319.08 in the purchase of food and beverages for home consumption in 2008 (IBGE, 2010b). The average monetary value per capita for the purchased foods that make up the scope of this study corresponds to R$ 190.30. That is, 59.64% of the total spent in 2008 on the purchase of food for home consumption. In this sense, Figure 3 (a, b) shows the per capita and household monetary average of food purchased, with the monetary value corresponding to waste for the Regions.

The average monetary value of food purchase was R$ 631.29 per household, as shown in Figure 3 (b). The Northern Region (R$ 726.29) presented the highest monetary values spent on food acquisition analyzed in this study. On the other hand, the Midwest Region (R$ 548.24) had the lowest expenditure per household, among the analyzed regions.

When analyzing the valuation of waste generated per household, the Southern Region (R$ 44.73) presented the lowest monetary value. On the other hand, the Northeast Region (R$ 80.94) presented the highest value. Comparing with the value of the basic food basket calculated by DIEESE[9], in January 2009, the value corresponding to

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[9] The products of the Basic Basket and their respective monthly quantities are different by region and were defined by Decree Law No. 399 of 1938, (which remains in force). Foods that make up the basic basket

household waste generated in the Southern Region corresponds to 18% of the average value of the basic food basket calculated among the three capitals of the Southern Region. Brazil, corresponding to R$ 235.64 (DIEESE, 2009). Developing the same ratio for the Northeaster capitals studied by DIEESE, the average value calculated for the basic food basket was R$ 188.66 (DIEESE, 2009). Thus, the monetary value corresponding to household waste generated in the Northeast Region was almost half (42%).

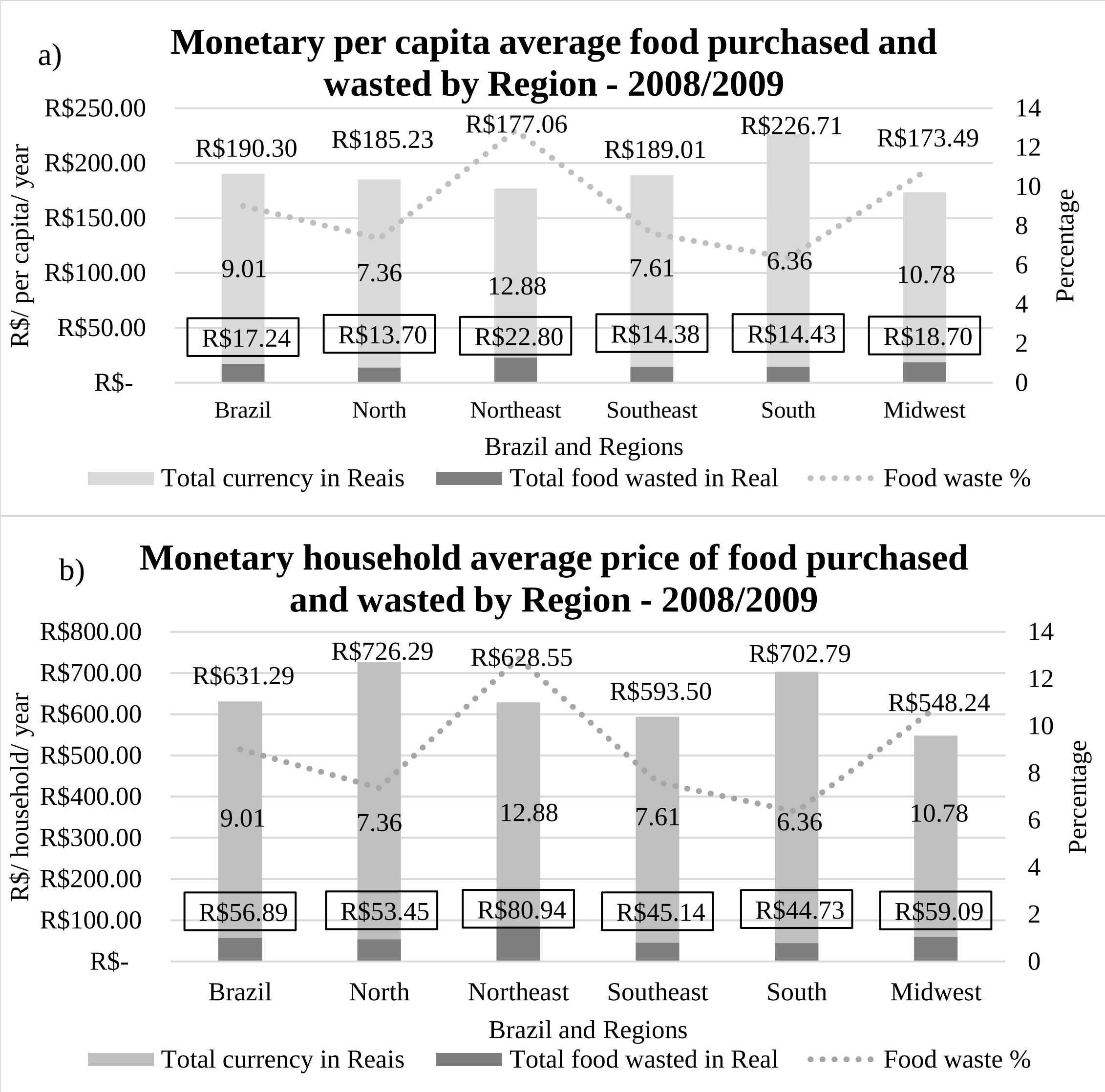


Figure 3 - Monetary values of food purchased and wasted in the Brazilian Regions - 2008/2009.

Treating the relationship between income and waste, Gustavsson et al. (2011) state that poverty and limited household income make food waste unacceptable. However, Cox and Dowling (2007) point out that low-income families tend to waste more food. Aliber (2009) studied household food spending in South Africa. The author found that low-income households spend 37% of total food spending, compared with 7% for high-income households. Therefore, although high-income households generate more waste

prepared by DIEESE: meat, milk, beans, rice, flour, potatoes, vegetables (tomato), french bread, coffee powder, fruit (banana), sugar, lard / oil and butter (DIEESE, 2016).

per capita, the proportion of food waste to total waste is generally higher among low-income households.

Regarding this relationship of income and food waste, there is still no consensus in the literature (Marangon et al, 2014). Stefan et al. (2013) found that higher family income generates more waste. Williams et al. (2012) in an exploratory study conducted with 61 Swedish families found no correlation between income and waste. Another study by Quested and Johnson (2009) based on self-reports from 300 participants in the United Kingdom found that differences in the amount of food waste between socioeconomic classes were minimal. However, it is known that low-income people waste food because they are less likely to plan their purchases WRAP (2010). In addition, individuals with higher incomes tend to waste more (Monier et al., 2011).

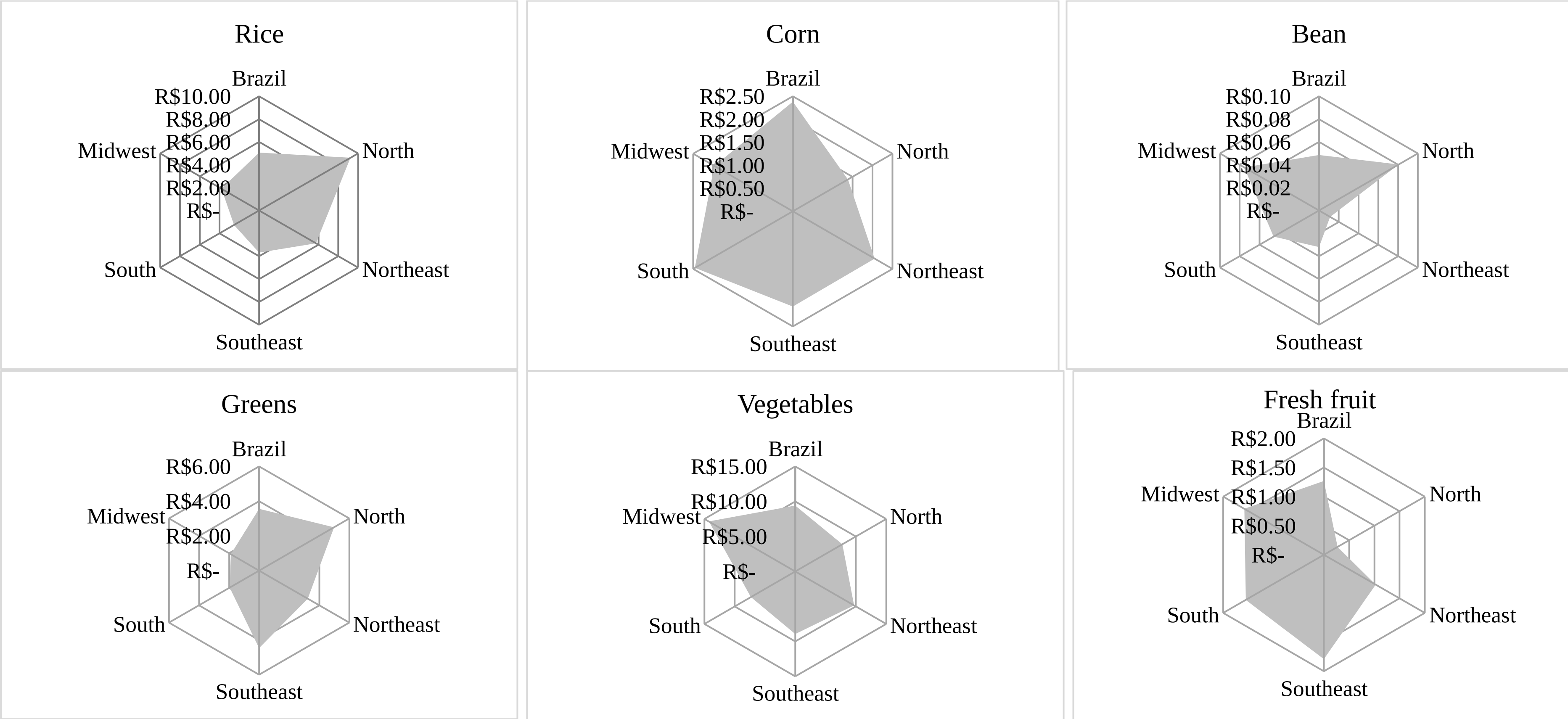
There is an inversely proportional relationship established between household income and the share of food expenditure in the household budget, compared between different income classes in the same country or different countries (Seale et al., 2003; Hicks, 2013). Therefore, in low per capita income countries such as Brazil, a greater relative loss of income in food waste is expected. In developing countries, food costs can account for more than half of the household budget, and FLW can have a disproportionate impact (Pinstrup-Andersen, Gitz, and Meyback, 2016). On the other hand, the authors argue that in richer countries, food spending does not exceed 15% of household income. Therefore, that is to say that higher food prices and economic losses caused by consumer waste have less impact on livelihoods.

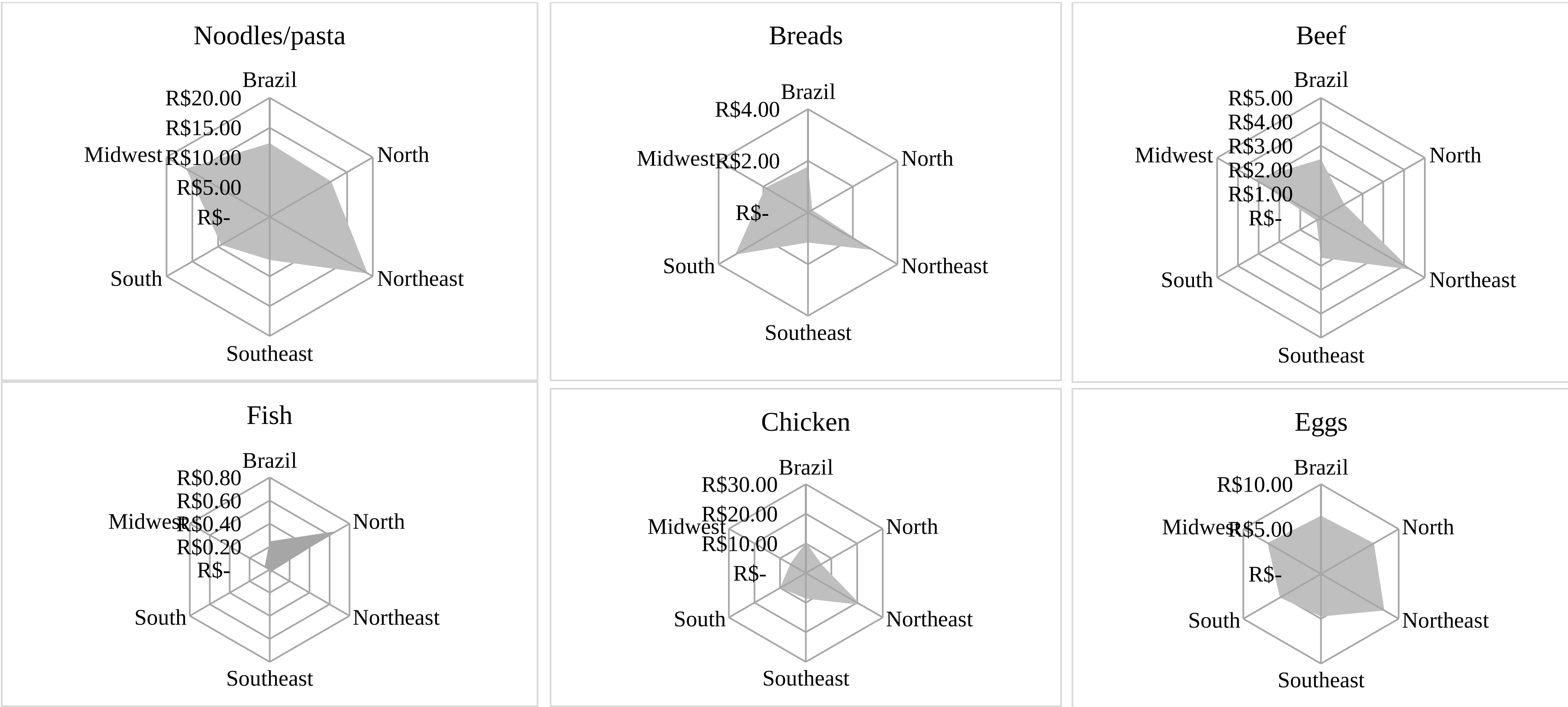
The relationship of income to household food transition, especially in developing countries, results in changes in dietary patterns of starch staple food consumption to more diversified diets with relatively high-value animal products (Oelofse and Nahman, 2013). This transition also leads to increased consumption of perishable and short-shelf foods such as fruits and vegetables, resulting in greater food waste (Lundqvist, Fraiture and Molden, 2008).

In Brazil, the poorest Region obtained the highest monetary value in wasted food. This can be explained by the study by Porpino, Parente, and Wansink (2015), which found that the lower-income population uses consumption strategies instead of saving money, generating more food waste. Such strategies can be: buying bulk foods, buying monthly, preferring a certain supermarket, cooking from scratch and preparing food in abundance. Moreover, the same research pointed out that among the distinct behaviors related to food acquisition in Brazil, abundance at table prevails. It should also be noted that, on the consumer side, staple food accounts for a large portion of the poorest population's spending (FAO, 2011). It should also be noted that staple foods represent the most widely cultivated distinct crops in developing countries, especially small farms.

Figure 4 shows the change in the monetary value of FLW in Brazilian households. For each food group analyzed, a comparison was made between the different Regions. The foods that presented the highest values of waste per household were noodles and pasta (R$ 76.13) along with chicken (R$ 62.71), vegetables (R$ 57.38) and eggs (R$ 38.38).

The Northeast Region presented the highest monetary values of food waste per household for five of the 13 food groups analyzed. The groups were chicken (R$ 21.47), pasta and pasta (R$ 19.00), eggs (R$ 8.17), meat (R$ 4.32) and milk (R$ 3.32). On the other hand, the Northern Region presented the highest monetary values of food waste for the rice groups (R$ 9.23) and vegetables (R$ 4.98), while the Southern Region presented the largest groups of bread (R$ 3.26) and corn (R$ 2.46).


Rice
Brazil
R$10.00
R$8.00
R$6.00
R$4.00
R$2.00
R$-
North
Northeast
Southeast
South
Midwest
Corn
Brazil
R$2.50
R$2.00
R$1.50
R$1.00
R$0.50
R$-
North
Northeast
Southeast
South
Midwest
Bean
Brazil
R$0.10
R$0.08
R$0.06
R$0.04
R$0.02
R$-
North
Northeast
Southeast
South
Midwest
Greens
Brazil
R$6.00
R$4.00
R$2.00
R$-
North
Northeast
Southeast
South
Midwest
Vegetables
Brazil
R$15.00
R$10.00
R$5.00
R$-
North
Northeast
Southeast
South
Midwest
Fresh fruit
Brazil
R$2.00
R$1.50
R$1.00
R$0.50
R$-
North
Northeast
Southeast
South
Midwest


Noodles/pasta
Brazil
North
Northeast
Southeast
South
Midwest
R$20.00
R$15.00
R$10.00
R$5.00
R$-
Breads
Brazil
North
Northeast
Southeast
South
Midwest
R$4.00
R$2.00
R$-
Beef
Brazil
North
Northeast
Southeast
South
Midwest
R$5.00
R$4.00
R$3.00
R$2.00
R$1.00
R$-
Fish
Brazil
North
Northeast
Southeast
South
Midwest
R$0.80
R$0.60
R$0.40
R$0.20
R$-
Chicken
Brazil
North
Northeast
Southeast
South
Midwest
R$30.00
R$20.00
R$10.00
R$-
Eggs
Brazil
North
Northeast
Southeast
South
Midwest
R$10.00
R$5.00
R$-

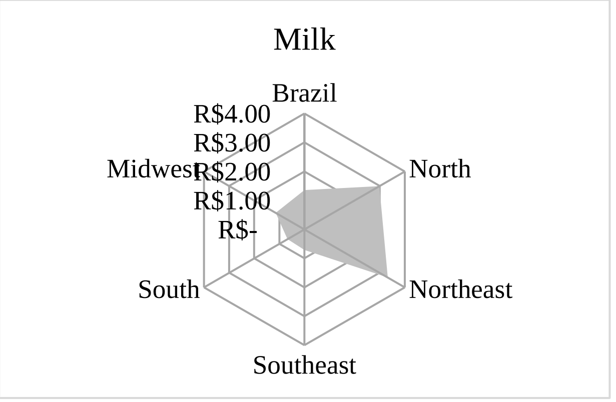


Figure 4 - Average monetary value of household waste for different food groups in Brazil and Regions - 2008/2009.

Beans, corn, fruits, bread, fish, and milk presented the lowest monetary values of household waste. Noodles and pasta, chicken, vegetables, eggs, and rice contributed the most to the monetary value of household food waste, as shown in Supplementary Figure 4. On the other hand, the foods with the lowest monetary values of waste are beans, the fish, the milk and the fruits. None of these foods presented average monetary values of household waste greater than 3%.

Typical staples (including rice, wheat, maize, cassava, and potatoes. However, there might be other specific crops such as onions in India, chili peppers in Indonesia) generally have a smaller share of household budgets compared to cereals, fruits, vegetables and animal protein (FAO, 2011). This relationship causes local foods to have a lower aggregate monetary value and their waste may be little considered economically. On the other hand, foods that are transported from other regions have added value, in which any wasted amount will result in high monetary value, focusing on the generated household food waste.

It should be noted that, on average, consumption waste equals eight times more "waste" energy than the loss generated immediately after harvest (Dobbs et al. 2011). Dairy products, for example, require about 3,500g of CO_2 equivalents per kilogram for their production, processing, packaging, storage, transportation, and marketing (Schneider et al., 2013). According to the authors, this value is higher than for fruits and vegetables (320g CO_2 equivalent per kg) and bread and pasta (830g CO_2 equivalent per kg).

Table 1 presents the averages of monetary expenditure values for the Brazilian household food acquisition by Region. The Region with the highest value was the Northeast, followed by the Southeast. It was estimated on average that R$ 56.89 per household was wasted on home consumption. This represented an expense of R$ 3.2 billion in 2008. Converting to the dollar currency, the monetary value of Brazilian household food waste was US$ 1.3 billion.

Table 1 - Average monetary values per household – 2008/2009.

Brazil and Regions	Average value of food purchase	Average value of food waste generated	Number of households	Total value of Brazilian household food waste (in millions)	Corresponding amount in Dollar * (in millions)
Brazil	R$ 631,29	R$ 56,89	57.691.780	R$ 3.282	$ 1,378
North	R$ 726,29	R$ 53,45	3.933.640	R$ 210	$ 88
Northeast	R$ 628,55	R$ 80,94	15.075.821	R$ 1.220	$ 512
Southeast	R$ 593,50	R$ 45,14	25.432.953	R$ 1.148	$ 482
South	R$ 702,79	R$ 44,73	8.874.965	R$ 396	$ 166
Midwest	R$ 548,24	R$ 59,09	4.374.401	R$ 258	$ 108

Note: The minimun wage reference of the survey was R$ 415.00, effective in January 15, 2009.
*The value of the dollar was considered the average of January 2009, being US$ 2.38. Available at: https://www.bcb.gov.br/

Considering the amount of R$ 415.00, attributed as a reference of the monthly minimum wage in Brazil, on January 15, 2009, it can be stated that 13.70% of this value was discarded in the generation of household food waste. This observation becomes important because a significant part of the Brazilian population has low income. In a Brazilian study that analyses the costs of healthy eating, the authors compared current food spending in Brazil across different economic strata. It was observed that households with worse income situations (R$ 71.40 / month, calculated from POF 2008/2009) would need to increase their real food expenditure by 58.1% to meet national consumption (Borges et al., 2015). In 2017, almost ten years after the analysis of these data, the poorest 50% of the Brazilian population has an average income of R$ 787.69 per month, with Brazil being among the ten most unequal countries in the world (OXFAM, 2018). In this sense, the lower the income, the greater the relative share that can be wasted via purchased and uneaten food.

In relation to food, Brazil can be described as the land of abundance and diversity, in which Brazilian cuisine and eating habits were formed from the cultural construction between native Indians, Africans and Portuguese (Porpino, 2015). According to Cardim (1925), the diversity of Brazilian food is intrinsic, even before the Portuguese colonization. The importance of food abundance on the Brazilian table has prevailed since the colonial period (Freyre, 2002). This abundance is characterized as a trait of receptivity, known as a habit of the colonial period (Cascudo, 1968).

Abundant and mixed food is a cultural feature of Brazil and was described by DaMatta (1984) as one of the most important traits to transform eating into a Brazilian gesture. Brazilians celebrate food when it satisfies and fills, extolling its fullness (Fajans, 2012).

It is also worth noting that descriptions of aspects related to what is meant by food waste were identified by Freyre (2002), and comprise part of the Brazilian culture in colonial times. These aspects are associated with the approach to conservation and food supply, in which Cascudo (1968) points out that food storage results from a winter habit and is absent in tropical climates. This may mean that practices related to food consumption in a household are intrinsically related to history and its construction in cultural terms (Casotti, 2002). Presently, these cultural issues can cause several problems associated with FLW generation.

Some activities that can be undertaken to mitigate household food waste (Quested et al., 2013): i) plan meals; ii) check food levels in cabinets and refrigerators; iii) make a shopping list; (iv) store meat and cheese in appropriate packaging; v) use freezer to prolong the life of the food; vi) store perishable food in the refrigerator (fruits and vegetables); vii) portioning the prepared carbohydrates (eg rice, pasta, etc); viii) Insert date labels on refrigerated foods and prepared leftovers; ix) use leftover food.

For the Brazilian context, the importance of food waste mitigation is emphasized given the characteristics of Brazil. A food-exporting country that still has food insecurity problems, with low per capita fruit and vegetable consumption and growing overweight among the low-income population (Porpino, 2018).

Reducing food waste within a country will require a wide range of initiatives to target different subpopulations simultaneously. They should range from small-scale initiatives or technological improvements, such as innovative packaging to extend shelf life, to globally bound national or policy requirements. The food waste report prepared for the European Commission has inventoried over 100 such initiatives (Bio Intelligence Service, 2010). However, data limitations in developed and developing countries mean it will still be difficult to assess any progress in reducing food waste and accurately estimate the potential of these reductions that can be effectively used for human consumption.

Because of the difficulty of changing consumer behavior, composed of individuals dispersed in different families in different regions and countries, and because of economies of scale, it is believed that major initiatives to mitigate waste should be led by industry and retail or by government policies. Thus, they would have greater potential to reduce food waste. As more food is recovered for human consumption, food insecurity can be reduced by supplementing existing food assistance efforts. In contrast, it provides tax savings for producers, manufacturers, food retailers, and foodservice establishments, and consumers.

Economic incentives and consumer behavior become paramount in their commitment to meeting the diverse and conflicting goals of contemporary and unequal society. Such goals include reducing food waste and waste, achieving an acceptable return on investment from members of the food industry, protecting the environment and worker safety, satisfying consumer demand for food safety, product quality, and a variety. variety of nutritious, tasty and reasonably priced food (Buzby and Hyman, 2012). Therefore, there is a need for further research to quantify and value FLW along FSC in Brazil and other developing countries. It is also important to identify and value the inedible part of food that can be input in other production processes. This information can help raise awareness of the FLW generated in society.

4 Conclusions

Growing population and scarce resources make food waste a topic of worldwide interest, and it is necessary to conduct research and studies on the subject. In this sense, we sought to estimate the percentage and monetary value corresponding to the Brazilian household food waste.

Household waste is part of food loss and waste. This study showed that the average household food waste was 80 kilograms, representing 12.83% of the total annual volume of food purchased by Brazilian households. The generation of this waste corresponded to R$ 56.89 per household. This amount attributes the generation of household food waste to the amount of R$ 3.282 billion or the US $ 1.378 billion.

The importance of knowing the values that food waste represents means that industry, policymakers, and society can use to raise awareness of the problem. In addition, decisions and policies must be based on sound cost-benefit analysis to ensure that the right incentives or appropriate measures are implemented. In this sense, future studies to provide a better understanding of the quantity and generation of wasted food relationship are still needed. However, it is known that strategies to reduce food waste and increase the efficiency of the food system need to be intertwined with strategies that value surplus production and help to manage production capacity, storage, processing, and distribution, resulting in waste mitigation. of food.

The main limitations of this study refer to the impossibility of crossing POF socioeconomic microdata that could be used and analyzed to make other inferences on the subject. The period difference is also associated with the data used. However, this research contributes to the discussion on food loss and waste as well as corroborating with the other research, which has already been developed. Moreover, it should be noted that replication of this analysis from more recent data may reveal similar or divergent estimates from those identified for the 2008/2009 period.

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CAPÍTULO 5

Considerações finais

A busca por alimento, como em todos os seres vivos, sempre foi a maior preocupação da humanidade. Os antepassados dependiam da coleta e da caça. Posteriormente desenvolveram a prática da agricultura, que ao longo de toda a história, ocupou novas áreas, acompanhando o crescimento e a expansão das populações.

Apesar do constante aumento das áreas plantadas ao longo dos anos, a fome sempre acompanhou a história da humanidade. O aparente problema do aumento da produção de alimentos frente ao crescimento populacional ocupou parte das discussões acadêmicas no passado. A grande questão debatida era que a humanidade cresceria tanto que não haveria mais alimento para todos.

Mais recentemente a introdução da Revolução Verde na agricultura provocou uma mudança na segurança alimentar mundial. Amplamente difundida a partir de 1970, a disseminação desse pacote de tecnologias fez com que as colheitas aumentassem significativamente, deixando de lado o espectro da fome causada pela falta de alimentos. Entretanto, estudos preliminares desenvolvidos nos últimos anos mostram que a humanidade passou de períodos de escassez de alimentos para desperdício de alimentos. Dados estimam que 1/3 da produção mundial de alimentos é perdida anualmente e que 50% dos alimentos são jogados fora, tanto na Europa quanto nos Estados Unidos (Gustavsson et al, 2011).

Condições inadequadas de colheita, transporte e armazenagem, adoção de práticas que valorizam elevados padrões visuais na aquisição dos alimentos e fixação de prazos de validade rigorosos são algumas das questões iniciais que nortearam estudos sobre perdas e desperdício de alimentos (FLW – *Food Loss and Waste*). Porém, recentes pesquisas revelaram novo crescimento populacional para o século XXI, ressaltando a necessidade de aumento da produção de alimentos. Além disso, novas questões sobre alterações climática, escassez de recursos naturais, mudanças no comportamento do consumidor e crescimento econômico nos países em desenvolvimento ampliam as discussões que influenciam a oferta de alimentos e seu respectivo impacto ambiental.

Nesse sentido, a temática de FLW tornou-se um problema de pesquisa atual e necessário, envolto de questionamentos complexos, os quais vêm sendo respondidos, principalmente, ao longo dos últimos dez anos. Todavia, pontos divergentes e a falta de esclarecimentos de alguns aspectos causam inquietudes na sociedade, nas organizações e no ambiente científico. Tais preocupações estão associadas ao processo produtivo e ao aproveitamento do alimento gerado. Portanto, ao invés de estimular o aumento produtivo e a ampliação do uso de recursos para explorar novas áreas, discute-se a introdução de medidas de eficiência para um melhor aproveitamento dos alimentos produzidos.

Além disso, o desenvolvimento socioeconômico, ou a falta dele, possui relação direta com a temática, levando a casos de esbanjamento ou de escassez e inacessibilidade de alimento. Logo, a redução das perdas e desperdício de alimentos deve ser uma prioridade global e pode auxiliar no enfrentamento do desafio de aumentar a produção de alimentos para abastecer a população em crescimento.

A atual dinâmica que envolve a temática e questões correlatas precisam ser discutidas. Nesse sentido, esta tese apresentou três aspectos com objetivos específicos: o primeiro visa identificar métodos quantitativos utilizados para mensurar FLW; o segundo, estimar o volume físico de FLW ao longo da FSC brasileira e, por fim, estimar o volume físico e o valor monetário do desperdício gerado nos domicílios brasileiros.

Cabe salientar que os objetivos foram revistos ao longo do desenvolvimento da tese a fim de adequar-se às possibilidades factíveis de utilização e execução dos dados disponíveis. Tendo como objetivo estimar o volume físico e o valor monetário correspondente à geração de perdas e desperdício de alimentos no Brasil, elaborou-se diferentes documentos que expressam importantes informações, inserindo o país no grupo de nações que debatem a temática. Mesmo com algumas limitações, os objetivos propostos foram alcançados. Consequentemente, a soma de distintos elementos que abordam a temática de FLW, associados aos resultados e conclusões identificados ao longo dos capítulos, pode auxiliar no processo de tomada de decisão a fim de desenvolver ações para minimizar a geração de FLW no Brasil.

O capítulo 2, que teve como objetivo identificar métodos quantitativos utilizados para mensurar perdas e desperdícios de alimentos, trouxe como se pesquisa o assunto mundialmente. Conforme discutido no capítulo, as definições utilizadas na mensuração de FLW estão relacionadas com as instituições e suas respectivas políticas. Assim, identificou-se uma variação de metodologias e estatísticas utilizadas para mensurar ou estimar a FLW. As diferentes metodologias são reflexo da exequibilidade na aplicação das diversas pesquisas nas etapas da FSC e/ou nos diferentes alimentos estudados. A principal contribuição do capítulo foi de construir um mapeamento teórico das mensurações quantitativas de FLW existentes na produção científica mundial.

Nesse meandro metodológico, percebeu-se a importância da definição dos termos utilizados em relação aos objetivos pretendidos. Essa relação foi imprescindível na delimitação metodológica para a mensuração de FLW, tanto na ótica qualitativa quanto na quantitativa. Ressalta-se que a temática de FLW é criticada por não possuir uma padronização de conceitos, por ser difícil de mensurar e por utilizar múltiplos procedimentos metodológicos heterogêneos.

As definições e métricas para a mensuração de FLW variam conforme o objetivo almejado e impactam conforme suas possibilidades de aplicação e busca por resultados. A busca por estimativas quantitativas passa desde um processo de estudo local ou regional, até um estudo realizado para identificar quantidades de FLW mundialmente. Ademais, as metodologias utilizadas podem ser compostas por métodos diretos, indiretos ou mistos. Essa relação está associada com o conjunto de dados disponível para a mensuração.

As pesquisas desenvolvidas utilizaram diferentes unidades de medidas, bem como analisaram diferentes etapas da cadeia produtiva. Estimativas de FLW em quilogramas e percentual formam a maioria dos estudos. Verificou-se que estudos que utilizam estimativas em percentual são mais usados por pesquisadores nas etapas de distribuição e de produção agrícola. Nesse sentido, pode-se dizer que ao se conhecer a quantidade total produzida de determinado produto, torna-se mais simples aplicar um valor percentual sobre ela para estimar o FLW gerado. Já estimativas em quilogramas foram desenvolvidas, principalmente, na etapa de consumo. Assim, ao final da cadeia, torna-se possível estimar a quantidade de FLW gerada, por amostras de indivíduos ou domicílios, pesando as sobras ou o descarte. Portanto, multiplica-se a amostra pelo número de indivíduos ou domicílios para obter o montante de interesse. Conclui-se que, estratégias são desenvolvidas para mensurar FLW a partir dos dados disponíveis, objetivo almejado ou por conveniência na etapa de estudo desejada. Assim, diversos estudos tendem a focar em apenas uma etapa da FSC.

Os estudos sobre FLW, em maioria, focam na etapa de consumo. Isso se deve pela facilidade de desenvolver diferentes recortes de pesquisa e a possibilidade de utilização de distintos métodos para estimar quanto de FLW é gerado pelo consumidor. Entretanto, existe uma dificuldade em construir amostras representativas de desperdício alimentar que não possuam interferência, alterações ou quaisquer tipos de vieses que possam influenciar nas estimativas identificadas, principalmente, quando autodeclaradas.

Torna-se necessário que entidades que compõem a FSC – desde a produção até o consumo –, juntamente com universidades, instituições e governos, unam esforços para reduzir o FLW melhorando métodos de produção, desenvolvimento de produtos, conservação e armazenagem, marketing e distribuição. Todos devem unir-se em prol de uma FSC sustentável, que ofereça segurança alimentar e nutricional aos consumidores.

Obviamente, ao se explorar apenas um produto ou determinada cadeia produtiva, há a necessidade de maior detalhamento na mensuração de FLW. Abordagens conceituais e metodológicas precisas refletem a carência de dados que atinjam o objetivo proposto. Assim, faz-se necessário uma metodologia mais sofisticada, até mesmo com cálculos complexos, que satisfaça as questões abordadas. No entanto, quanto mais complexa for uma metodologia mais difícil de ser utilizada, padronizada, comparada e replicada. É importante notar que os resultados de diferentes estudos que estimam FLW geralmente não podem ser comparados, visto a inacessibilidade das medidas e análises utilizadas.

Apesar das questões metodológicas abordadas, uma estimativa de FLW deve considerar a disponibilidade de dados que possa ser utilizada de forma simples, padronizada, com possibilidade de ser comparada e replicada em outros estudos. Uma metodologia simples torna os estudos relativamente comparáveis e discutíveis. Isso facilita a replicação em um mesmo ambiente ou em ambientes correlatos. Do mesmo modo, a padronização do método converte-se em possível comparabilidade entre os estudos de mensuração. Isso torna-se importante a fim de obter dados precisos para definir ações assertivas, mesmo em diferentes circunstâncias.

De modo específico, no Brasil, não há mensurações confiáveis (seja em quilogramas, percentuais ou quilocalorias) que representem estimativas de FLW em grande escala, para toda a FSC, ou até mesmo que possam ser utilizados como referência crível. A existência desses valores tornaria o trabalho ainda mais relevante e condizente com a realidade brasileira, fornecendo resultados mais precisos sobre os níveis de FLW nas diferentes etapas das cadeias.

O capítulo 3 teve como objetivo estimar os volumes físicos das perdas e desperdícios de alimentos nas diferentes etapas da cadeia alimentar de abastecimento brasileira. A identificação e quantificação do FLW em cada etapa específica da FSC torna-se indispensável. Mesmo com as restrições derivadas da indisponibilidade de índices mais precisos de FLW, o capítulo 3 utiliza parâmetros estabelecidos na literatura científica para estimar tais índices, calculando FLW para as diferentes etapas da FSC brasileira. Compreender a quantidade de FLW gerada e o que ela representa é muito importante, sendo a principal contribuição desse capítulo. As tentativas globais de quantificar FLW foram motivadas pela necessidade de avaliar a escala de geração de resíduos alimentares, poder estabelecer uma linha baseada em metas de redução desses resíduos, além de mensurar a eficiência das iniciativas de prevenção de FLW e seus respectivos impactos na sociedade atual.

Após um processo de definição de objetivos, metodologia e delimitação do método, a mensuração de FLW torna-se uma importante etapa. Entretanto, é latente a falta de dados e informações que possam contribuir com a mensuração nos países em desenvolvimento e, até mesmo, em alguns países desenvolvidos. No caso brasileiro, a FLW gerada ao longo da FSC foi estimada e representa 42% da oferta doméstica de alimentos. Isso significa que mais de um terço dos alimentos produzidos para o consumo humano não são utilizados para essa finalidade. Contudo, não se pode afirmar que a FSC brasileira é pouco eficiente ou ineficaz quanto à gestão e à utilização dos recursos empregados, embora se possa indicar que há um comprometimento quantitativo e monetário elevado na geração de FLW na FSC brasileira, dispendioso para todos os *stakeholders* envolvidos. Além disso, uma geração de FLW elevada testemunha baixa preocupação quanto ao desenvolvimento de externalidades negativas ao longo da FSC.

Dentre as etapas analisadas na produção agrícola, no manejo e armazenamento pós-colheita e no processamento, os grupos de frutas e vegetais, raízes e tubérculos e cereais apresentaram as maiores quantidades de FLW. Na etapa de distribuição, os grupos de frutas e vegetais e de cereais e leite compõem a maior quantidade de FLW. Já na etapa de consumo, as quantidades de FLW são compostas principalmente pelos grupos de frutas e vegetais, raízes e tubérculos, e cereais e leite.

Ações imediatas voltadas ao grupo de frutas e vegetais são necessárias, e não há uma única solução imaginável. Soluções que minimizem FLW para esse grupo são mais complexas. Isso devido ao grupo ser constituído por produtos frescos e altamente perecíveis, que necessitam de uma gestão de cadeia produtiva integrada, dinâmica e logisticamente organizada, desde a produção até o consumidor. O desenvolvimento de estratégias para cada cadeia de frutas e vegetais pode ser a solução mais plausível. Todavia, deve-se observar os custos relacionados com o processo, bem como a real eficiência destes com a qualidade dos produtos. Outra solução está associada ao desenvolvimento de cadeias curtas, nas quais os alimentos não transitam por intermediários, passando do produtor ao consumidor.

De modo geral, os resultados expressam estimativas elevadas de FLW. A necessidade de maiores investigações que reforcem ou refutem essa realidade torna-se evidente. Existem referências a estudos específicos voltados a FLW pós-colheita. No entanto, são estudos pontuais, realizados em determinados produtos ou em etapas específicas, que não refletem a realidade ou não podem ser ampliados. Portanto, o desenvolvimento de pesquisas básicas, por meio de coleta de dados primários, torna-se imprescindível nas pesquisas futuras de mensuração de FLW.

Pesquisas futuras têm a responsabilidade de mensurar FLW por cadeia produtiva, objetivando a quantificação e identificação de estimativas desde a etapa de produção da FSC. Ademais, faz-se necessário adicionar outros dados e fontes que possam produzir um modelo nacional mais realista e condizente com as peculiaridades existentes em cada região brasileira. Portanto, uma avaliação mais precisa da FLW poderia facilitar melhores práticas de gerenciamento durante as etapas da FSC. Assim, o uso de estratégias para reduzir a FLW no país, sua mitigação e/ou seu monitoramento ao longo do tempo, pode aumentar a eficiência dos elos da cadeia.

Em busca disso, este estudo lança luz sobre a situação da FLW no Brasil, e os resultados podem inspirar uma nova agenda para o sistema produtivo de alimentos. Sendo um dos principais produtores mundiais de alimentos, o Brasil pode se colocar como líder em políticas para a redução de FLW, não como ação dependente do Estado, mas por meio de medidas conjuntas que possam gerar conscientização sobre o assunto entre os membros da indústria alimentícia, governos e consumidores.

Torna-se oportuno repensar a FSC brasileira de maneira mais ampla. Esforços em pesquisa tem sido direcionado ao longo dos anos para os processos de produção, transformação e consumo de alimentos. Contudo, boa parte desses esforços de produzir cada vez mais se converte em geração de FLW, em que as estimativas estabelecem valores nada desprezíveis. Cabe, portanto, um redirecionamento dos esforços de pesquisa para esse importante aspecto que é a geração de FLW, salvando assim boa parte do alimento produzido e garantindo sua maior disponibilidade. Desse modo, incluir pesquisas e discussões sobre sistemas de produção e consumo alinhados com políticas públicas de segurança alimentar, desenvolvimento de planos integrados que minimizem FLW em todas as etapas da cadeia, redução de emissões de gases de efeito estufa e externalidades negativas oriundas do processo produtivo, bem como priorizar o uso eficiente dos alimentos produzidos, caracterizam um novo pensar global na produção e consumo de alimentos. Essas ações diretas refletem as novas necessidades de uma sociedade majoritariamente urbana e até mesmo pouco conhecedora do meio rural.

A mitigação de FLW gerada se tornará um desafio mundial na próxima década. A redução desses índices ainda é uma questão essencial em todo o mundo. Todavia, a coordenação de ações voltadas a esse objetivo passa por uma conscientização social, como estratégia de longo prazo. Isso faz com que medidas voltadas ao consumidor precisem ser desenvolvidas. Por estar no elo final da FSC, o consumidor pode influenciar no desenvolvimento de políticas para a coordenação da temática nas cadeias de produção, melhorando a eficiência e reduzindo a geração de FLW. Entretanto, medidas de curto prazo também podem ser adotadas: 1) a criação de linhas de ação que fomentem pesquisa, desenvolvimento e inovação quanto à mensuração de FLW gerado nas principais cadeias de alimentos brasileiras ou em cadeias de alimentos perecíveis podem ser desenvolvidas e implementadas; 2) o desenvolvimento de um programa de capacitação técnica sobre prevenção e redução de FLW em pontos críticos das cadeias de alimentos; 3) a elaboração e disseminação de materiais informativos voltado a boas práticas de produção, manuseio, transporte, conservação e consumo para os principais agentes da FSC; 4) estímulo a parcerias entre varejistas, atacadistas, distribuidores e organizações sociais para a doação de alimentos, reutilização, recuperação ou destinação adequada; e 5) melhoria e modernização da infraestrutura e logística desde a produção, armazenamento, processamento, transporte, distribuição e comercialização de alimentos.

A principal contribuição do capítulo 4 foi estimar o volume físico e o valor monetário do desperdício de alimentos nos domicílios brasileiros. Cabe salientar que o desperdício domiciliar compõe parte do desperdício alimentar na etapa de consumo, integrante do FLW gerado nas diferentes etapas da FSC brasileira.

Dentre os alimentos estudados, estimou-se que o desperdício médio por domicílio, no Brasil, foi de 80 quilogramas em 2008. Esse valor representa 12,83% do total de alimentos adquiridos para o consumo no domicílio. A região Nordeste foi a que apresentou o maior percentual de desperdício, sendo de 18,18%.

A pesquisa demonstrou que a valoração monetária do desperdício alimentar domiciliar média para o ano de 2008 foi de R$ 56,89 por domicílio. Dentre as regiões, a Nordeste foi a que apresentou o maior valor referente aos alimentos adquiridos e desperdiçados, sendo de R$ 80,94 por domicílio. O valor monetário atribuído à geração de desperdício alimentar domiciliar no Brasil foi de R$ 3.282 bilhões, o que representa US$ 1,378 bilhão para o ano de 2008.

Os determinantes da geração de desperdício, em consumo domiciliar, perpassam o simples ato da preparação e do cozer alimentar. Contudo, fatores comportamentais são particularmente importantes influenciadores nessa etapa. A geração de FLW no nível de consumo domiciliar inicia-se com as práticas de aquisição de alimentos.

As relações de compra de alimentos podem ser influenciadas por fatores econômicos e sociais. A renda familiar é um influenciador nas quantidades e tipos de itens alimentares adquiridos para consumo domiciliar. Ademais, alterações na renda acarretam em alterações no consumo alimentar, refletindo em uma transição alimentar, geralmente observada em países em desenvolvimento. Atrelada à renda, a recente modernização do setor varejista e sua relação de poder com os demais elos das cadeias produtivas auxilia no processo de transição alimentar e no estímulo de compras não planejadas.

O responsável atual pelo sistema de provisão de alimentos, pela oferta em escala e pela padronização dos produtos tidos como comercializáveis é o varejo, influenciando diretamente na relação de compra das famílias. Além disso, questões relacionadas com a embalagem dos alimentos interferem na relação entre consumo e geração de desperdício. Embalagens difíceis de manusear e armazenar, com rótulos diversos de difícil interpretação, além de não protegerem adequadamente os produtos, contribuem na geração de desperdício pelo consumidor. Associa-se a essas questões a discussão da data de validade do produto, geralmente atribuída pelo consumidor a uma proibição do consumo como prevenção de perigo à sua saúde.

O tamanho do domicílio, o gênero responsável pela aquisição de alimentos e o comportamento adotado pelo indivíduo encarregado do fornecimento das refeições também influenciam na geração de desperdício alimentar. Fatores comportamentais podem ser impulsionados ou desencorajados pelos próprios hábitos de consumo existentes no domicílio. Ademais, a não utilização de alimentos anteriormente preparados demonstram a pouca conscientização do consumidor sobre a temática.

Os métodos de preparo também estão relacionados com o desperdício. O preparo mais adequado a cada tipo de alimento deve ser observado. Assim, após o processo de preparo e cocção, o alimento poderá ser melhor consumido. Ademais, o armazenamento inadequado ou prolongado faz com que as quantidades de desperdício de alimentos nos domicílios sejam maiores.

Campanhas nacionais sobre o problema do FLW e o respectivo alinhamento a programas de combate à fome podem contribuir com a conscientização social necessária para mitigar o desperdício no nível domiciliar. Ademais, ações voltadas às implicações éticas e morais dessa geração são importantes constructos na modificação da consciência comportamental tanto dos consumidores quanto dos produtores de alimentos.

O reaproveitamento de preparos ou alimentos em novas refeições é uma ação fundamental do consumidor e reflexo de mudanças comportamentais. Conectar potenciais doadores de alimentos a organizações que combatam a fome, como bancos de alimentos, resulta em um novo destino ao produto. Em casos de alimentos inapropriados para o consumo, reciclá-los para a alimentação animal ou seu uso para compostagem, bioenergia ou a produção de fertilizantes auxilia na destinação correta desses alimentos.

Ainda cabe salientar que a redução do FLW pode ser vista como uma forma de aumentar a eficiência da FSC brasileira, reduzindo os custos para os produtores e os preços para os consumidores, além de mitigar externalidades negativas originárias no processo produtivo. Isso pode resultar no aumento das exportações de produtos alimentares para o mercado mundial. Ademais, o Brasil é composto por diferentes contextos socioeconômicos, onde transitam hábitos alimentares ou padrões alimentares distintos, que refletem seus mercados consumidores.

A identificação das causas de FLW em diferentes níveis, seus pontos críticos, possíveis soluções e níveis de intervenção devem ser coordenadas entre os setores, conforme os objetivos almejados. Todavia, a definição de metas e incentivos para a redução de FLW pode ser resultante de uma política econômica ou de incentivos governamentais que apoiem esforços desenvolvidos por toda a sociedade.

Uma nova visão sobre economia circular, onde os recursos são utilizados de forma mais sustentável, vem sendo desenvolvida nos países industrializados. São ações sustentáveis que promovem mudanças nas estruturas de produção e consumo. Portanto, a mitigação de FLW é vista como um exemplo positivo na cadeia de abastecimento alimentar mundial. Essas novas estratégias podem influenciar os consumidores quanto às escolhas de alimentação mais sustentáveis ou saudáveis, bem como ações comportamentais de compra, preparação e consumo dos alimentos e até mesmo influenciando positivamente em seus hábitos alimentares.

Os três capítulos que compõem a presente tese podem ser vistos como uma sequência lógica de iniciativas de pesquisa e, juntos, fornecem um melhor entendimento sobre a temática proposta. Contudo, as causas da FLW são complexas e interligadas, variando entre países industrializados e em desenvolvimento. Fatores relevantes que dizem respeito a mensuração de FLW iniciam pela delimitação de um método a fim de conseguir dados e informações representativas para o objetivo proposto.

Construir um sistema alimentar mais sustentável, em que os consumidores estejam cientes das dificuldades associadas à produção de alimentos e ao valor da própria comida, exige esforços de todos os atores da cadeia alimentar. A integração de agricultores, indústria, varejistas, agentes públicos e consumidores torna-se fundamental para obter melhores resultados sobre a mitigação de FLW em todas as etapas da FSC.

As estimativas de FLW mensuradas nesta tese apresentaram elevados valores, deixando um alerta importante. Muito precisa ser feito para mitigar esses valores ao longo da FSC brasileira. Ainda se faz necessário desenvolver o trabalho básico de estimativa de FLW para definir, posteriormente, ações assertivas. O trabalho básico será árduo, devido à heterogeneidade da produção, da miscigenação e de fatores socioeconômicos da população brasileira e da diversidade e dimensão do país.

Questionamentos e reflexões sobre a temática que ficarão para estudos futuros dizem respeito a distintas dimensões, tais como: i) a mensuração de FLW a partir de metodologias e métricas diretas de quantificação, em diferentes contextos geográficos, altera a composição do FLW gerado e sua possível comparação entre os estudos?; ii) a implementação de ações voltadas à mitigação de FLW em áreas prioritárias de pesquisa pode ser uma solução inicial na resolução desse problema?; iii) abordar etapas-chave na cadeia produtiva, ou de determinados alimentos, e realizar um acompanhamento de médio prazo auxiliaria na formulação e implementação de políticas que minimizem a geração de FLW e otimizem a eficiência dos recursos?; iv) compreender a quantidade de FLW produzida, bem como seu valor e impactos causados na FSC, são informações relevantes?; v) o desenvolvimento de um banco de dados e de estatísticas permanentes auxiliaria no controle e avaliação do FLW gerado a longo prazo?; vi) quais ações de mitigação de FLW podem impactar positivamente a sociedade?

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APÊNDICE A: Documents that integrate the systematic review

Table S1. Overview of systematic review results.

Author	Year	Country /Region	Method	Study methodo logy	Product	Food supply chain: (kg)					
						Agricultural production	**Postharvest handling and storage**	**Processing and packaging**	**Distribution**	**Consumption**	**Total**
Griffin et al. (2009)	1998-1999	USA/New York	Data obtained through interviews. In addition to, data from published state and national public sources	Mixed	Many products	89363,59 kg/year	-	13164,61 kg/year	1392973,0964 kg/year	5170701,27 kg/year	-
Lanfranchi et al. (2014)	2009-2013	Italy/Sicilia	Datas from 13 points of sale.	Direct	fennel, zucchini, tomato, eggplant, lettuce, spinach and others	-	-	-	100230,08 kg/year	-	100230,08 kg/year
Nahman and Lange (2013)	2007-2009	South Africa	FAO data on the amount of initial feed of the chain x proportion lost or wasted.	Indirect	Groups: cereals, roots and tubers, oilseeds and	cereals: 788; roots and tubers: 282; Oilseeds and legumes: 144; fruits and	cereals: 988; roots and tubers: 312; Oilseeds and legumes: 84; fruits and	cereals: 398; roots and tubers: 213; Oilseeds and legumes: 78; fruits and	cereais: 289; raízes e tubérculos: 107; Sementes oleaginosas e	cereals: 142; roots and tubers: 41; Oilseeds and legumes: 13; fruits and	cereals: 2605; roots and tubers

					legumes, fruits and vegetables, meat, fish and seafood, milk	vegetables: 846; meat: 382; fish and seafood: 38; milk: 186	vegetables: 685; meat: 15; fish and seafood: 38; milk: 321	vegetables: 1733; meat: 108; fish and seafood: 54; milk: 3	leguminosas: 27; frutas e vegetais:986; beef:196; seafood: 85; milk: 318.	vegetables: 241; meat: 52; fish and seafood: 10; milk: 3	: 955; Oilseeds and legumes: 346; fruits and vegetables: 4491; beef: 753; fish and seafood: 225; milk: 831
Oelofse and Nahman (2013)	not provide	South Africa	Estimates based on the Swedish Institute for Food and Biotechnology (SIK), as	Indirect	<u>Groups:</u> cereals, roots and tubers, oilseeds and legumes,	cereals: 789.3; roots and tubers: 282,4; oilseeds and legumes: 54.4; fruits	cereals: 989; roots and tubers: 312; oilseeds and legumes: 32; fruits and vegetables:	cereals: 398; roots and tubers: 213; oilseeds and legumes: 29; fruits and vegetables:	cereals: 289; roots and tubers: 107; Oilseeds and legumes: 27; fruits and vegetables:	cereals: 108; roots and tubers: 23; oilseeds and legumes: 3; fruits and vegetables 210;	cereals: 2504; roots and tubers

			reported by the Food and Agriculture Organization of the United Nations (FAO) (Gustavsson et al., 2011).		fruits and vegetables, meat, fish and seafood, milk	and vegetables; 823.0; meat: 238.1; fish and seafood: 12.8; milk: 187.1	667; meat: 9; fish and seafood: 13; milk: 323	1685; meat: 67; fish and seafood18; milk: 3	986; meat: 196; fish and seafood: 85; milk: 318	meat 24; fish and seafood 3; milk 2	: 892; oilseeds and legumes: 126; fruits and vegetables: 4244; meat: 427; fish and seafood: 74; milk: 775; <u>TOTAL:</u> 9040.9
Dias-Ferreira et al. (2015)	not provide	Portugal	Data collected in a hospital, with the sum of samples of the	Direct	soup, main meal,	-	-	-	-	953g of food per day; soup: 12; Main course: 52;	953 g of food per

			waste in the morning (between 7 and 14 h) and afternoon / evening (between 14 and 22 h).		bread, fruit					bread: 54; fruit: 18; 348Kg per year per person	day; soup: 12; Main course: 52; bread: 54; fruit: 18; 348Kg per year per person
Buzby and Hyman (2012)	2008	USA	LAFA data to estimate food losses. Nielsen Homescan data to estimate national average annual retail prices. USDA Center for Nutrition Policy and	Indirect	<u>Groups</u>: meat, poultry and fish; vegetables; dairy products; fruits; grains; fats and oils;	-	-	-	64 kg/per capita	123.9 kg/per capita	188kg /per capita

			Promotion's Food Prices (2003-2004) data to compare the prices expected.		sugars and sweeteners; nuts and peanuts; eggs.						
Soares et al. (2011)	2005	Brasil/Minas Gerais	Collected data.	Direct	meal	-	-	-	-	From 24g to 60g / per capita = 176kg to 1,213kg for month	-

Falasconi et al. (2015)	not provied	Italy/Verona	Six schools were identified according to their location, consisting of three primary schools and three elementary schools. The data were collected to categorize the quantity and nutritional characteristics of the processed (prepared) food, but not served and discarded. For five days a week (Monday through Friday).	Direct	Entrance: beef stew, noodles, fish stew, tomato, stew, vegetable stew, soup, risotto, pasta with oil Main: course beef, peru, chicken, pork, pizza, cold cut, fish, cheese, eggs, side dish, raw,	-	-	-	-	entry: 2533,60kg; beef stew with noodles: 307.47; fish stew with noodles: 135.27; tomato stew with noodles: 462.71; vegetable stew with noodles: 289.27; soup: 440.73; risot: 629.15; noodles with oil: 268.99; Main course: 960.84; beef: 241.62; Peru: 116.12; chicken: 160.14; pork39,77 ;: pizza: 47.47; cold cut: 39.58;	6523, 35 kg

					vegetables, cooked vegetables, fruits, yogurt, bread and others.					fish: 91.72; eggs: 138.53; cheese: 85.893; monitoring: 1883,96 raw vegetables: 680.96; cooked vegetables: 1202,10; fruit - yogurt: 144.26 bread: 900.58 other: 101.01	

Dora et al. (2013)	not provide	Belgium	Case study based on a sample of four companies from different subsectors. This study includes interviews with plant managers, application of questionnaires and local observation.	Direct	Areas: vegetable and fruit processing, pasta and sugar manufacturing, and baking and dairy processing	-	-	Company A: 59,677kg; Company B: 110,400kg; Company C: 7773 tons; Company D: 5124 tons.	-	-	-
Reynolds et al. (2016)	2011	New Zealand	Data from the landfill of the Ministry of the Environment.	Direct	organic waste	901 tons	-	22.778 tons	223.266 tons	-	Household: 224.000 tons; Industry: 103.000 tons

Nahman et al. (2012)	2004	South Africa	Data from the Waste Background Paper produced for the South Africa Environment Outlook report on behalf of the Department of Environmental Affairs and Tourism (Fiehn and Ball, 2005).	Indirect	household waste	-	-	-	-	Low income: 1,012,688; average income: 321,577; high income: 104,713;	1,438,977 tons/year
Yamada et al. (2017)	2011	Japan/Kyoto	A sample of 268 bags of waste from 216 households was collected in three districts of Kyoto. In addition, commercial waste was investigated in	Direct	household waste	-	-	-	-	household waste: 437 g / per capita / day) commercial waste: 6112g / per capita / day)	households 30,000 tons/year. Comercial 34,000 tons per year.

			a sample of 37 industries comprising 137 commercial facilities.								total 64,000 tons / year
Amato and Musella (2017)	2016	Italy/Naples	Data from interviews in a sample of 100 operating units (50 for restaurants and 50 for bars) resulted in the collection of 89 completed questionnaires.	Direct	organic waste	-	-	-	-	745 tons/year	-
Love et al. (2015)	2009-2013	USA	Data from government sites, reports, and peer reviewed papers.	Indirect	seafood	0.26 millions of tons	0.01 millions of tons	0.03 millions of tons	0.15 millions of tons	0.59 millions of tons	Average 44% of seafood lost. Kg per capita

											: 2009: 2.89–4.21; 2010: 2.85–4.20; 2011: 2.71–4.00; 2012: 2.60–3.83; 2013: 2.62–3.84.
Tostivint et al (2017)	not provied	Pakistan	Interviews were conducted in 18 farms, 12 collection centers and 8 different retailers and wholesalers. In addition, a consumer	Direct	milk and yogurt	7000 thousand tons	-	-	-	-	-

			focus group was conducted with 8 urban women and 3 specialists.								
Liu et al. (2016)	not provide	Japan	Official Statistics Portal of Japan data.	Indirect	all foods	3,81 millions of tons	3,95 millions of tons	-	19,96 millions of tons	10,14 millions of tons	37,86 millions of tons
Strotmann et al. (2017)	not provide	City of Germany	Data from three organizations were separated by food classes and type of losses (preparation losses, service losses, plate residues).	Direct	meal	-	-	-	-	Hospital (g/person/day): 1st analysis: 1502 2nd analysis: 1209 Cafeteria (g/person/day): 1st analysis: 602 2nd analysis: 662 Nursing home (g/person/day): 1st analysis: 1399 2nd analysis: 1480	-
Author	**Year**		**Method**		**Product**	**Food supply chain: (%)**					

		Country /Region		Study methodology		Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution	Consumption	Total
Loke and Leung (2015)	2010	USA/Hawaii	The sum of local production and imports, minus exports, was used. Available food supply data is used with estimates of food waste derived from the US Department of Agriculture (USDA) Adjusted Adjustment Food Availability (LAF) dataset.	Indirect	seafood protein; other protein; fresh vegetables; fresh fruit; rice grain; fresh milk; others (oils and fats, processed foods, other grains, sugar and sweeteners).	-	seafood protein: 0.3%; Other protein: 0.2%; fresh vegetables: 3.2%; fresh fruits: 9.7%; rice grain: 0.0%; fresh milk: 0.0%; others: 0.0%	-	seafood protein: 8.6%; Other protein: 4.1%; fresh vegetables: 10%; fresh fruit: 15%; rice grain: 12.5%; fresh milk: 12.5%; other: 6.8%	seafood protein: 30.9%; Other protein: 20.5%; fresh vegetables: 22.7%; fresh fruits: 22.9%; rice grain: 28.9%; fresh milk: 17.5%; other: 11.6%	161,5 kg /person/year

Arivazhagan et al (2016)	not provide	India/Chennai	The data were collected through a structured questionnaire with 335 farmers, traders, owners of cold stores, owners of processing units and retailers.	Direct	mango, banana, grape, sapotila and guava	6.90%	6.60%	17.90%	Shopping/Trade: 4.5% Retail: 24.7%	-	60.60 %
Ju et al. (2017)	not provied	Japan	Data from different national statistical sources (wholesale, food factories, retail stores and restaurants). The total of inedible parts was subtracted from the actual	Indirect	Product groups: grains; vegetables; fruits; dairy products; meat; Seafood; processed or cooked food; others	-	-	-	Grains: 3.4%; vegetables: 1.5%; fruits: 1.5%; dairy products: 3.1%; meats: 2.6%; eggs: 3.6%; seafood: 3.6%; seasoning: 4.9%; Oils and fats: 6.4%;	Restaurant: Grains: 35%; vegetables: 35%; meats: 13%; eggs: 12%; seafood: 11%; processed or cooked food: 39% Household: Grains: 4%; vegetables: 21%; fruits:	Wholesale: 0.4; manufacturing: 1.3; retail: 2.2; restaurants: 2.5; houses: 8.8.

			amount of food waste.						processed or cooked food: 1%	19%; milk products: 1%; meats: 7%; seafood: 20%; Processed or Cooked Foods: 6%; Other: 10%	
Lebersorger and Schneider (2014)	2011-2012	Austria	Data was provided based on approximately 7300 articles for each of the approximately 700 outlets per month.	Direct	fruits and vegetables; dairy products; breads and confectionery; return of breads and confectionery	-	-	-	Quilograms: Fruits and vegetables: 4.19%; dairy products: 1.14%; breads and confectionery: 3.99%; return of breads and confectionery. Monetary value: Fruits and vegetables: 4.25%; dairy products: 1.27%;	-	-

									breads and confectionery: 2.83%; return of breads and confectionery: 9.69%		
Engström and Carlsson-Kanyama (2004)	not provied	Sweden	Data from four kitchens: two in schools and two in restaurants.	Direct	meat and fish; potato, rice and pasta; and vegetables	-	-	-	-	<u>Types of loss:</u> storage and preparation: 4%; serving losses and unserved food: 6%; losses in the dish: 10%. Schools: Meat and fish: 20%; vegetables 30%; potatoes, pasta and rice: 50%. Restaurants: meat and fish: 7-18%; vegetables: 43-55%; potatoes,	200 kg/day

										pasta and rice: 27-45%	
Eriksson et al. (2012)	not provide	Sweden/ Stockholm	Supplier and retailer data. Additional information was obtained through observations at six stores and informal interviews with store employees.	Direct	fresh fruits and vegetables	-	-	-	Waste before the store: 3.01%; store waste registered: 0.99%; unregistered store waste: 0.3%	-	Average waste of 4.3%
Betz et al., (2015)	2015	Switzerland	Data collection occurred for five consecutive days (in addition, storage losses were collected over a four-week period). The losses were divided into four	Direct	Groups: meat and fish, starch, vegetables, fruits, dessert, others and inevitable	-	-	-	-	Company A: meat and fish: 7.5; starch monitoring: 24; vegetables: 23; fruits: 2; dessert: 3%; others: 18%; inevitable: 13%; Company B: meat and fish: 4.5%; starch	Company A: 201.35 kg (10.73%) of the total food used. Company B: 318.2

			categories according to Engström and Carlsson-Kanyama (2004).							monitoring: 31%; vegetables: 26%; fruits: 4%; dessert: 2%; others: 11%; Inevitable: 23%	1 kg (7.69 %) of the total.
Alexander et al. (2017)	2011	Global food system	From the FAO data, losses classified into six categories: agricultural production; livestock production; handling, storage and transportation; processing; consumer waste; consumption.	Indirect	animal products - dry mass: 2%; wet mass: 2.6%; protein: 2.3%; energy: 1.9%	Dry mass: 10%; Wet mass: 8.4%; protein: 7.6%; energy: 11.3%	-	Commodity processed - Dry mass: 24.2%; Wet mass: 59.2%; protein: 33.4%; energy: 14.7%	-	Dry mass: 9%; Wet mass: 10.1%; protein: 9%; energy: 8.6%.	-

Rahman et al. (2014)	not provide	Bangladesh	Information collected in households randomly selected from 96 villages, representing more than 14,000 families of rice producers in the marginal, small, medium and large categories.	Direct	Rice: aus; anam; boro	Aus: 6.3%; Anam:6.3%; Boro:7.12%	Aus: 2.98%; Anam:2.7%; Boro:3.06%	Aus: 0.86%; Anam:0.65%; Boro:0.94%	Aus: 5.73%; Anam:5.55%; Boro:6.16%	-	-
Underhill and Kumar (2015)	2014	Fiji/Viti Levu	Harvest and post-harvest management practices were observed in a commercial farm.	Direct	tomato	25,50%	1%	6,40%	29,90%	-	60,80 %
Underhill et al. (2017)	2015	Samoa/Apia	Interviews with suppliers and dealers.	Direct	fruits and vegetables	-	-	-	Vegetables: 2,3 % fruits: 2,5 %	-	-

Minten et al (2016)	2009-2010	India, Bangladesh e China	For each country, primary questionnaires were applied in a moderate sample of actors for each segment of the value chain: farmers, refrigerated warehouses, rural and urban wholesalers and urban retailers.	Direct	-	Dhaka: 1,2%; Beijing: 2,2%; Delhi: 0%	Dhaka: 3,2%; Beijing: 4,6%; Delhi: 0.3%	Dhaka: 2%; Beijing: 3,2%; Delhi: 3,0%	Dhaka: 2%; Beijing: 3,17%; Delhi: 2,96%	-	-
Willersinn et al. (2015)	2000-2012	Switzerland	Foi utilizado banco de dados gradual que combina dados estatísticos privados com aqueles disponíveis publicamente pelo Escritório	Mixed	potato	Quality standard: Organic Fresh potato: 29%; non-organic fresh potatoes: 21%; organic processed potato: 33%;	Organic fresh potato: 28%; non-organic fresh potatoes: 16%; organic processed dressing: 13%; processed	19%	2% (non-organic) and 4% (organic)	Organic fresh potato: 14.5%; non-organic fresh potatoes: 15.4%; organic processed dressing: 2.1%; processed non-organic potato2.0%.	Organic fresh potato: 55.5%; non-organic fresh potato

			Federal de Estatísticas (BFS), pelo Escritório Federal para Agricultura (BLW) e pelo Sindicato dos Agricultores Suíços (SBV).			processed non-organic potato: 28%. Bottom quality: Organic fresh potato: 26%; non-organic fresh potatoes: 17%; organic processed potato: 28%; Processed non-organic potato: 17%.	non-organic potato7%.				es: 53%; organic processed dressing: 41.3%; Processed non-organic potato: 45.6%.
White et al. (2011)	2008-2009	Australia / Queensland	Data from a banana farm.	Mixed	banana	15% of total production = 37 000 tons	-	-	-	-	-

Munhuweyi et al. (2016)	2011	South Africa/Stellenbosch	Three point of sale data.	Direct	cabbage	-	-	-	-	13 to 30%, mean of 21%.	20.000 tons
Redlingshöfer et al. (2017)	not provied	France	Technical reporting data and interviews with academic and professional experts.	Mixed	-	Calculated from primary production to processing: Cereals 3%; oil plants 10.6%; legumes 6%; fruits and vegetables 12%; vegetables for processing 4-5%; potatoes 12.7%; milk 3.4-5%; eggs 4.5%; beef 8.4%; lamb 2.7%; porcine 6%; chicken 4.8%; farmed fish 3.4%			-	-	-
Underhill and Kumar (2014)	2013	Fiji/Viti Levu	Post-harvest horticultural losses were evaluated simultaneously in three municipal fruit and vegetable markets during a commercial week.	Direct	long beans; small beans (cow peas); french beans; lettuce; pepper; chili; lime; eggplant; okra; tomato;	-	-	-	long beans: 0.07%; small beans (cow peas): 0.10%; French beans: 0.46%; lettuce: 0.67%; pepper: 0.70%; Pepper: 1.62%; Lima: 1.05%; Berinjela1.67 %; okra:	-	-

					pineapple; banana; orange				2.14%; tomato: 2.44%; pineapple: 4.07%; banana: 6%; orange: 10%		
Beretta et al. (2013)	not provide	Switzerland	There were 22 analyzed foods, the main ones of the basic basket. The identified FLW was classified among unavoidable losses (U), possibly avoidable (PA) and avoidable losses (A).	Direct	Categories: all foods, fresh vegetables, breads and cakes, eggs	all food: U:9%; PA:2.4%; A:0.8%; fresh vegetables: U:6.5%; PA:14%; A:8%; Breads and cakes: U7%; PA:10%; A:0%; eggs: U:3.5%; PA:0%; A:2.4%;	all food: U: 0.6%; PA: 0.4%; A: 0.3%; fresh vegetables: U: 0%; PA: 3.5%; A:0.3%; Breads and cakes: U:1%; PA:0%; A:0%; eggs U:0.5%; PA:0%; A:0%;	all food: U: 16.3%; PA:9.8%; A:13.2%; fresh vegetables: U:15%; PA:5%; A:10%; Breads and cakes: U:19.3%; PA:22.8%; A:15.3%; eggs U:31.2%; PA:0%; A:7.4%;	all food: U:0%; PA:0%; A:1.8%; fresh vegetables: U:0%; PA:0%; A:9.4%; Breads and cakes: U:0%; PA:0%; A:4.8%; eggs U:0%; PA:0%; A:1.4%;	all food: U:2.3%; PA:4.9%; A:15.6%; fresh vegetables: U:9%; PA:17%; A:21%; Breads and cakes: U:0%; PA:6.5%; A:36%; eggs: U:18.6%; PA:0%; A:9.3%;	

Fine et al. (2015)	not provide	France	The data were collected mainly from professional specialists through its institution or oil company (CETIOM, SAIPOL, CREOL).	Direct	canola oil, sunflower oil, soybean oil and tofu	Canola Oil: 25.6%; sunflower oil: 4.1%; soybean oil: 1.4%; tofu: 2.6%	Canola Oil: 7.3%; sunflower oil: 3.0%; soybean oil: 1.6%; tofu: 0.3%	Canola Oil: 17.7%; sunflower oil: 7.2%; soybean oil: 3.5%; and tofu: 0.5%	-	-	Canola Oil: 50.6%; sunflower oil: 14.3%; soybean oil: 6.5%; and tofu: 3.4%
Author	**Year**	**Country /Region**	**Method**	**Study methodology**	**Product**	**Food supply chain: (kcal)**					
						Agricultural production	**Postharvest handling and storage**	**Processing and packaging**	**Distribution**	**Consumption**	**Total**

Kummu et al. (2012)	2011	Global food system	FAO data on the material flows of each product were used after the post-harvest stage by dividing by the quantity produced locally, stock variation, import and export. Data in kcal/cap/day.	Indirect	Groups: cereals, roots and tubers, oilseeds and legumes, fruits and vegetables.	Sub-Saharan Africa: 206; Europe (including Russia):188; Industrialised Asia:125; Latin America: 277; North Africa & West-Central Asia: 217; North America & Oceania: 381; South & Southeast Asia: 156.	Sub-Saharan Africa: 187; Europe (including Russia):70; Industrialised Asia: 103; Latin America: 187; North Africa & West-Central Asia: 192; North America & Oceania: 129; South & Southeast Asia: 122.	Sub-Saharan Africa: 17; Europe (including Russia):33; Industrialised Asia: 27; Latin America: 54; North Africa & West-Central Asia: 30; North America & Oceania: 65; South & Southeast Asia: 18.	Sub-Saharan Africa: 69; Europe (including Russia):66; Industrialised Asia: 68; Latin America: 83; North Africa & West-Central Asia: 115; North America & Oceania: 90; South & Southeast Asia: 53.	Sub-Saharan Africa: 26; Europe (including Russia):386; Industrialised Asia: 358; Latin America: 143; North Africa & West-Central Asia: 232; North America & Oceania: 711; South & Southeast Asia: 54.	-

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APÊNDICE B: Supplementary file

Extracted data

Table S1. Brazilian food balance data by commodity group (source: FAOSTAT, 2010).

Commodity groups	*Production quantity (1000 tonnes/year)*						
	2007	2008	2009	2010	2011	2012	2013
Cereals	65758	75735	66701	71420	73098	86062	97157
Roots and tubers	30871	31181	28556	29243	30056	27502	25520
Pulses (only)	3189	3486	3514	3172	3456	2804	2946
Fruits and vegetables	49137	48862	48182	50026	52561	49496	47662
Meat	21815	22859	22611	23630	24312	24829	26011
Fish and seafood	1072	1157	1240	1264	1432	1549	1549
Milk	26274	28580	29229	30864	32246	32454	32653
Commodity groups	*Stock variaction (1000 tonnes/year)*						
	2007	2008	2009	2010	2011	2012	2013
Cereals	-500	-854	500	-158	2029	2641	451
Roots and tubers	0	0	0	0	0	0	0
Pulses (only)	100	-250	-155	100	-155	200	250
Fruits and vegetables	2	0	0	0	0	0	0
Meat	0	0	0	0	0	0	0
Fish and seafood	0	0	0	0	0	0	0
Milk	55	2	0	1	1	0	0
Commodity groups	*Export quantity (1000 tonnes/year)*						
	2007	2008	2009	2010	2011	2012	2013
Cereals	11697	7865	9005	12765	13335	23513	28923
Roots and tubers	90	65	67	37	51	50	46
Pulses (only)	31	2	33	4	20	43	35
Fruits and vegetables	13340	11674	9749	8583	8419	12102	13307
Meat	6550	6369	6164	6208	6048	6318	6529
Fish and seafood	103	94	60	53	54	65	65
Milk	612	988	335	212	144	133	143
Commodity groups	*Import quantity (1000 tonnes/year)*						
	2007	2008	2009	2010	2011	2012	2013
Cereals	10560	9569	9679	9897	9401	10365	10768
Roots and tubers	301	325	308	509	574	524	647
Pulses (only)	144	264	156	243	270	370	374
Fruits and vegetables	862	910	1000	1322	1348	1243	1457
Meat	37	37	41	42	45	69	71
Fish and seafood	407	433	489	605	766	765	765
Milk	275	342	766	664	1087	1233	1032
Commodity groups	*Domestic supply quantity (1000 tonnes/year)*						
	2007	2008	2009	2010	2011	2012	2013
Cereals	64122	76585	67875	68395	71193	75556	79454
Roots and tubers	31083	31442	28797	29796	30578	27976	26121
Pulses (only)	3402	3498	3482	3511	3550	3331	3535
Fruits and vegetables	36661	38097	39435	42665	45490	38638	35811
Meat	15301	16527	16487	17464	18309	18580	19552
Fish and seafood	1376	1495	1670	1816	2144	2250	2250
Milk	25992	27936	29660	31317	33190	33555	33542

Information on the methodology used

Table S2. Estimated/assumed waste percentage for each commodity group in each step of the food supply chain for Latin America. (Reprinted from Food and Agriculture Organization of the United Nations (2011), Gustavsson J, Cederberg C, Sonesson U, van Otterdijk R and Meybeck A, Global food losses and food waste: Extent, Causes and Prevention with permission from the FAO).

Commodity groups	Agricultural production (AP)	Postharvest handling and storage (PHS)	Processing and Packaging (PP)	Distribution (D)	Consumption at household level
Cereals	6%	4%	4.5%*	4%	10%
Roots and tubers	14%	14%	12%	3%	4%
Oil seeds and pulses	6%	3%	8%	2%	2%
Fruits and vegetables	20%	10%	20%	12%	10%
Meat	5.3%	1.1%	5%	5%	6%
Fish and seafood	5.7%	5%	9%	10%	4%
Milk	3.5%	6%	2%	8%	4%

*may range from 2% to 7 *, the mean value was used.

Table S3. Food crop products included in the analysis.

Commodity group	*Products*
Cereals	wheat, rice (milled), barley, maize, rye, oats, millet, sorghum, other cereals
Roots and tubers	potatoes, sweet potatoes, cassava, yams, other roots
Pulses (only)	soybeans, groundnuts
Fruits and vegetables	oranges and mandarins, lemons and limes, grapefruit, other citrus, bananas, plantains, apples, pineapples, dates, grapes, other fruit, tomatoes, onions, other vegetables
Meat	bovine meat, mutton/goat meat, pig meat, poultry meat, other meat, offals
Fish and seafood	freshwater fish, demersal fish, pelagic fish, other marine fish, crustaceans, other mollusk, cephalopods, other aquatic products, aquatic mammal meat, other aquatic animals, aquatic plants.
Milk	milk

Calculated data

Table S4. Quantity of food to calculate loss and waste in each stage of the Brazilian food supply chain (2007-2013).

Commodity groups	*Agricultutal Production (1000 tonnes/year)* [production quantity]							
	2007	2008	2009	2010	2011	2012	2013	2007-2013 (Avarage)
Cereals	65758	75735	66701	71420	73098	86062	97157	76561.57
Roots and tubers	30871	31181	28556	29243	30056	27502	25520	28989.86
Pulses (only)	3189	3486	3514	3172	3456	2804	2946	3223.86
Fruits and vegetables	49137	48862	48182	50026	52561	49496	47662	49418.00
Meat	21815	22859	22611	23630	24312	24829	26011	23723.86
Fish and seafood	1072	1157	1240	1264	1432	1549	1549	1323.29
Milk	26274	28580	29229	30864	32246	32454	32653	30328.57
Total	**198116**	**211860**	**200033**	**209619**	**217161**	**224696**	**233498**	**213569.00**

Commodity groups	*Postharvest handling and storage (1000 tonnes/year)* [production quantity + stock variaction]							
	2007	2008	2009	2010	2011	2012	2013	2007-2013 (Avarage)
Cereals	65258	74881	67201	71262	75127	88703	97608	77148.57
Roots and tubers	30871	31181	28556	29243	30056	27502	25520	28989.86
Pulses (only)	3289	3236	3359	3272	3301	3004	3196	3236.71
Fruits and vegetables	49139	48862	48182	50026	52561	49496	47662	49418.29
Meat	21815	22859	22611	23630	24312	24829	26011	23723.86
Fish and seafood	1072	1157	1240	1264	1432	1549	1549	1323.29
Milk	26329	28582	29229	30865	32247	32454	32653	30337.00
Total	**197773**	**210758**	**200378**	**209562**	**219036**	**227537**	**234199**	**214177.57**

Commodity groups	*Processing and packing (1000 tonnes/year)* [production quantity + stock variaction + import quantity]							
	2007	2008	2009	2010	2011	2012	2013	2007-2013 (Avarage)
Cereals	75818	84450	76880	81159	84528	99068	108376	87182.71
Roots and tubers	31172	31506	28864	29752	30630	28026	26167	29445.29
Pulses (only)	3433	3500	3515	3515	3571	3374	3570	3496.86
Fruits and vegetables	50001	49772	49182	51348	53909	50739	49119	50581.43
Meat	21852	22896	22652	23672	24357	24898	26082	23772.71
Fish and seafood	1479	1590	1729	1869	2198	2314	2314	1927.57
Milk	26604	28924	29995	31529	33334	33687	33685	31108.29
Total	**210359**	**222638**	**212817**	**222844**	**232527**	**242106**	**249313**	**227514.86**

Commodity groups	*Distribution (1000 tonnes/year)* [production quantity + stock variaction + import quantity - export quantity]							
	2007	2008	2009	2010	2011	2012	2013	2007-2013 (Avarage)
Cereals	64121	76585	67875	68394	71193	75555	79453	71882.29
Roots and tubers	31082	31441	28797	29715	30579	27976	26121	29387.29
Pulses (only)	3402	3498	3482	3511	3551	3331	3535	3472.86
Fruits and vegetables	36661	38098	39433	42765	45490	38637	35812	39556.57
Meat	15302	16527	16488	17464	18309	18580	19553	17460.43
Fish and seafood	1376	1496	1669	1816	2144	2249	2249	1857.00
Milk	25992	27936	29660	31317	33190	33554	33542	30741.57
Total	**177936**	**195581**	**187404**	**194982**	**204456**	**199882**	**200265**	**194358.00**

Commodity groups	*Consumption (1000 tonnes/year)* [Domestic Supply quantity]							
	2007	2008	2009	2010	2011	2012	2013	2007-2013 (Avarage)
Cereals	64121	76585	67875	68394	71193	75555	79453	71882.29
Roots and tubers	31082	31441	28797	29715	30579	27976	26121	29387.29
Pulses (only)	3402	3498	3482	3511	3551	3331	3535	3472.86
Fruits and vegetables	36661	38098	39433	42765	45490	38637	35812	39556.57
Meat	15302	16527	16488	17464	18309	18580	19553	17460.43
Fish and seafood	1376	1496	1669	1816	2144	2249	2249	1857.00
Milk	25992	27936	29660	31317	33190	33554	33542	30741.57
Total	**177936**	**195581**	**187404**	**194982**	**204456**	**199882**	**200265**	**194358.00**

Results

Table S5. Quantity of food loss and waste per year at each step of the Brazilian food supply chain (2007–2013).

Commodity groups	*Agricultutal Production (1000 tonnes/year)* [production quantity]							
	2007	2008	2009	2010	2011	2012	2013	2007-2013 (Avarage)
Cereals	3945.48	4544.10	4002.06	4285.20	4385.88	5163.72	5829.42	4593.69
Roots and tubers	4321.94	4365.34	3997.84	4094.02	4207.84	3850.28	3572.80	4058.58
Pulses (only)	191.34	209.16	210.84	190.32	207.36	168.24	176.76	193.43
Fruits and vegetables	9827.40	9772.40	9636.40	10005.20	10512.20	9899.20	9532.40	9883.60
Meat	1156.20	1211.53	1198.38	1252.39	1288.54	1315.94	1378.58	1257.36
Fish and seafood	61.10	65.95	70.68	72.05	81.62	88.29	88.29	75.43
Milk	919.59	1000.30	1023.02	1080.24	1128.61	1135.89	1142.86	1061.50
Total	**20423.05**	**21168.78**	**20139.22**	**20979.42**	**21812.05**	**21621.56**	**21721.11**	**21123.60**
Commodity groups	*Postharvest handling and storage (1000 tonnes/year)* [production quantity + stock variaction]							
	2007	2008	2009	2010	2011	2012	2013	2007-2013 (Avarage)
Cereals	2610.32	2995.24	2688.04	2850.48	3005.08	3548.12	3904.32	3085.94
Roots and tubers	4321.94	4365.34	3997.84	4094.02	4207.84	3850.28	3572.80	4058.58
Pulses (only)	98.67	97.08	100.77	98.16	99.03	90.12	95.88	97.10
Fruits and vegetables	4913.90	4886.20	4818.20	5002.60	5256.10	4949.60	4766.20	4941.83
Meat	239.97	251.45	248.72	259.93	267.43	273.12	286.12	260.96
Fish and seafood	53.60	57.85	62.00	63.20	71.60	77.45	77.45	66.16
Milk	1579.74	1714.92	1753.74	1851.90	1934.82	1947.24	1959.18	1820.22
Total	**13818.14**	**14368.08**	**13669.31**	**14220.29**	**14841.90**	**14735.93**	**14661.95**	**14330.80**
Commodity groups	*Processing and packing (1000 tonnes/year)* [production quantity + stock variaction + import quantity]							
	2007	2008	2009	2010	2011	2012	2013	2007-2013 (Avarage)
Cereals	3411.81	3800.25	3459.60	3652.16	3803.76	4458.06	4876.92	3923.22
Roots and tubers	3740.64	3780.72	3463.68	3570.24	3675.60	3363.12	3140.04	3533.43
Pulses (only)	274.64	280.00	281.20	281.20	285.68	269.92	285.60	279.75
Fruits and vegetables	10000.20	9954.40	9836.40	10269.60	10781.80	10147.80	9823.80	10116.29
Meat	1092.60	1144.80	1132.60	1183.60	1217.85	1244.90	1304.10	1188.64
Fish and seafood	133.11	143.10	155.61	168.21	197.82	208.26	208.26	173.48
Milk	532.08	578.48	599.90	630.58	666.68	673.74	673.70	622.17
Total	**19185.08**	**19681.75**	**18928.99**	**19755.59**	**20629.19**	**20365.80**	**20312.42**	**19836.97**
Commodity groups	*Distribution (1000 tonnes/year)* [production quantity + stock variaction + import quantity - export quantity]							
	2007	2008	2009	2010	2011	2012	2013	2007-2013 (Avarage)
Cereals	2564.84	3063.40	2715.00	2735.76	2847.72	3022.20	3178.12	2875.29
Roots and tubers	932.46	943.23	863.91	891.45	917.37	839.28	783.63	881.62
Pulses (only)	68.04	69.96	69.64	70.22	71.02	66.62	70.70	69.46
Fruits and vegetables	4399.32	4571.76	4731.96	5131.80	5458.80	4636.44	4297.44	4746.79
Meat	765.10	826.35	824.40	873.20	915.45	929.00	977.65	873.02
Fish and seafood	137.60	149.60	166.90	181.60	214.40	224.90	224.90	185.70
Milk	2079.36	2234.88	2372.80	2505.36	2655.20	2684.32	2683.36	2459.33
Total	**10946.72**	**11859.18**	**11744.61**	**12389.39**	**13079.96**	**12402.76**	**12215.80**	**12091.20**
Commodity groups	*Consumption (1000 tonnes/year)* [Domestic Supply quantity]							
	2007	2008	2009	2010	2011	2012	2013	2007-2013 (Avarage)
Cereals	6412.10	7658.50	6787.50	6839.40	7119.30	7555.50	7945.30	7188.23
Roots and tubers	1243.28	1257.64	1151.88	1188.60	1223.16	1119.04	1044.84	1175.49
Pulses (only)	68.04	69.96	69.64	70.22	71.02	66.62	70.70	69.46
Fruits and vegetables	3666.10	3809.80	3943.30	4276.50	4549.00	3863.70	3581.20	3955.66
Meat	918.12	991.62	989.28	1047.84	1098.54	1114.80	1173.18	1047.63
Fish and seafood	55.04	59.84	66.76	72.64	85.76	89.96	89.96	74.28
Milk	1039.68	1117.44	1186.40	1252.68	1327.60	1342.16	1341.68	1229.66
Total	**13402.36**	**14964.80**	**14194.76**	**14747.88**	**15474.38**	**15151.78**	**15246.86**	**14740.40**

APÊNDICE C: Arquivo suplementar

Supplementary Figure 1 - Adaptation of the POF food groups that make up the study food categories.

Food categories used by Porpino et al. (2018)	**Foods used according to subgroups of categorization in POF 2008/2009**	**Food categories used in this paper**
Rice	Unspecified rice and polished rice	Rice
Bean	Feijão-fradinho (*Vigna unguiculata*), feijão-jalo, feijão-manteiga, feijão-mulatinho, feijão-preto, feijão-rajado, feijão-roxo, (different beans of the species *Phaseolus vulgaris*)	Bean
Noodles and Pasta	Pasta	Noodles and Pasta
Corn	Corn grain, pickled green corn, green corn on the cob	Corn
Fresh fruit	Fruits	Fresh fruit
Breads	Breads	Breads
Beef	Prime beef, second beef and other beef	Beef
Fish	Fish (fresh and saltwater)	Fish
Chicken	Chicken wing, unspecified chicken meat, chicken leg, chicken back, slaughtered chicken (whole), live chicken, chicken giblets, chicken breast, other chicken meat	Chicken
Eggs	Eggs	Eggs
Milk	Fresh Cow Milk, Pasteurized Cow Milk, Degreased Milk Powder, Whole Milk Powder, Unspecified Milk Powder, Other	Milk
Greens	Leaf and flowers vegetables	Greens
Vegetables	Fruit vegetables, tuberous vegetables and other	Vegetables

Supplementary Figure 2 - Data collected for calculations of the percentage of wasted food in households in 2008.

	Average per capita food acquisition per food group in 2008 - Kilograms[1]														Average residents per household[1]
Brazil and Regions	Rice	Corn	Bean	Greens	Vegetables	Fresh fruit	Noodles and pasta	Breads	Beef	Fish	Chicken	Eggs	Milk	Total	
Brazil	26.50	2.80	9.12	3.23	23.85	28.86	4.74	15.82	17.04	4.03	13.02	3.22	37.38	189.60	3.3
North	28.33	3.38	10.05	2.21	17.21	20.51	4.04	14.41	23.68	17.54	19.59	3.33	20.34	184.62	3.9
Northeast	27.06	3.57	12.29	1.64	20.44	26.75	4.59	15.27	16.74	4.97	14.38	3.31	22.95	173.97	3.55
Southeast	25.55	1.73	7.96	3.75	24.25	29.74	4.69	17.19	14.05	2.06	11.05	2.91	43.14	188.07	3.14
South	22.25	2.89	6.15	5.34	33.26	36.53	6.20	15.89	21.86	1.60	13.76	4.22	58.60	228.54	3.1
Midwest	36.25	5.21	8.41	3.26	23.40	25.97	3.42	11.52	18.41	1.62	10.32	2.51	36.65	186.95	3.16

[1] Source: IBGE (2010).

	Average household food acquisition by food group in 2008 - Kilograms*													
Brazil and Regions	Rice	Corn	Bean	Greens	Vegetables	Fresh fruit	Noodles and pasta	Breads	Beef	Fish	Chicken	Eggs	Milk	Total
Brazil	87.45	9.25	30.10	10.64	78.71	95.25	15.99	52.22	56.22	13.31	42.95	10.62	123.36	626.05
North	110.49	13.17	39.21	8.61	67.12	79.99	15.76	56.20	92.35	68.42	76.38	12.99	79.31	720.00
Northeast	96.07	12.68	43.64	5.83	72.55	94.96	16.30	54.19	59.43	17.63	51.06	11.76	81.49	617.58
Southeast	80.22	5.44	24.99	11.77	76.13	93.38	14.72	53.98	44.12	6.48	34.68	9.13	135.46	590.52
South	68.98	8.97	19.06	16.54	103.10	113.25	19.21	49.25	67.78	4.95	42.64	13.07	181.67	708.47
Midwest	114.56	16.47	26.57	10.29	73.95	82.06	13.97	36.40	58.18	5.12	32.61	7.94	115.81	593.92

*Note: calculated from per capita food acquisition x average residents per household.

Average household food waste per food group in 2008 - Kilograms*

Brazil and Regions	Rice	Corn	Bean	Greens	Vegetables	Fresh fruit	Noodles and pasta	Breads	Beef	Fish	Chicken	Eggs	Milk	Total
Brazil	19.73	3.51	14.27	1.95	6.93	1.79	7.61	1.65	0.86	0.77	12.45	2.03	1.87	75.41
North	23.62	2.42	18.36	2.79	4.70	0.30	6.31	0.26	0.56	3.17	12.48	1.93	1.93	78.83
Northeast	21.41	5.00	19.63	2.62	7.33	1.32	9.93	2.27	2.05	0.06	21.23	2.40	2.81	98.05
Southeast	17.82	1.95	11.40	2.31	6.59	2.81	4.71	0.76	0.54	0.28	9.91	1.69	1.11	61.87
South	15.42	3.23	7.35	1.08	6.10	2.04	6.37	3.30	0.08	0.10	9.92	1.72	1.28	57.98
Midwest	20.36	4.97	14.60	0.92	9.93	2.47	10.73	1.66	1.08	0.22	8.73	2.41	2.24	80.32

*Note: calculated from Porpino et al (2018).

Percentage of household food waste by food group in 2008*

Brazil and Regions	Rice	Corn	Bean	Greens	Vegetables	Fresh fruit	Noodles and pasta	Breads	Beef	Fish	Chicken	Eggs	Milk	Total
Brazil	22.56	37.97	47.40	18.29	8.80	1.88	47.59	3.16	1.53	5.75	28.99	19.10	1.52	12.05
North	21.38	18.35	46.82	32.44	7.00	0.38	40.04	0.47	0.61	4.63	16.34	14.86	2.43	10.95
Northeast	22.29	39.45	44.99	44.87	10.10	1.39	60.95	4.18	3.45	0.36	41.57	20.40	3.45	15.88
Southeast	22.22	35.80	45.59	19.66	8.65	3.01	32.02	1.40	1.22	4.29	28.58	18.51	0.82	10.48
South	22.36	35.98	38.59	6.55	5.91	1.80	33.14	6.69	0.12	2.07	23.26	13.12	0.71	8.18
Midwest	17.77	30.20	54.94	8.98	13.43	3.01	76.80	4.57	1.86	4.22	26.76	30.30	1.94	13.52

* Note: calculated from household food purchase x household food waste.

Supplementary Figure 3 - Data collected for calculating monetary value for household food waste in 2008.

Brazil and Regions	Average monetary value of per capita acquisition for each food group analyzed in 2008[1]														Average residents per household[1]
	Rice	Corn	Bean	Greens	Vegetables	Fresh fruit	Noodles and pasta	Breads	Beef	Fish	Chicken	Eggs	Milk	Total	
Brazil	R$ 6.81	R$ 1.90	R$ 0.03	R$ 5.89	R$ 32.39	R$ 20.48	R$ 7.88	R$ 16.99	R$ 48.28	R$ 1.30	R$ 10.95	R$ 10.28	R$ 27.12	R$ 190.30	3.3
North	R$ 11.07	R$ 1.93	R$ 0.04	R$ 3.94	R$ 28.36	R$ 18.26	R$ 7.64	R$ 10.14	R$ 47.49	R$ 3.70	R$ 9.50	R$ 11.74	R$ 31.41	R$ 185.23	3.9
Northeast	R$ 7.25	R$ 1.47	R$ 0.01	R$ 2.03	R$ 27.04	R$ 20.75	R$ 8.78	R$ 19.51	R$ 35.29	R$ 1.98	R$ 14.54	R$ 11.28	R$ 27.13	R$ 177.06	3.55
Southeast	R$ 5.28	R$ 1.84	R$ 0.02	R$ 7.24	R$ 32.93	R$ 18.97	R$ 7.19	R$ 26.35	R$ 43.44	R$ 0.32	R$ 9.58	R$ 8.17	R$ 27.69	R$ 189.01	3.14
South	R$ 3.67	R$ 2.20	R$ 0.04	R$ 9.64	R$ 39.98	R$ 27.81	R$ 9.12	R$ 15.71	R$ 60.76	R$ 0.12	R$ 13.89	R$ 13.03	R$ 30.73	R$ 226.71	3.1
Midwest	R$ 6.78	R$ 2.06	R$ 0.04	R$ 6.61	R$ 33.62	R$ 16.62	R$ 6.68	R$ 13.23	R$ 54.42	R$ 0.38	R$ 7.22	R$ 7.18	R$ 18.64	R$ 173.49	3.16

Note: the symbol "R$" is the current monetary money in Brazil, the REAL.

[1]Source: IBGE (2010).

Average monetary value of home food acquisition for each food group in 2008*

Brazil and Regions	Rice	Corn	Bean	Greens	Vegetables	Fresh fruit	Noodles and pasta	Breads	Beef	Fish	Chicken	Eggs	Milk	Total
Brazil	R$ 22.47	R$ 6.27	R$ 0.10	R$ 19.44	R$ 106.87	R$ 67.59	R$ 26.01	R$ 56.06	R$ 159.33	R$ 4.29	R$ 36.12	R$ 33.93	R$ 89.50	R$ 631.29
North	R$ 43.18	R$ 7.54	R$ 0.17	R$ 15.36	R$ 110.61	R$ 71.20	R$ 29.81	R$ 39.54	R$ 185.21	R$ 14.42	R$ 37.03	R$ 45.80	R$ 122.51	R$ 726.29
Northeast	R$ 25.73	R$ 5.20	R$ 0.03	R$ 7.20	R$ 95.99	R$ 73.66	R$ 31.17	R$ 69.28	R$ 125.29	R$ 7.03	R$ 51.63	R$ 40.04	R$ 96.31	R$ 628.55
Southeast	R$ 16.57	R$ 5.78	R$ 0.07	R$ 22.72	R$ 103.40	R$ 59.57	R$ 22.58	R$ 82.73	R$ 136.40	R$ 1.02	R$ 30.07	R$ 25.65	R$ 86.95	R$ 593.50
South	R$ 11.36	R$ 6.83	R$ 0.12	R$ 29.90	R$ 123.94	R$ 86.21	R$ 28.26	R$ 48.70	R$ 188.37	R$ 0.36	R$ 43.07	R$ 40.40	R$ 95.26	R$ 702.79
Midwest	R$ 21.43	R$ 6.52	R$ 0.14	R$ 20.89	R$ 106.23	R$ 52.52	R$ 21.12	R$ 41.80	R$ 171.98	R$ 1.20	R$ 22.83	R$ 22.70	R$ 58.89	R$ 548.24

*Note: calculated from per capita food acquisition x average residents per household.

Note: the symbol "R$" is the current monetary money in Brazil, the REAL.

Average monetary value of household food waste for each food group in 2008*

Brazil and Regions	Rice	Corn	Bean	Greens	Vegetables	Fresh fruit	Noodles and pasta	Breads	Beef	Fish	Chicken	Eggs	Milk	Total
Brazil	R$ 5.07	R$ 2.38	R$ 0.05	R$ 3.56	R$ 9.41	R$ 1.27	R$ 12.38	R$ 1.77	R$ 2.45	R$ 0.25	R$ 10.47	R$ 6.48	R$ 1.36	R$ 56.89
North	R$ 9.23	R$ 1.38	R$ 0.08	R$ 4.98	R$ 7.75	R$ 0.27	R$ 11.94	R$ 0.18	R$ 1.13	R$ 0.67	R$ 6.05	R$ 6.81	R$ 2.98	R$ 53.45
Northeast	R$ 5.74	R$ 2.05	R$ 0.01	R$ 3.23	R$ 9.69	R$ 1.03	R$ 19.00	R$ 2.90	R$ 4.32	R$ 0.03	R$ 21.47	R$ 8.17	R$ 3.32	R$ 80.94
Southeast	R$ 3.68	R$ 2.07	R$ 0.03	R$ 4.47	R$ 8.95	R$ 1.79	R$ 7.23	R$ 1.16	R$ 1.67	R$ 0.04	R$ 8.59	R$ 4.75	R$ 0.71	R$ 45.14
South	R$ 2.54	R$ 2.46	R$ 0.05	R$ 1.96	R$ 7.33	R$ 1.55	R$ 9.36	R$ 3.26	R$ 0.22	R$ 0.01	R$ 10.02	R$ 5.30	R$ 0.67	R$ 44.73
Midwest	R$ 3.81	R$ 1.97	R$ 0.08	R$ 1.88	R$ 14.26	R$ 1.58	R$ 16.22	R$ 1.91	R$ 3.20	R$ 0.05	R$ 6.11	R$ 6.88	R$ 1.14	R$ 59.09
Total	R$ 30.06	R$ 12.31	R$ 0.29	R$ 20.07	R$ 57.38	R$ 7.49	R$ 76.13	R$ 11.18	R$ 12.99	R$ 1.04	R$ 62.71	R$ 38.38	R$ 10.19	R$ 340.23

*Note: calculated from the value of home food purchase x the percentage of waste.

Supplementary Figure 4 - Percentage of waste for each food group.