A pegada de Carbono de Ingredientes de Origem Animal

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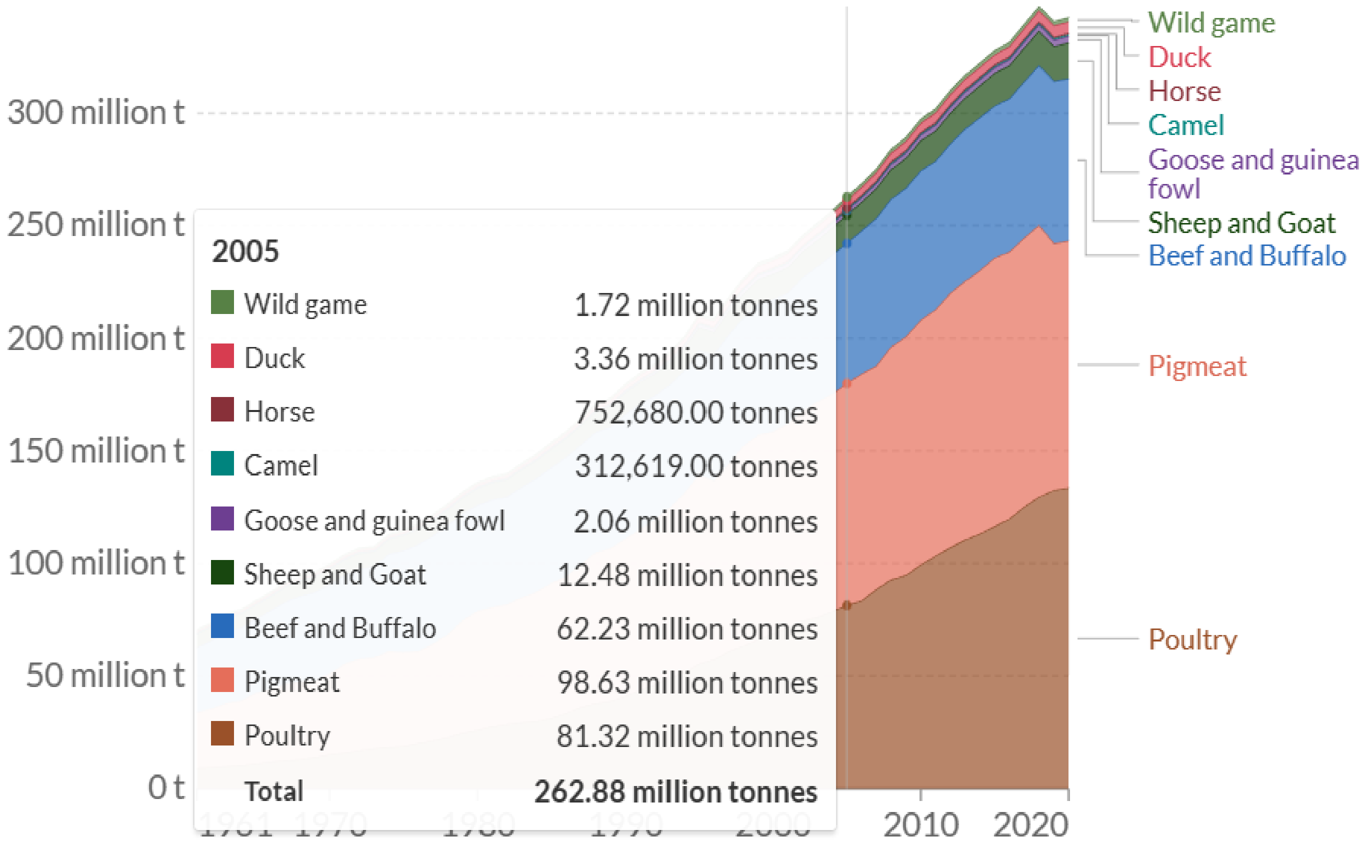
Ingredientes de origem animal

- **Animais vertebrados**
  - Renderização (apenas Feed)
    - Farinhas de origem animal (FOA's)
  - Ingredientes Food e Feed
    - Ingredientes Spray Dryer
    - Vísceras comestíveis
    - Ingredientes frescos
- **Animais invertebrados**
  - Insetos
  - Levedura e bactérias
  - Culturas de células

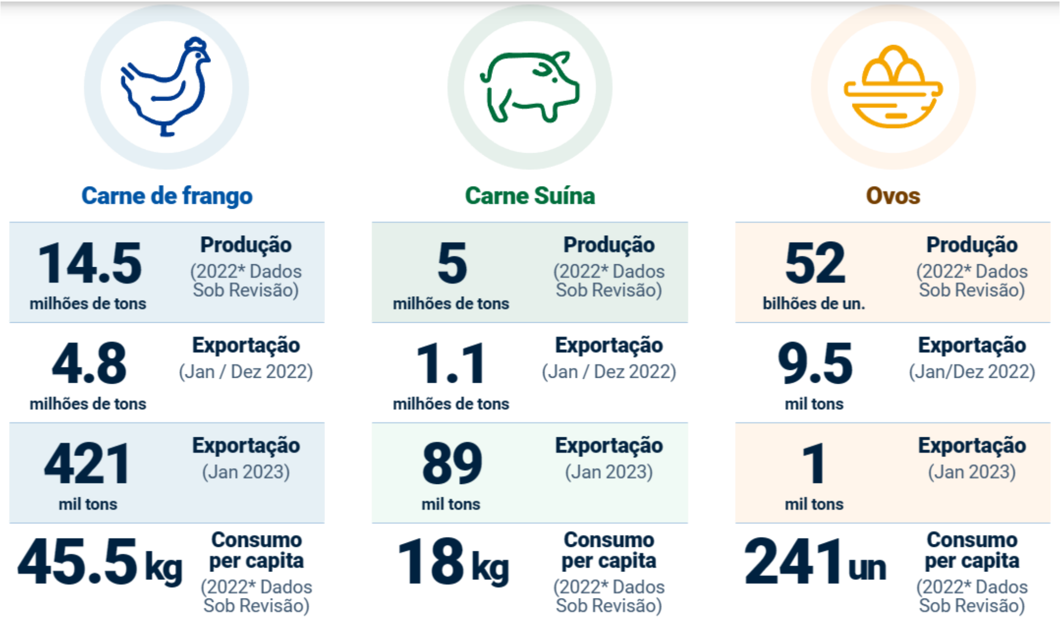
Alguns dados sobre o mercado de carne

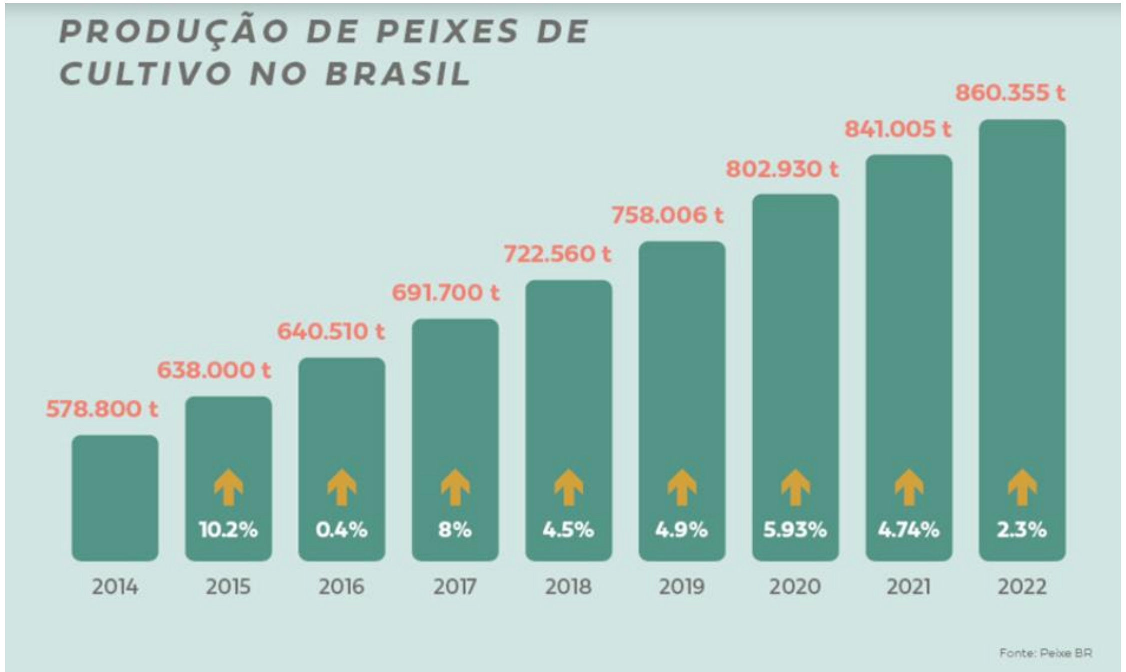
- **Produção global de carne**



Alguns dados sobre o mercado de carne

- Volume anual de produtos de origem animal





Alguns dados sobre o mercado de carne

- Volume anual de Bovinos (2022)

	Unidade	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Rebanho	Mil cabeças	181,5	181,4	183,5	186,9	187,5	189,4	188,2	187,5	188,9	190,8	196,5
Produção de Carne	Mil TEC	8.932	9.111	9.686	10.179	9.602	10.208	9.816	10.780	10.422	9.797	9.714
Exportação	Mil TEC	1.492	1.679	2.003	2.042	1.828	1.825	1.968	2.194	2.483	2.691	2.478
Importação	Mil TEC	45	60	57	77	59	64	57	47	50	63	71
Consumo	Mil TEC	7.485	7.493	7.740	8.215	7.832	8.446	7.905	8.633	7.989	7.169	7.307
Consumo per capita	Kg hab. ano	38	38	39	41	38	41	38	41	38	34	34

Fonte: Athenagro, Secex/Ministério da Economia, IBGE TEC: Tonelada Equivalente Carcaça

Projeções 2001-2031

Variável	Unidade	2001	2006	2011	2016	2021	2026	2031
Rebanho Total	1.000 cabeças	167.534	176.657	181.507	189.418	196.468	201.529	203.131
Produção	1.000 TEC	7.179	8.005	8.932	10.208	9.714	11.751	12.742
Exportações	1.000 TEC	835	2.186	1.492	1.825	2.478	2.658	2.852
Importações	1.000 TEC	42	28	45	64	71	68	66
Consumo Doméstico	1.000 TEC	6.386	5.848	7.485	8.446	7.307	9.162	9.956
Disponibilidade per capita	kg carcaça/hab/ano	36	31	38	41	34	42	44
Consumo estimado carne bovina	kg carne/hab/ano	29	25	31	33	28	34	35
Abate	1.000 cabeças	30.505	34.115	38.204	42.470	39.143	45.810	47.506
Área Pastagem	1.000 ha	182.932	180.478	177.228	167.113	163.152	155.874	151.582
Taxa de ocupação	cabeças/ha	0,92	0,98	1,02	1,13	1,20	1,29	1,34
Taxa de lotação	unidades animal/ha	0,75	0,78	0,81	0,90	0,93	1,00	1,03
Peso médio da carcaça	kg cabeça abatida	235,33	234,66	233,81	240,35	248,17	256,53	268,22
Desfrute (taxa de abate)	Porcentagem	18%	19%	21%	22%	20%	23%	23%

Fonte: Athenagro, IBGE, Secex/Ministério da Economia TEC: Tonelada Equivalente Carcaça

Produção Nacional "Rendering"

- **ABRA (2021)**

Pegada de carbono

- **O que é (Plassmann et al., 2010)**

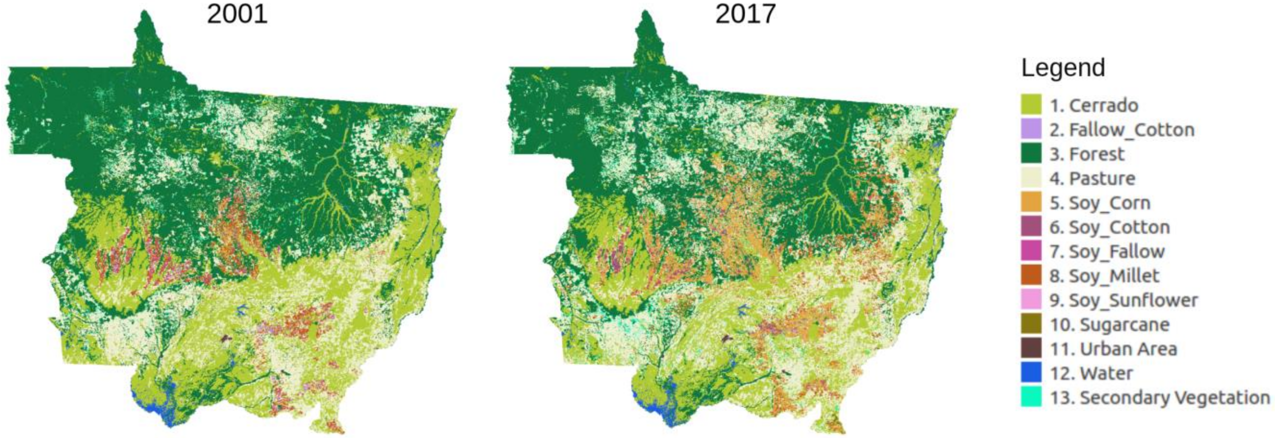
Uma pegada de carbono é o resumo final de GEEs emitidos pelo sistema em análise, que pode ser qualquer sistema, por exemplo uma fazenda, toda uma cadeia de abastecimento de alimentos, incluindo consumo e eliminação de resíduos, ou partes dos mesmos.

Há pelo menos **16** métodos de cálculo de emissão de GEE

Pegada de carbono

- **Diferença no impacto da pegada de Carbono entre países desenvolvidos e em desenvolvimento (Plassmann et al., 2010)**

Estima-se que as emissões de todos os setores em países menos desenvolvidos sejam menores que **5%** do valor Global, mas as emissões por mudança de uso de terra correspondem a mais de **20%** do valor Global nesta categoria de impacto, e as mudanças por Uso de Terra em áreas de floresta, por **74%** dos impactos Globais.



Pegada de carbono

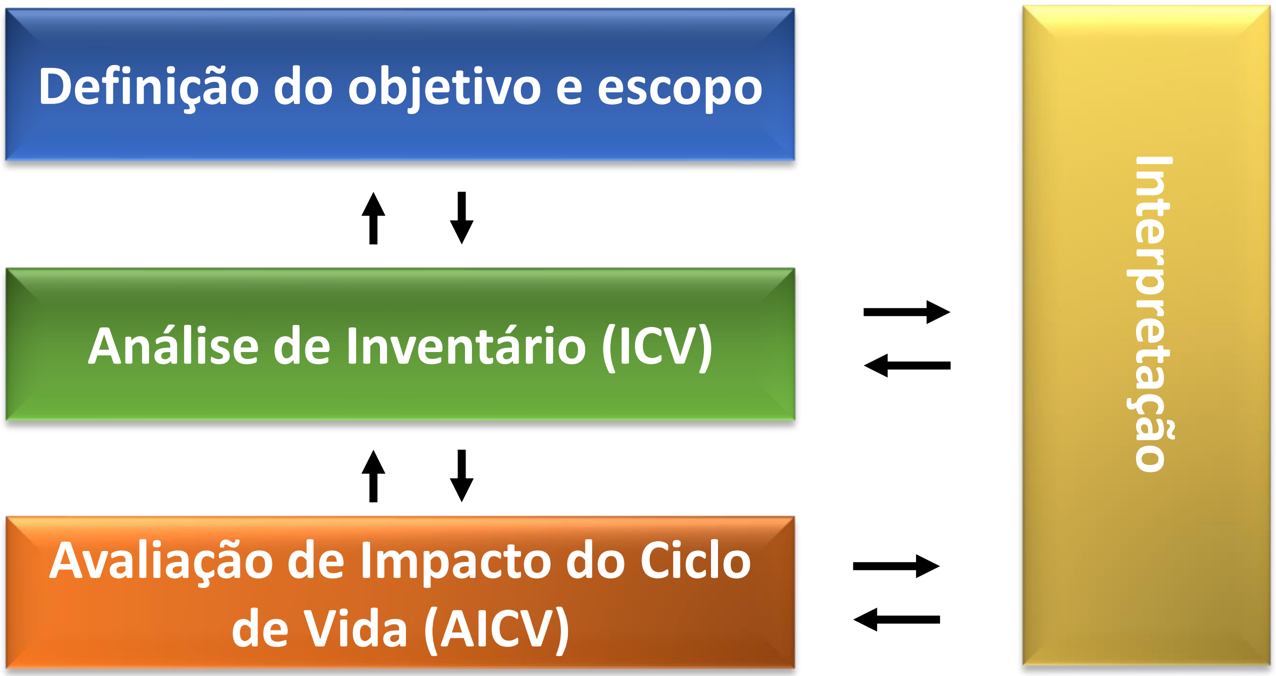
- **Gases de efeito estufa e carbono equivalente**

Dióxido de Carbono (CO2), Metano (CH4), Óxido Nitroso (N2O), Hexafluoreto de Enxofre (SF6) e duas famílias de gases, Hidrofluorcarbono (HFC) e Perfluorcarbono (PFC)

GEE	GWP
CO_2	1
CH_4	21
N_2O	310
HFC (134a)	1300

Como medir a Pegada de Carbono

- **Avaliação do Ciclo de Vida (ACV)**



(ABNT, 2009)

Série de normas ISO 14040 e 14044

Avaliação do Ciclo de Vida (ACV)

- **Etapa de Inventário**
    - o Dados Primários
    - o Dados secundários

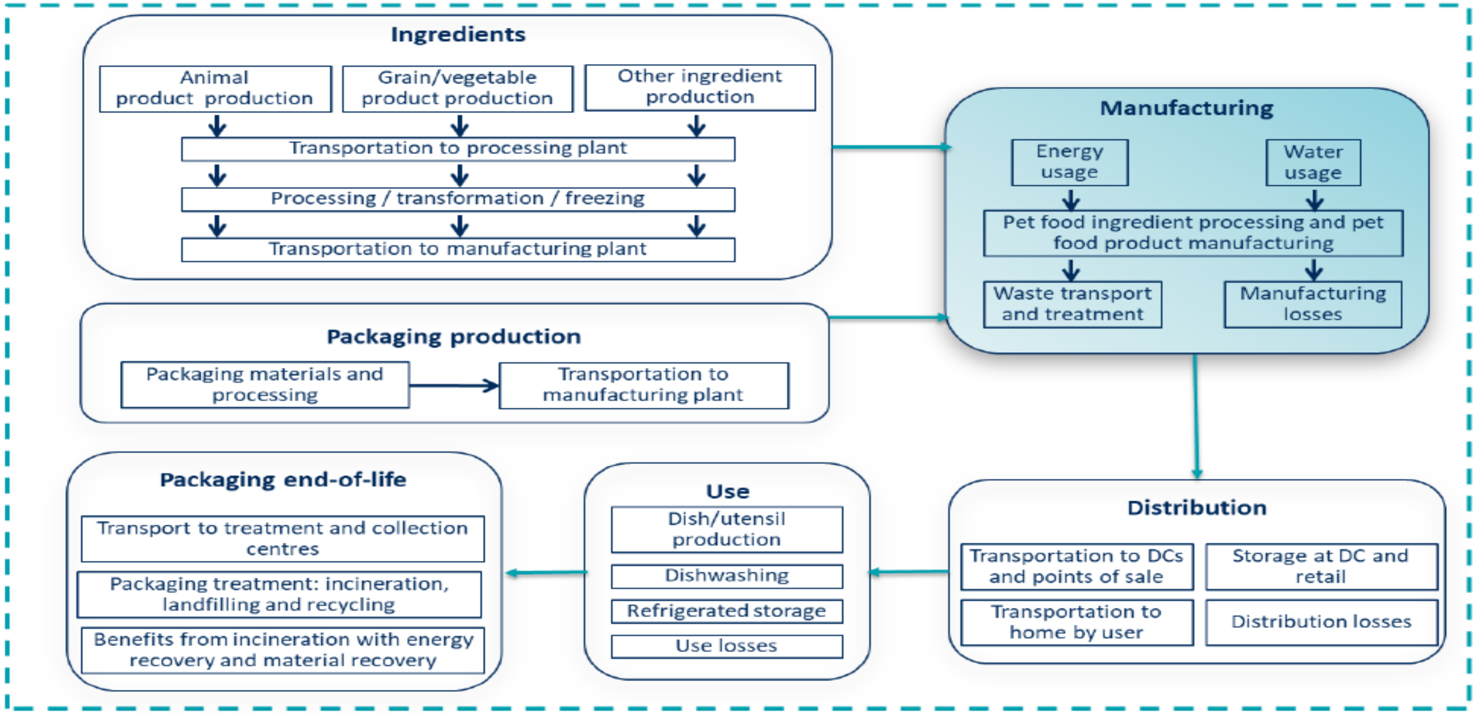
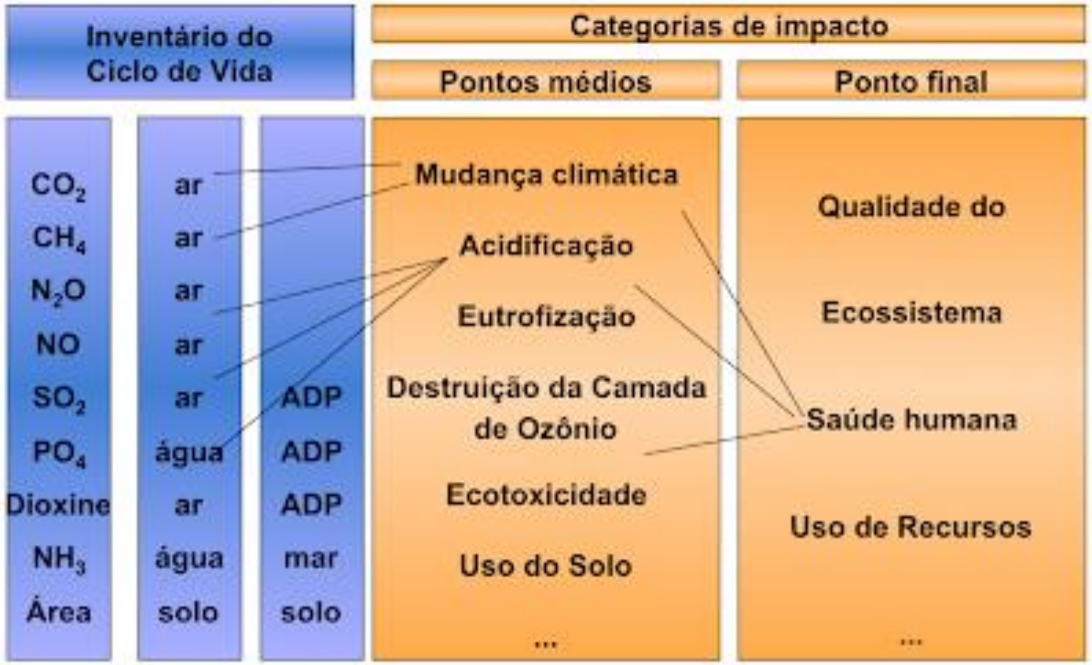


Figure 4 System boundaries and key activities where the foreground is highlighted in blue

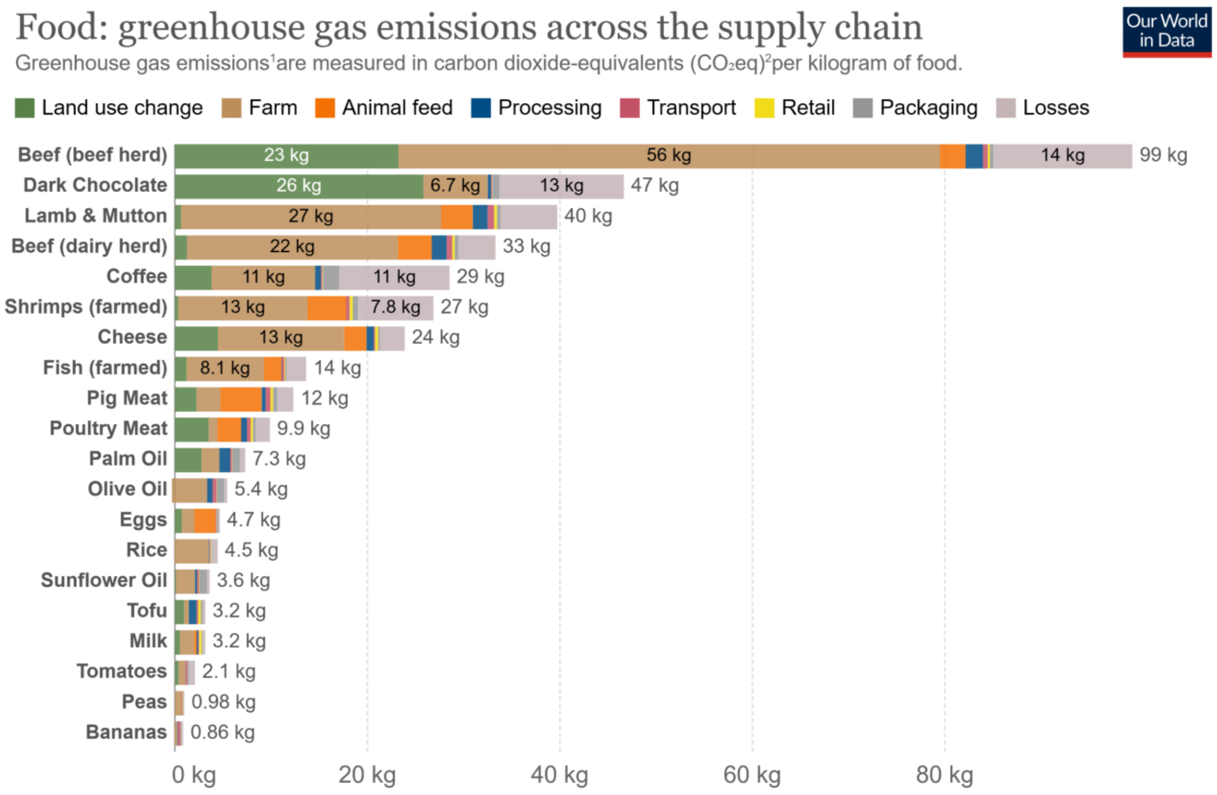
Avaliação do Ciclo de Vida (ACV)

- **Categorias de Impacto**
  - o Dependem do método usado
  - o Diversas formas de apresentação



Alguns dados sobre o mercado de carne

- **Impactos ambientais (GHG)**



Importância do processo de "Rendering"

- **EFPRA** – Woodgate e Verveen (2004)

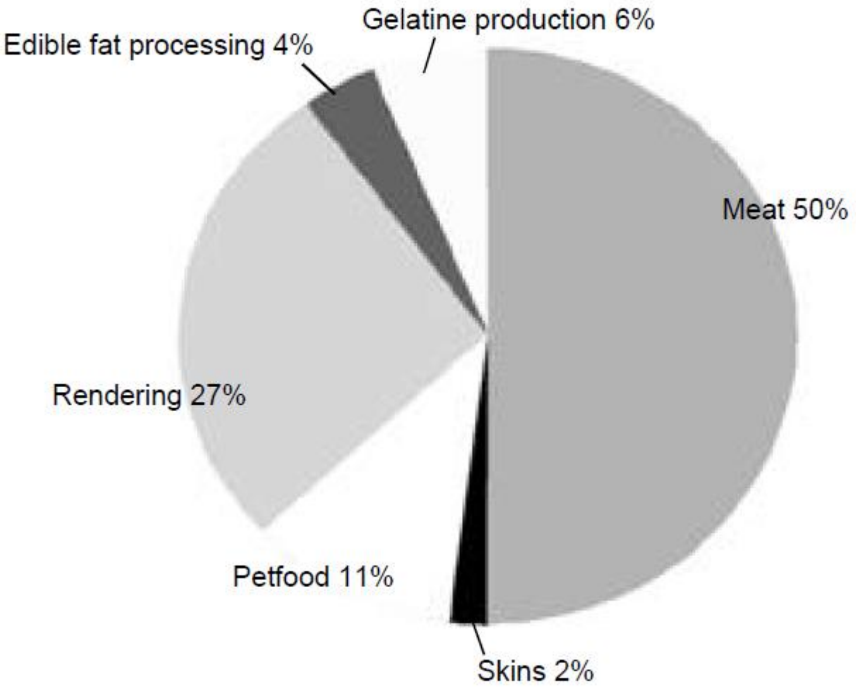
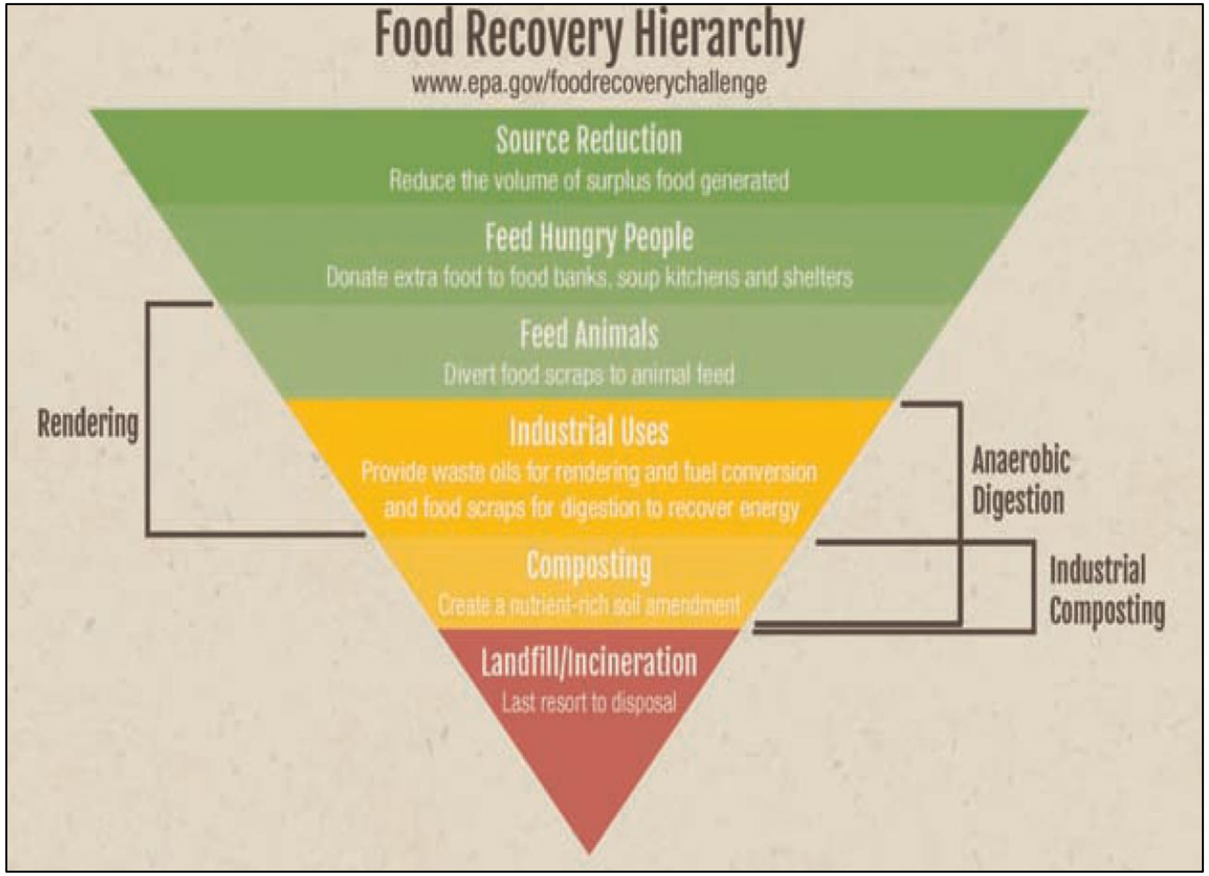
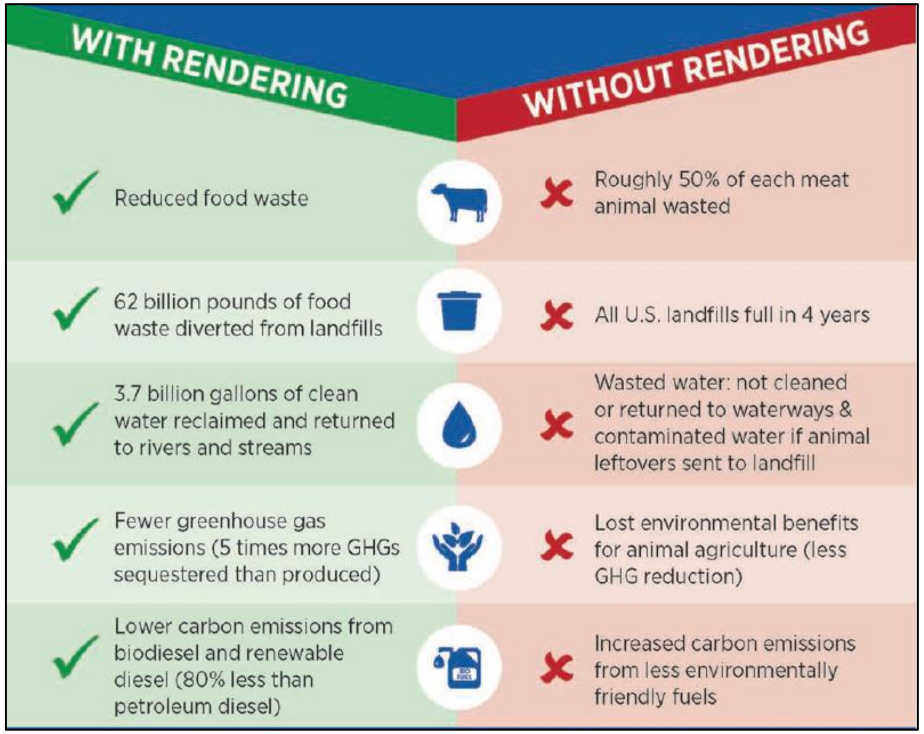


Figure 1. Estimated utilization of slaughtered animal (by % weight).

Processo de “Rendering”

- **Cenário de destinos**





Prevenção na emissão de Carbono e nitrogênio pelo "Rendering"

- **Estimativa nos EUA** (Meeker e Meisinger, 2015)

Table 9. Carbon removed in the form of rendered products (Gooding, 2012)

Product	Production, t	Carbon content, %	Carbon, t	CO_2, t
Animal fat	4,515,600	75.89	3,426,889	12,566,516
Meat and bone meal	2,314,600	24.27	561,661	2,059,629
Poultry byproduct meal	1,153,500	28.68	330,801	1,213,057
Feather meal	600,900	37.50	225,350	826,364
Pork meal	720,711	25.59	184,427	676,300
Blood products	102,512	37.50	38,444	140,976
Total all products	9,407,823		4,767,571	17,482,842

Table 10. Nitrogen removed in the form of rendered products (Gooding, 2012)

Product	Production, t	Protein, %	N, t
Meat and bone meal	2,314,600	55	203,685
Poultry byproduct meal	1,153,500	65	119,964
Feather meal	600,900	85	81,722
Pork meal	720,711	58	66,882
Blood products	102,512	85	13,942
Total protein meals	4,892,223		486,195

Economia circular no “Rendering”

- **North America Renderers Association (2021)**

Sangue e componentes

- Corantes e tintas
- Adesivos
- Medicamentos
- Materiais de laboratório

Pele

- Adesivos
- Folhas de papel
- Gelatina
- medicamentos

Ossos

- Carvão
- Fertilizantes
- Frascos

Cascos e chifres

- Adesivos
- Plásticos
- Filmes fotográficos
- Compensado
- Shampoo
- Papel de parede

Pêlos

- Filtros de ar
- Escovas
- Feltro
- Isolantes
- Gesso
- Têxteis

SNC e visceras

- Cremes anti-idade
- Medicamentos
- Cordas de inst. Musicais
- Hormônios
- Enzimas
- Vitaminas

Processo de “Rendering”

- **Farinhas de vísceras e farinha de penas de aves**

I. Campos et al. / Journal of Cleaner Production 252 (2020) 119845

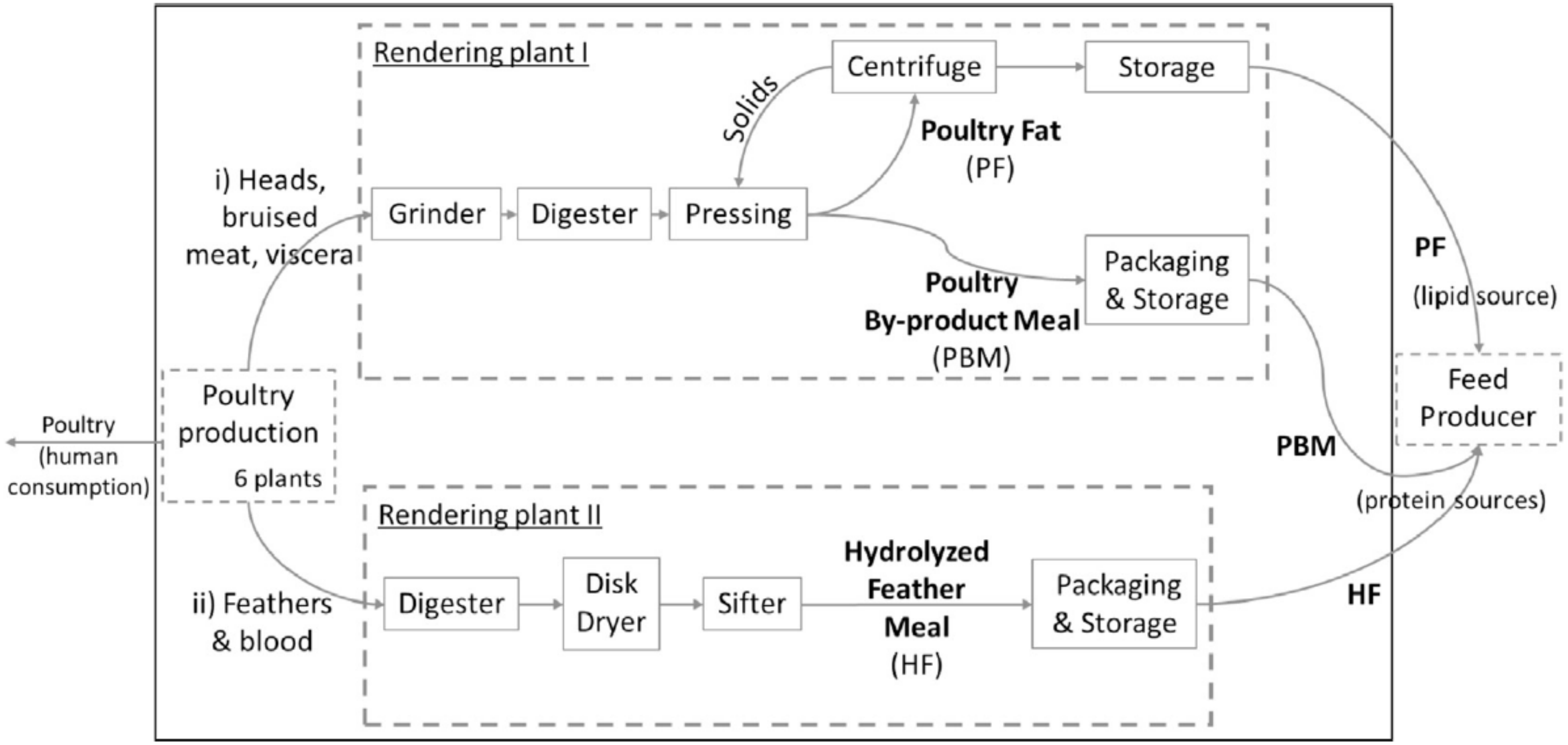
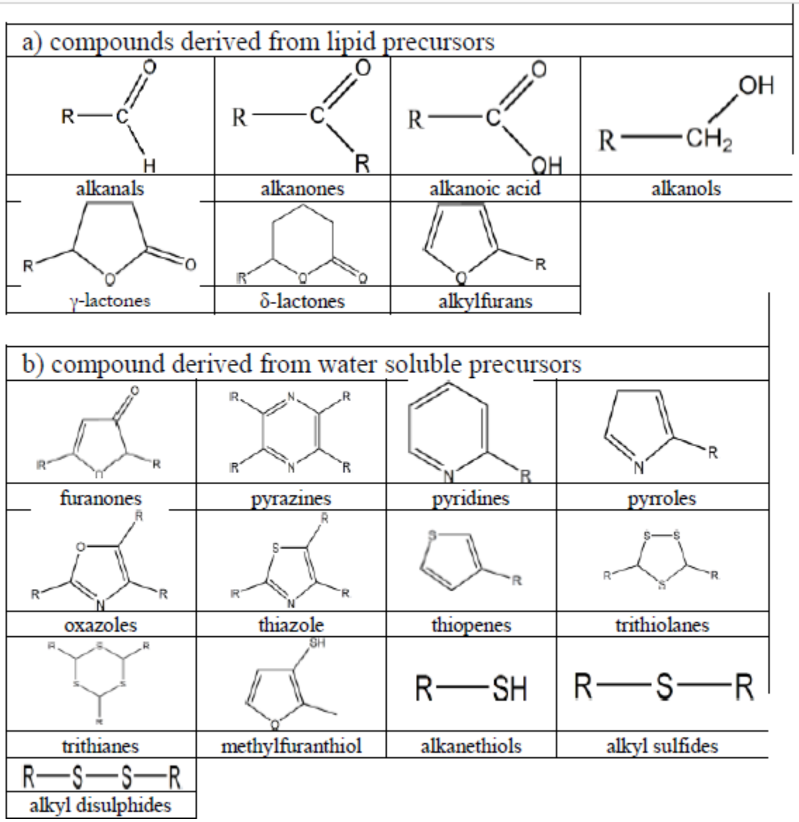


Fig. 1. System boundaries of the life cycle assessment of PF and PBM (top) and of HF (bottom). Dashed boxes represent different locations.

Emissões das Fábricas de Subprodutos

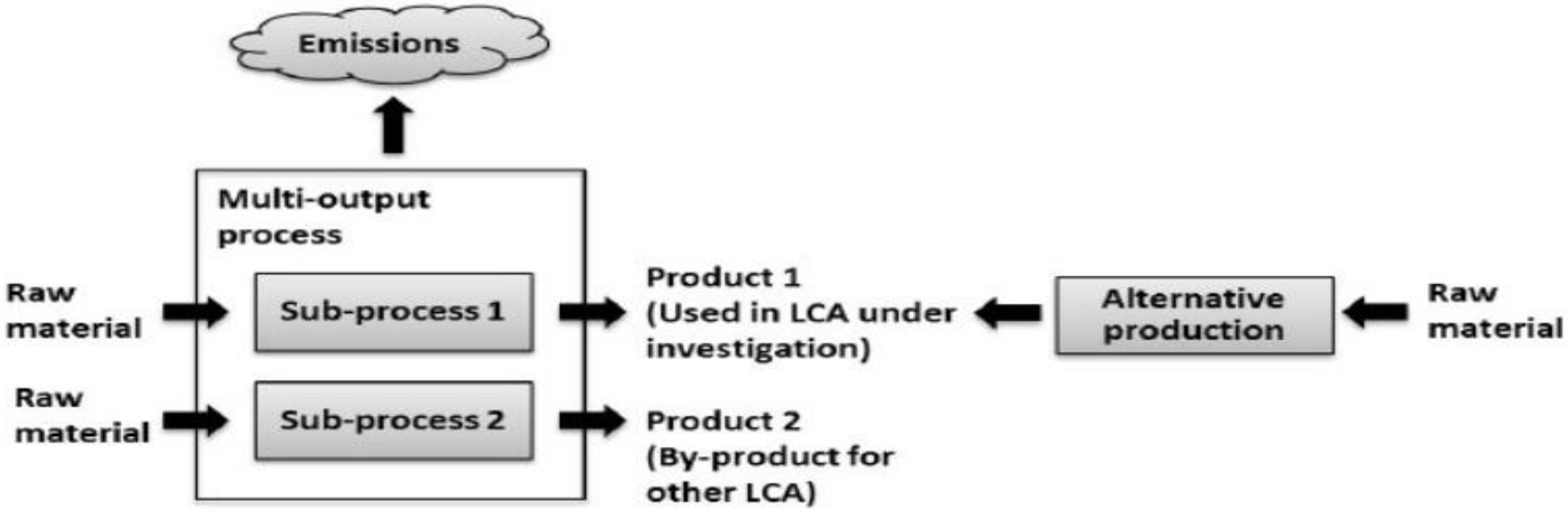
- **Uso de energia**
- **Poeira**
- **Geração de compostos de odor e gases**
  - Sulfetos orgânicos
  - Dissulfetos
  - Aldeídos
  - Trimetilamina
  - Hidrocarbonetos alifáticos
  - Ácidos orgânicos
  - Aminas e pirazinas



Anuar et al, 2017

Contabilização de impactos em Sistemas de produtos

- Procedimentos de alocação



Figure

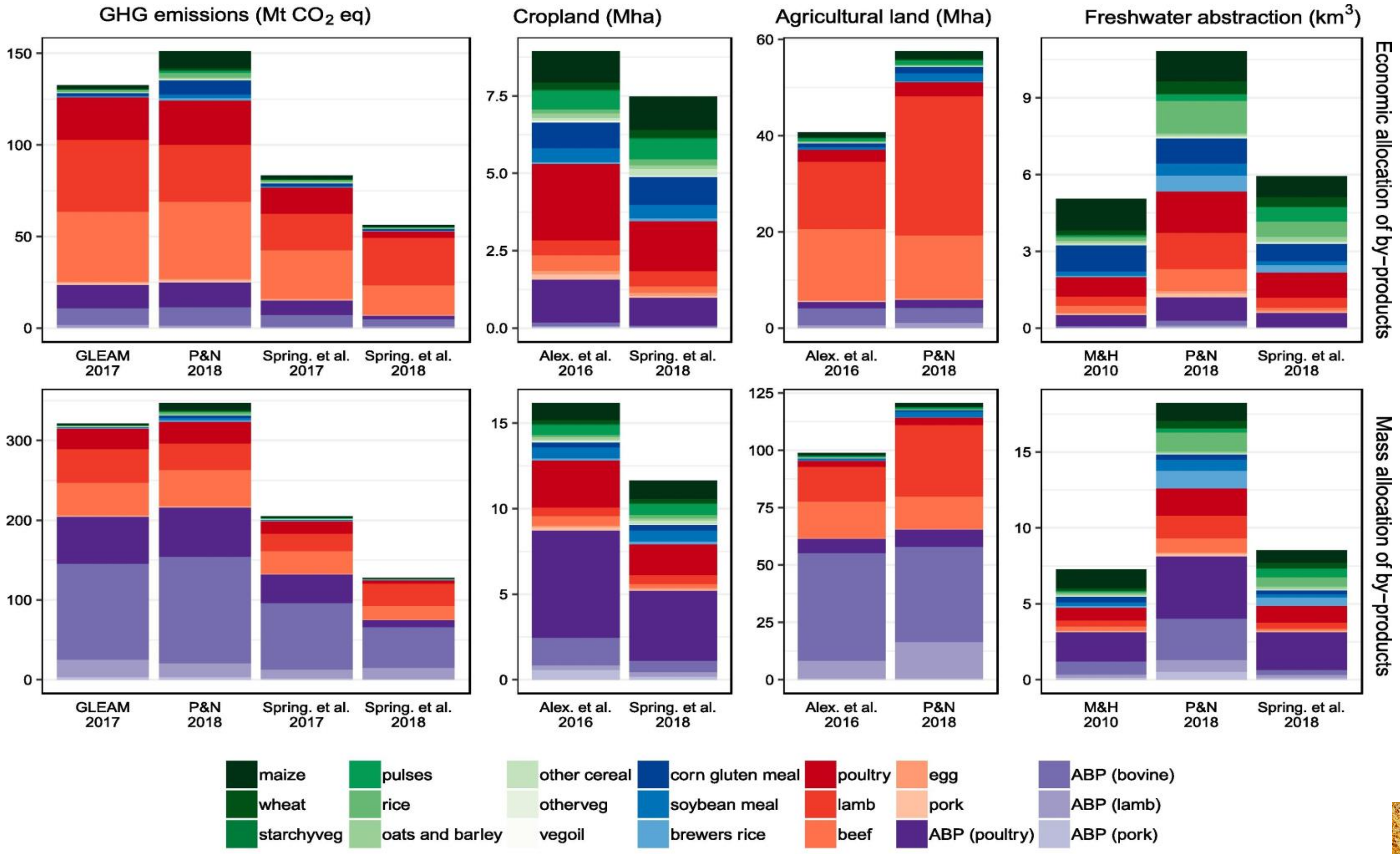
Caption

Figure 1. Overview of the allocation problem in multi-output processes.

(Messagie et al., 2013)

Contabilização de impactos em Sistemas de produtos

- Procedimentos de alocação
  - Alocação Econômica
  - Alocação de Massa



(Alexander et al., 2020)

Alocação de produtos em Rendering de frangos

- ## Alocação de farinha e gordura de frango

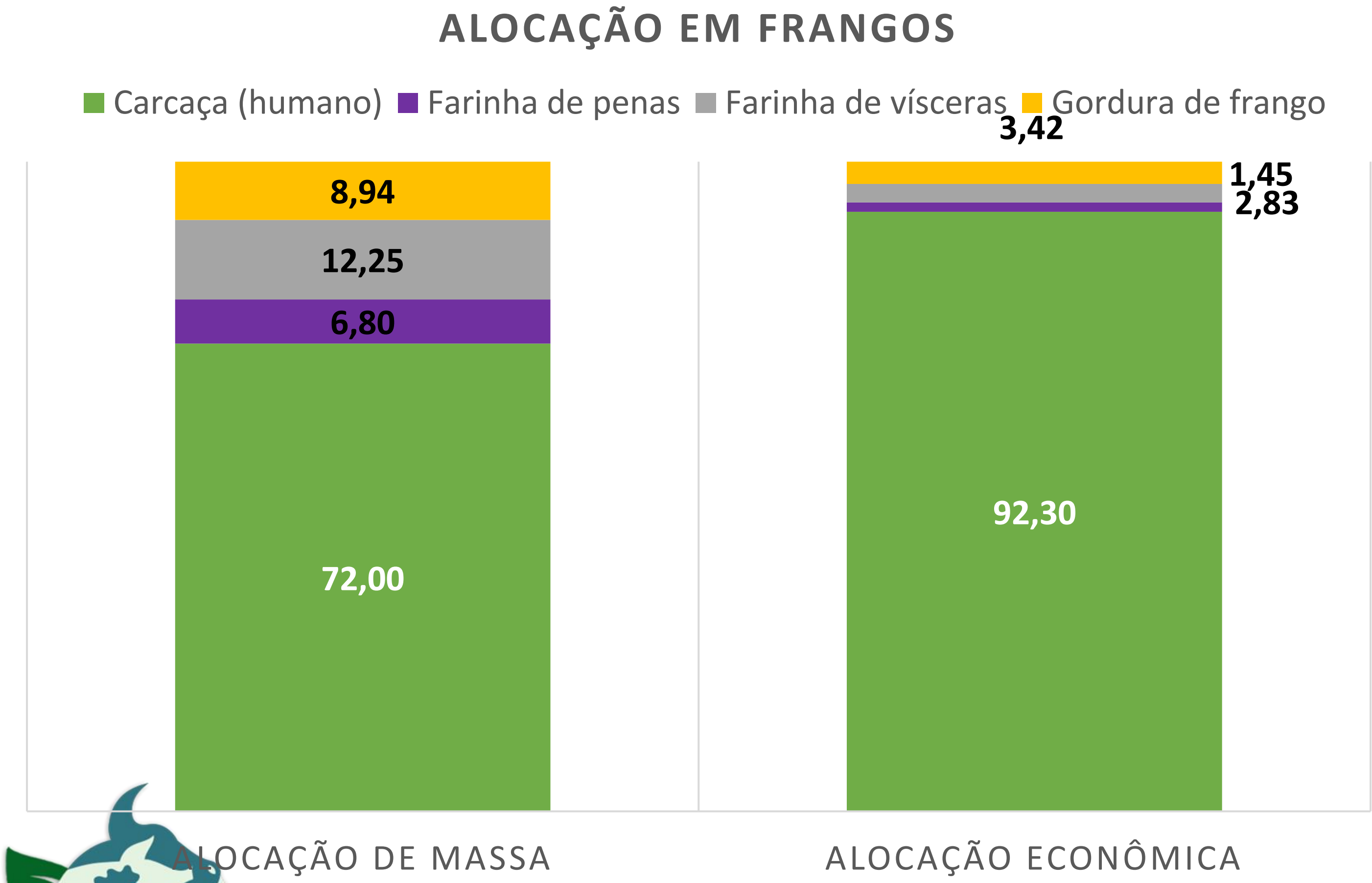


Table 3
Allocation factors for poultry production.

Products	Mass (%)	Economic (%) [a]
Poultry*	69	99.1
By-products i) (heads, bruised meat, viscera)	22	0.6
By-products ii) (feathers and blood)	9	0.3

For human consumption.
[a] Based on average market prices - poultry meat for human consumption: 2000 €/t; by-products i) and ii): 40 €/t.

Table 4
Allocation factors for PF and PBM co-production.

Products	Mass (%)	Economic (%) [a]
PF	38.9	37.2
PBM	61.1	62.8

[a] Based on average market prices - PF: 689 €/t; PBM: 741 €/t.

(Campos et al., 2020)

Alocação de produtos em Rendering de frangos

- **Etapas de produção e consumo de energia são os mais relevantes**

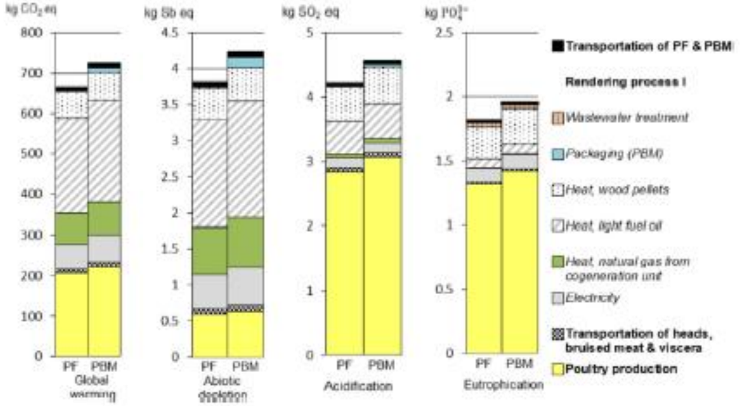


Fig. 2. Life cycle impacts of 1 t of PF and 1 t of PBM, based on economic allocation.

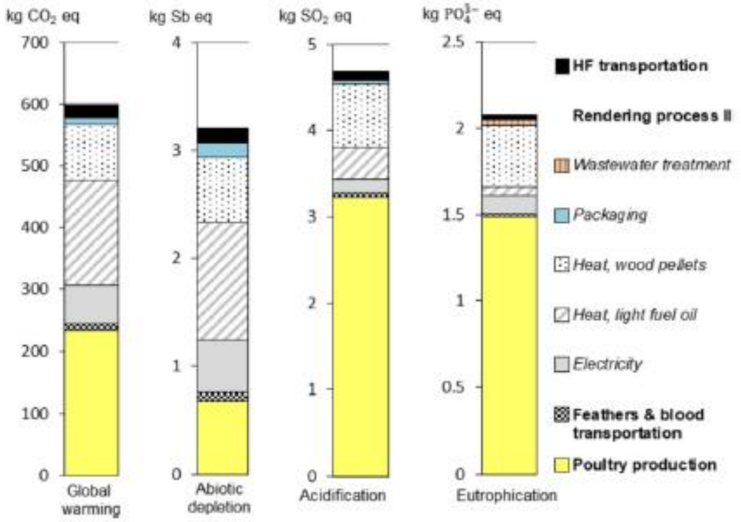


Fig. 3. Life cycle impacts of 1 t of HF, based on economic allocation.

I. Campos et al. / Journal of Cleaner Production 252 (2020) 119845

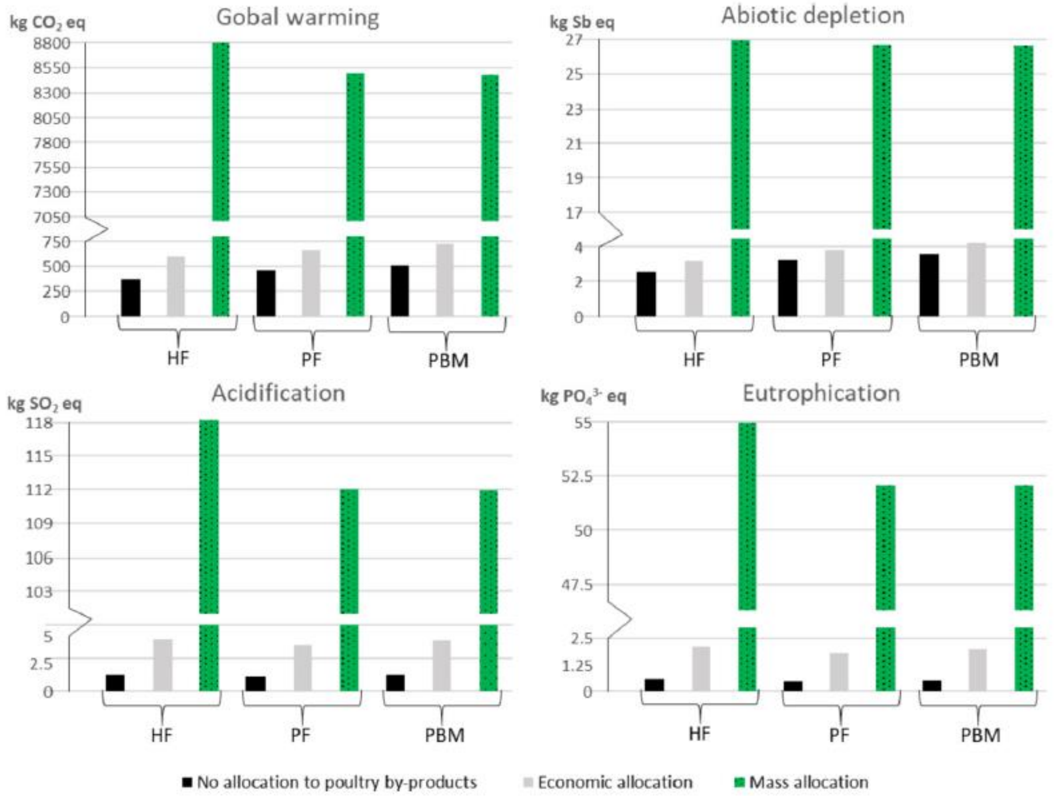


Fig. 4. Life cycle impacts of 1 t of HF, 1 t of PF and 1 t of PBM; comparison of three allocation approaches.

(Campos et al., 2020)

Geração de energia é o gargalo em Rendering

- **O tipo de energia tem grande influência nos impactos**

Table 6
Parameters for scenario analysis.

Parameters	Lower bound	Baseline	Upper bound
Type of fuel for process heat	Pellets	Mix of fuels	Fuel oil
Electricity generation	Hydro reservoir	Portuguese mix	Coal
By-products transportation distance	0 km	117 km to rendering plant I 40 km to rendering plant II	300 km

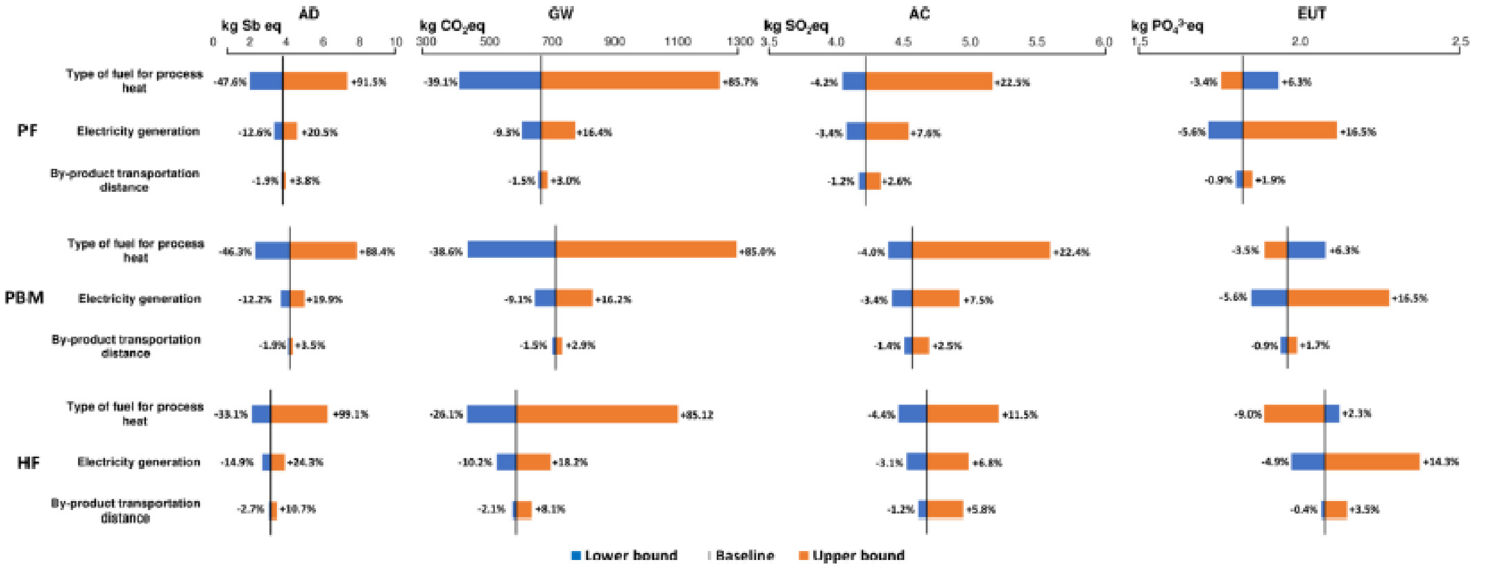


Fig. 5. Sensitivity analysis for the life cycle impacts of PF, PBM and HF production, regarding alternative sources of heat, electricity generation system and by-product transportation distances.

(Campos et al., 2020)

Considerações sobre os Ingredientes animais

- **Etapas de maior impacto na Produção**

    - Alimentação

    - Uso de energia

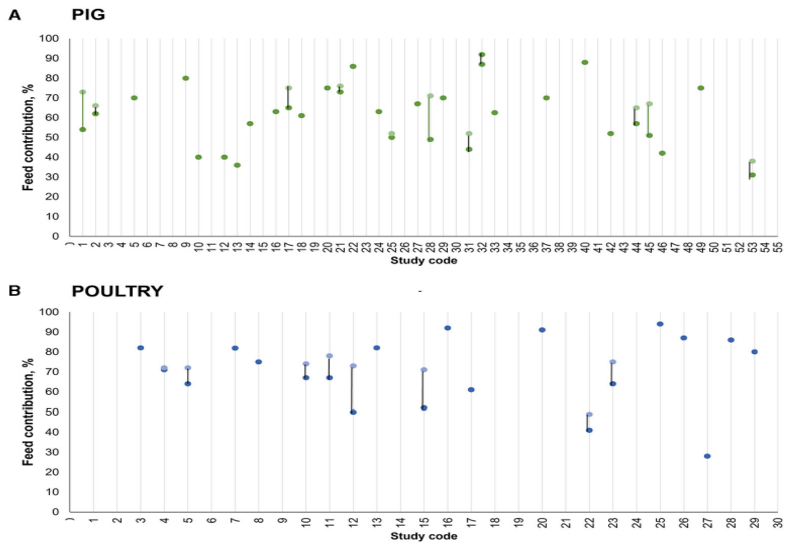


FIGURE 4 | Feed contribution to the potential impact of climate change in LCA studies focusing on pig **(A)** or poultry **(B)** production. Study codes are the same as those presented in **Tables 1**, **2** for pigs and poultry, respectively. Blank lines were used for studies where the exact information was not presented in the original publication (text or tables, as the exact value could not be obtained when information was presented in figures).

- **Etapas de maior impacto nas FSPs**

    - Uso de energia

Produção de carne – Pegada de carbono

- Röös et al. (2012) – Uso de energia e PC se correlacionam

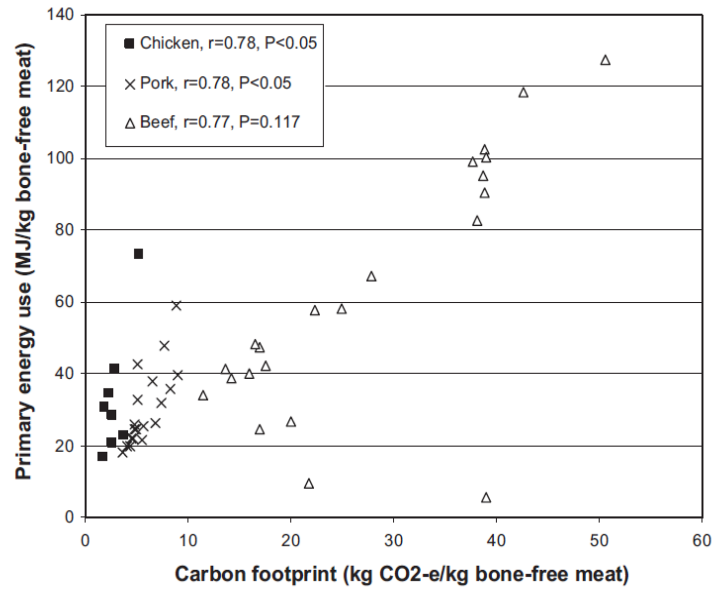


Fig. 1. Correlation between carbon footprint and primary energy use in livestock production, $r = 0.78$, $P < 0.05$ across all species.

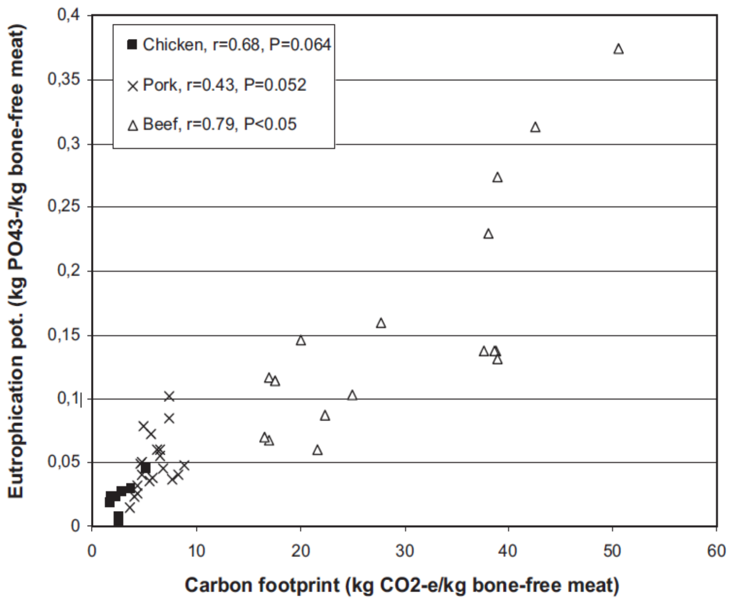


Fig. 4. Correlation between carbon footprint and eutrophication potential in livestock production, $r = 0.88$, $P < 0.05$ across all species.

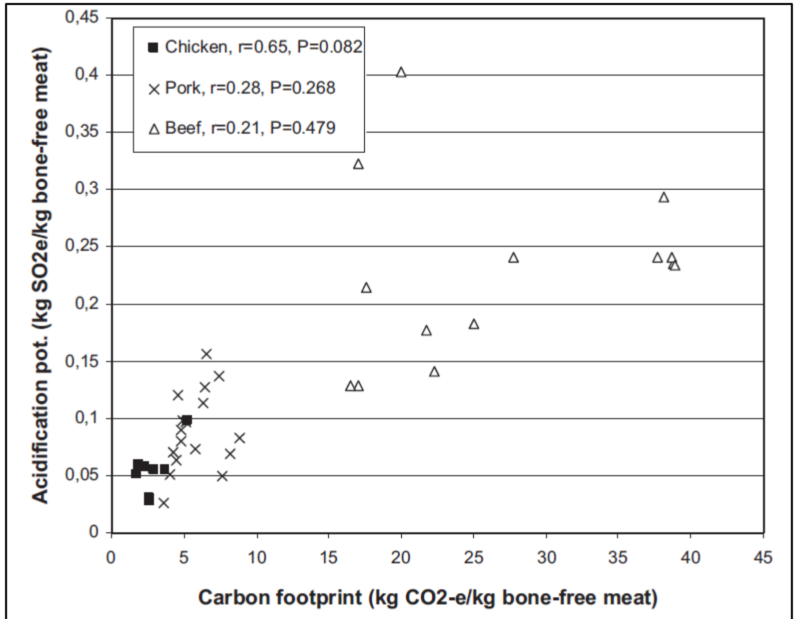


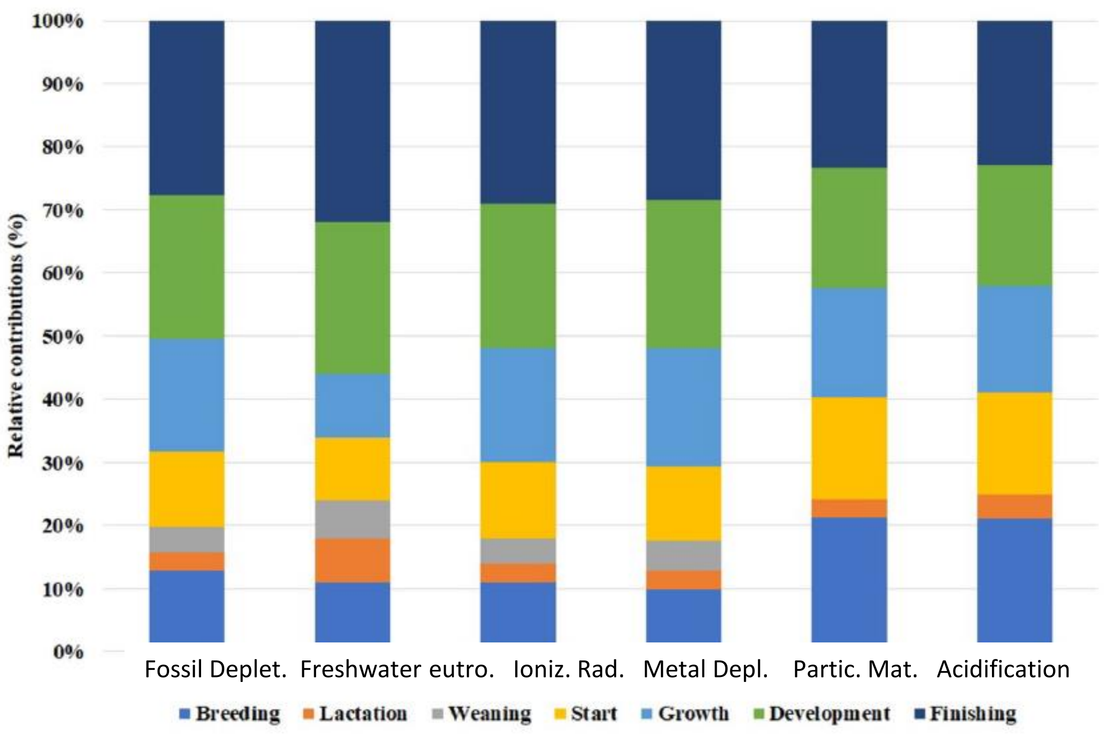
Fig. 3. Correlation between carbon footprint and acidification potential in livestock production, $r = 0.78$, $P < 0.05$ across all species.

Mitigação dos impactos da produção

- **Vários fatores podem ser trabalhados**

Villavicencio et al., 2022

  - Fase da produção
  - Sistema de produção
  - Nutrição
  - Genética
  - Energia
  - Destino de resíduos



Efeitos dos sistemas de produção

- **Emissão de gases de efeito estufa**

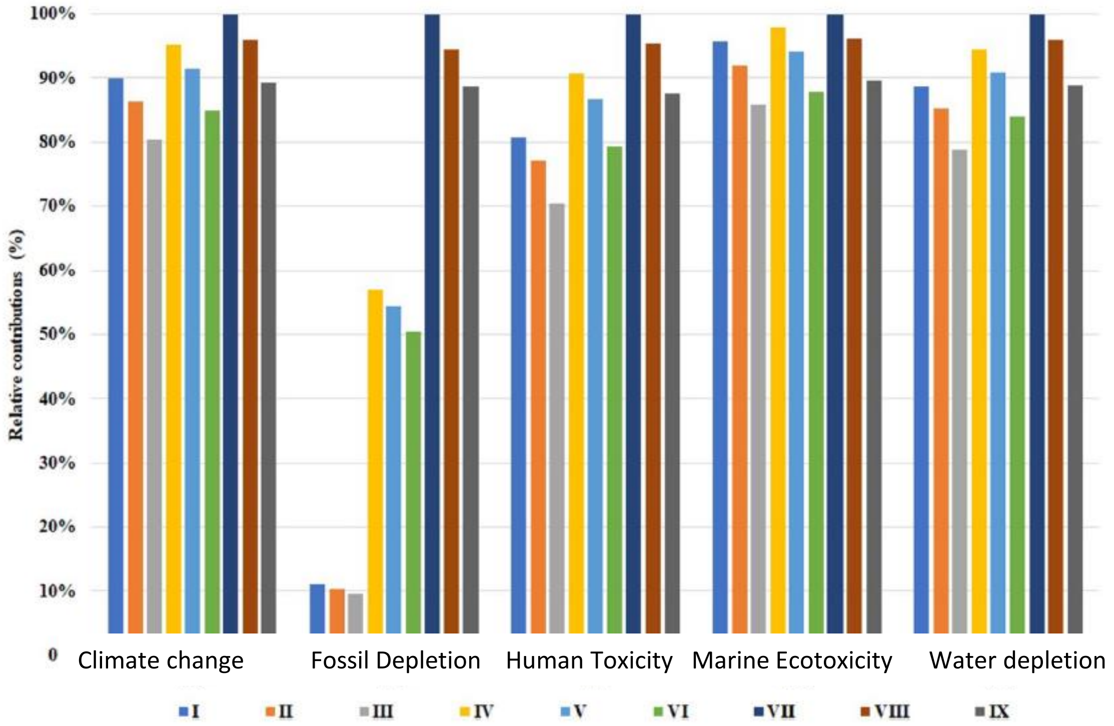
TABLE 3 Global warming potential (GWP) under different functional units

Species	System	Mass-based GWP (kg CO_2-eq/kg meat)	Quality-based GWP (kg CO_2-eq/g omega-3)	Quality-based GWP (kg CO_2-eq/g EPA + DHA)
Beef	Concentrate	9.8[a]	48.0	288.1
	Forage	18.3[a]	18.5	67.7
Lamb	Lowland	26.1[a]	28.7	99.2
	Upland	30.9[a]	30.0	98.9
Chicken	Intensive	4.4	1.2	25.1
	Free range	5.1	2.4	34.7
Pork	Intensive	7.4[a]	14.4	50.3

Notes. DHA and EPA are a subgroup of omega-3 fatty acids that are the most biologically active and do not need to compete with omega-6 for enzymes.
DHA: docosahexaenoic acid; EPA: eicosapentaenoic acid.
[a]Recalculated from values reported by the authors for cross-study comparability.

Mitigação dos impactos da produção

- **Abate dos animais com 90kg reduziu os impactos em 11%**



Villavicencio et al., 2022

Comparativo de eficiência em frangos

- **Sistemas Convencional vs. Orgânico vs. Orgânico-plus**

Table 1
Mean characteristics of the three poultry farming systems.

	C	O	OP
Genetic strain used	Fast-growing (Ross 308 – M + F)	Fast-growing (Ross 308 – only F)	Slow-growing (Gaina –M + F)
Total birds per cycle (*N*)	53,781	9600	65,800
Buildings area (m^2)	2955	2000	3,000[a]
Density indoor (birds/m^2)	18.2	9.6	16.6[b]
Pasture area (ha)	–	8.0	57.0
Density outdoor (birds/m^2)	–	0.25	0.10
Age at slaughter (d)	48 (mean for M + F)	81	100 (mean for M + F)
Cycles of production (*n*/year)	6.1	3.7	3.3

M = Male; F = Female.
[a] Buildings are used mainly in case of bad weather and during the night.
[b] For conventional and organic-plus systems, the values are means of the performance considering a female/male ratio = 1. Source: Direct surveys of the three systems.

Table 4
Economic indicators of the three poultry farming systems.

FS	C	O	OP
Indicators			
Final weight at slaughtering (kg)	2.65	3.48	2.45
Feed conversion ratio	1.9	2.9	3.6
Mortality rate (%)	3.8	5.1	6.0
Net income (€/kg)	0.01	0.13	0.05
Revenue (€/kg)	1.20	1.56	2.76
Labor per production unit (h/animal)	0.02	0.02	0.10

Source: Data directly collected in 6 farms in central Italy, 2010

Martinelli et al., 2012

Tendência na Produção Animal

- **Ambiente x Bem-estar**

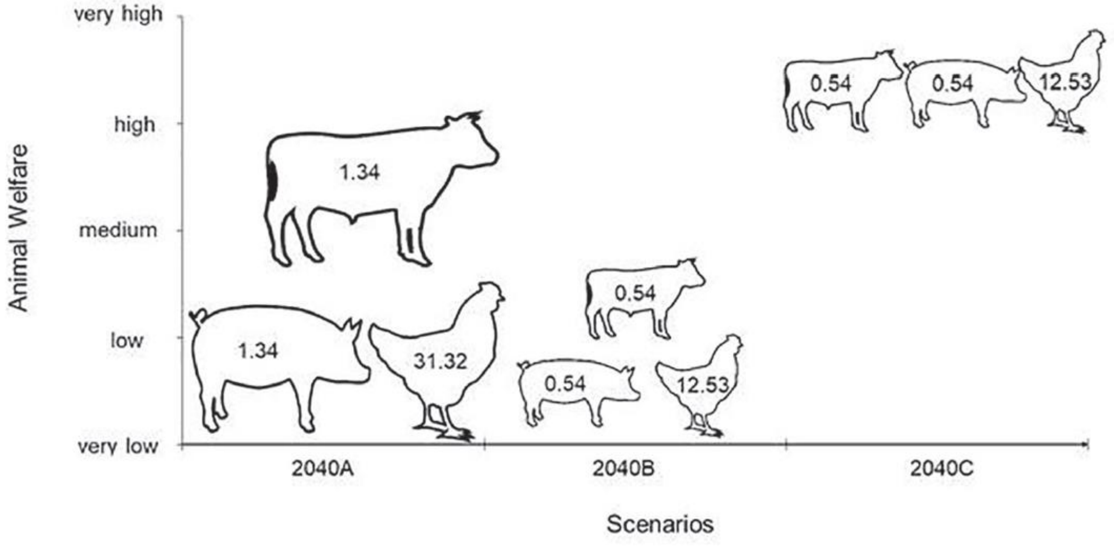


FIGURE 2 | Number of individual animals in each degree of animal welfare, in billions, considering the estimated total number of cattle, pigs, and chickens in 2040, assuming that total global meat production will be reduced to 40% of its 2019 level, following the projected insertion of 35% of cell-based and 25% of plant-based meat production (Gerhardt et al., 2019).

Heidemann et al., 2020

Comparativo de eficiência em frangos

- **Menor eficiência ambiental do OP, mas melhor escore geral**

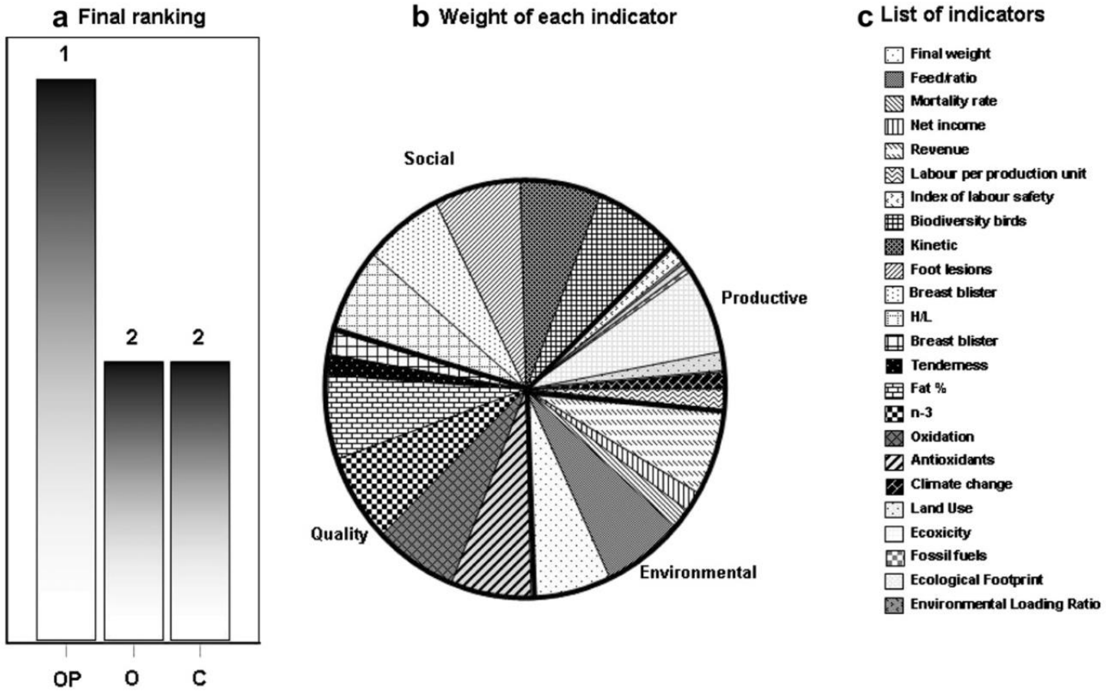


Table 7
Environmental performance of the three poultry farming systems.

FS	C	O	OP
Indicators			
Climate change (Daly × 10^3)	0.25	0.18	0.22
Land use (PDF*m^2*yr)	1.94	3.68	4.59
Ecotoxicity (PAF*m^2*yr)	0.24	0.76	0.91
Fossil fuels (MJ surplus)	1.68	1.45	1.74
Ecological footprint (gm^2*yr)	12.81	20.37	26.13
Environmental loading ratio	3.80	1.75	2.01

DALY: disability adjusted life years, PAF*m^2*yr: potentially affected species per m^2 per year, PDF*m^2*yr: potentially disappeared species per m^2 for year, MJ surplus: additional energy requirement to compensate lower future ore grade.

Martinelli et al., 2012

Alimentação e Pegada de Carbono

- **Custo mínimo vs. Formulação Multiobjetivo**

Table 3. Feed cost and environmental impacts (±1 SD) of 1 ton of a weighted blend (averaged on four economic scenarios) for pig (40 % grower and 60 % finisher), broiler (6 % starter, 20 % grower and 74 % finisher) and young bulls formulated with multi-objective (MO) formulation (at $\alpha = \alpha_{lim}$ averaged on the four economic scenarios)*
(Mean values and standard deviations)

		Criteria included in the MO function										Criteria excluded from the MO function			
		Price (€)		PD (kg P)		NRE (MJ)		CC (kg CO_2-eq)		LO (m²year)		AC (mol H^+-eq)		EU (kg PO_4^{3-}-eq)	
	α_{lim}	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pig feeds															
LIM-LC	–	216	12·4	3·4	0·36	5150	568·7	499	18·2	1418	59·5	9·7	0·48	3·6	0·05
LIM-MO	0·54	219	12·5	3·2	0·15	4475	347·2	427	4·6	1235	16·4	9·0	0·57	3·2	0·03
NLIM-LC	–	214	11·0	3·6	0·41	4750	503·9	456	64·1	1514	43·9	8·3	1·48	3·4	0·25
NLIM-MO	0·60	221	9·0	2·7	0·19	4082	196·4	350	10·4	1274	34·1	6·9	0·30	2·9	0·08
Δ LIM-MO *v.* LIM-LC (%)	–	1·6		−8·4		−13		−14		−7·2		−13		−11	
Δ NLIM-MO *v.* NLIM-LC (%)	–	3·5		−25		−14		−23		−16		−17		−17	
Δ NLIM-MO *v.* LIM-LC (%)	–	2·4		−21		−21		−29		−10		−29		−19	

(Garcia Launay et al., 2018)

Formulação Multi-objetivo

Multiobjective formulation of livestock feeds 1305

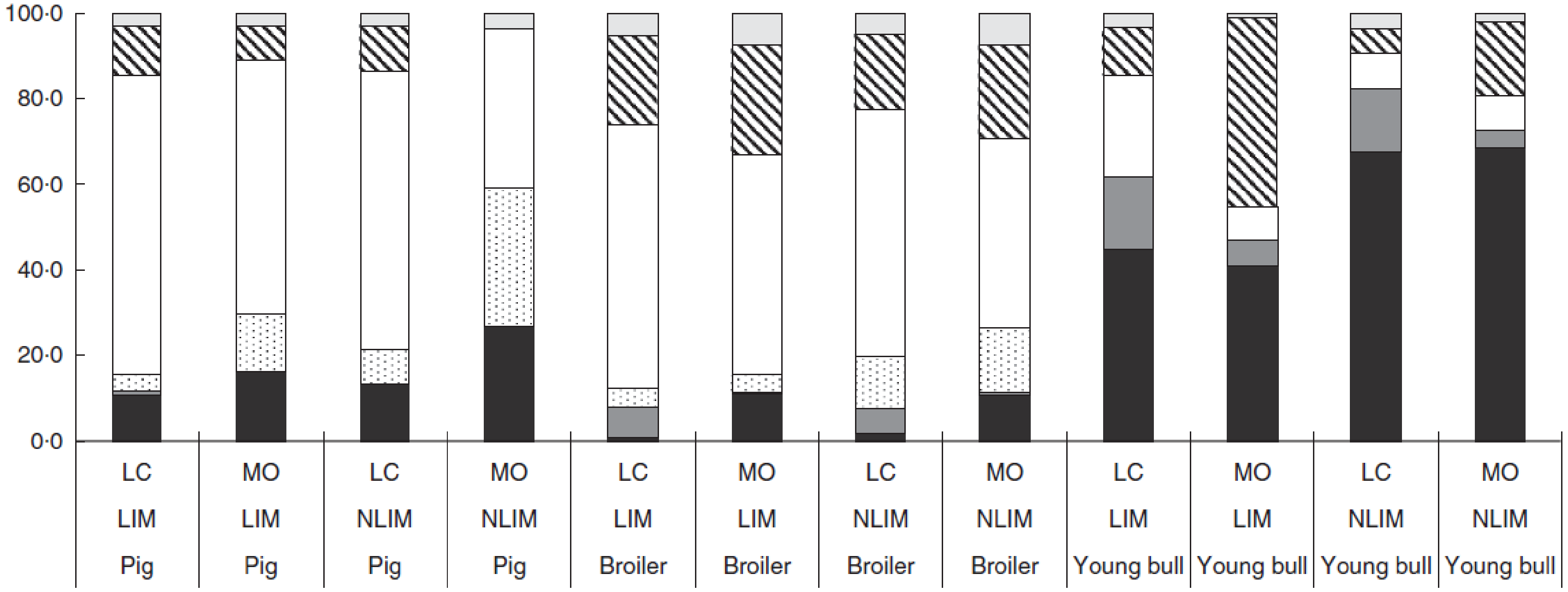
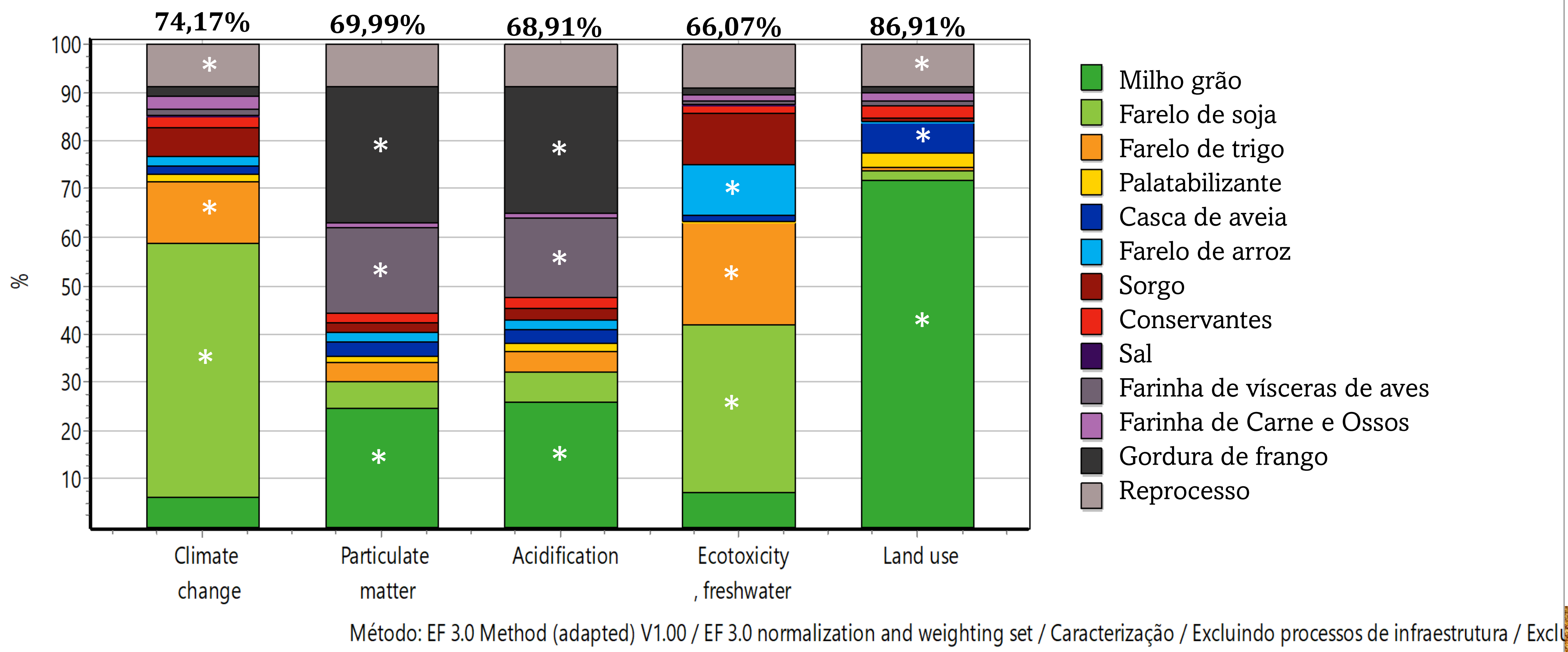


Fig. 2. Mean ingredient composition (%) of feed formulas obtained with least-cost (LC) and multi-objective (MO) formulation in contexts of limited (LIM) and non-limited (NLIM) ingredient availability. ■, Co-products of wheat; ■, co-products of maize; ⊡, oilseeds and protein crops; □, cereals; ▧, oil meals; □, other.

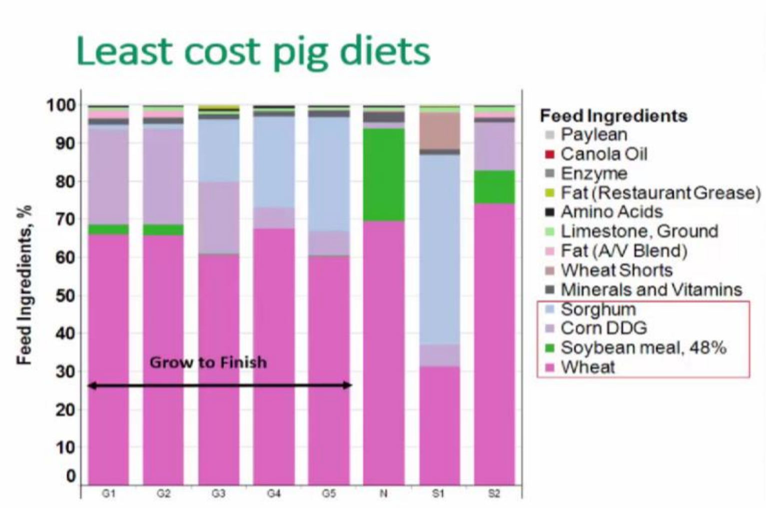
(Garcia Launay et al., 2018)

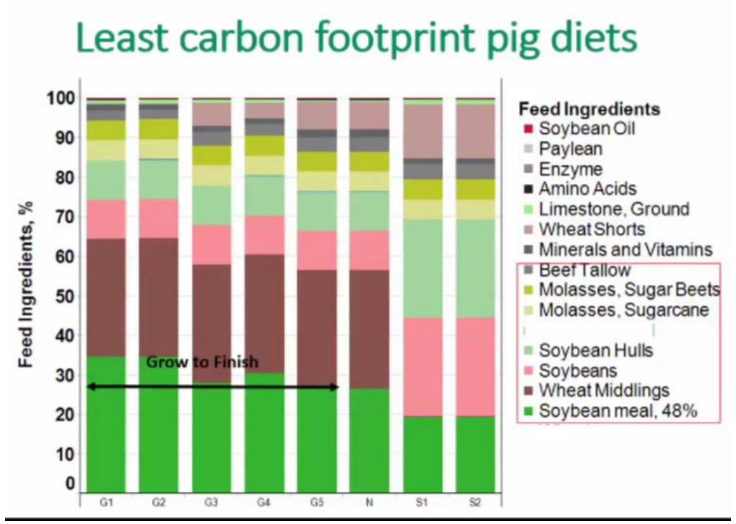
Categorias de Impacto em Pet food

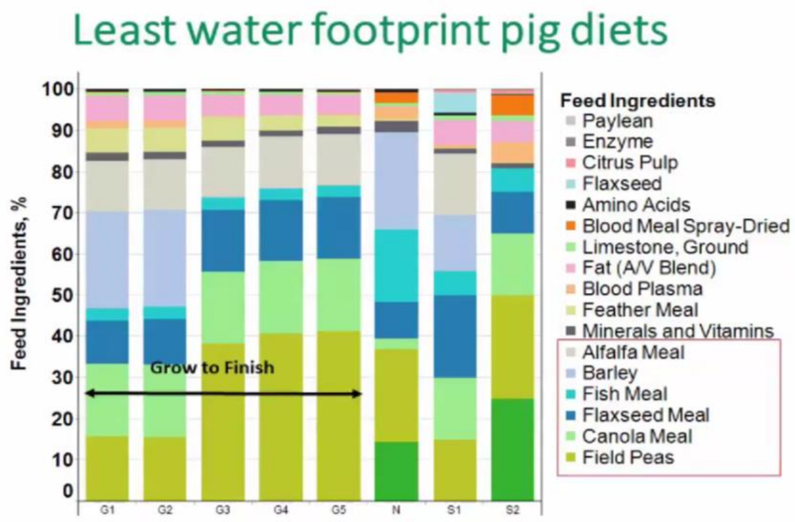
- **As FOAs são ingredientes viáveis do ponto de vista de PC**

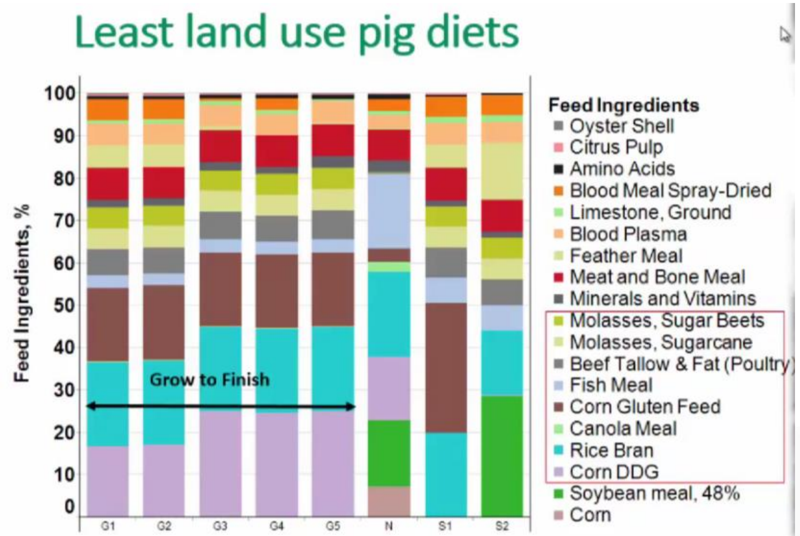


Abordagem Multiobjetivo para suínos









(Jasmina Burek, Universidade do Arkansas)

Abordagens com formulação de alimentos para animais

ALTERNATIVES

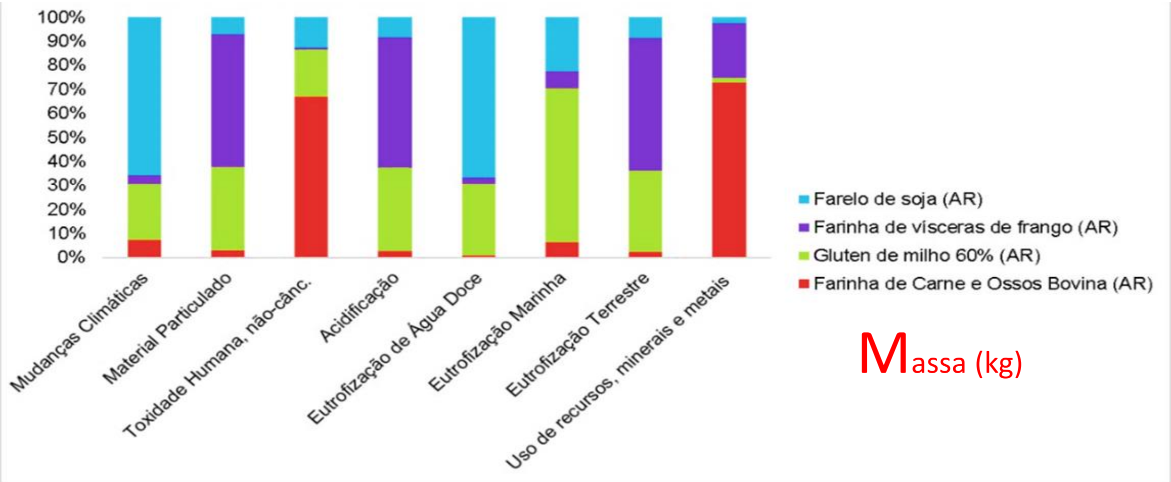
	Average US Pig Diets	Least Cost Pig Diets	Least Carbon Footprint Pig Diets	Least Water Footprint Pig Diets	Least Land Use Pig Diets
Cost ($/kg market pig, live weight)	0.91	0.87	1.13	2.04	1.46
Carbon Footprint (IPCC, 2007) (kg CO2-eq/kg market pig, live weight)	3.08	2.80	1.99	3.14	2.60
Water Footprint (ReCiPe, 2008) (m³/kg market pig, live weight)	0.24	0.24	0.14	0.07	0.11
Land Use (ReCiPe, 2008) (m²a/kg market pig, live weight)	4.25	7.75	6.04	11.05	1.49

Least diagonal

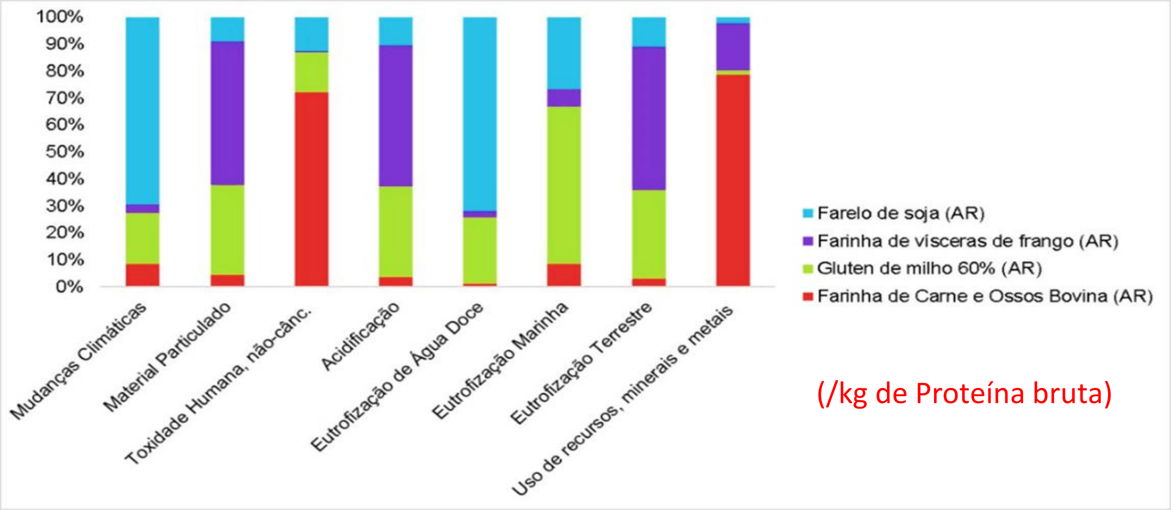
(Jasmina Burek, Universidade do Arkansas)

Comparativo ingredientes

- **Comparativo de Ingredientes de Origem Animal e Vegetal**



Massa (kg)



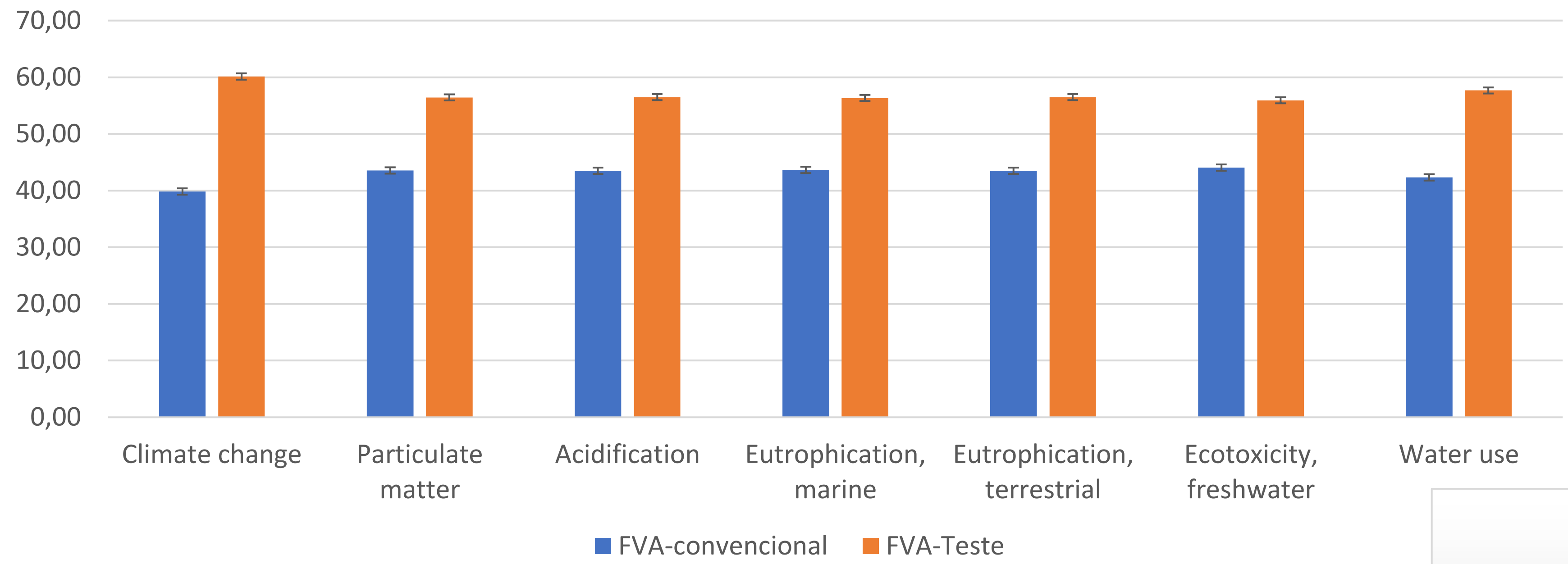
(/kg de Proteína bruta)

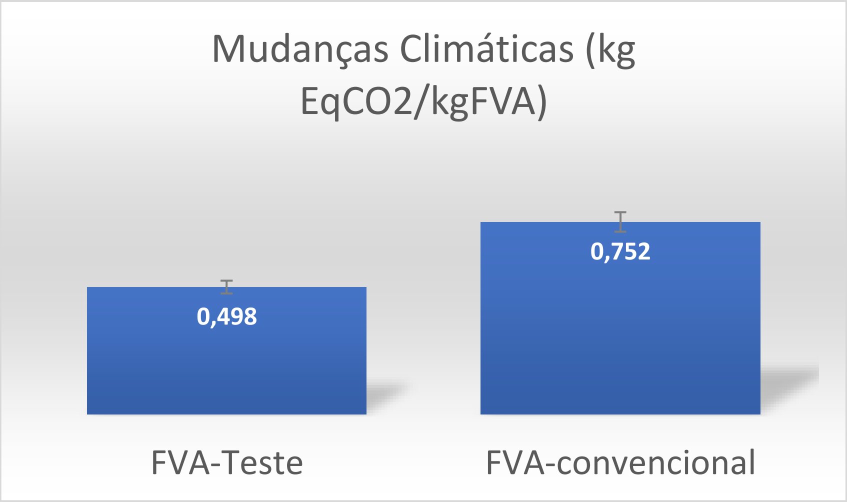
F DE SOJA	FCO	FVA
Mudanças Climáticas (67%)	Toxidade humana não cânc. (67%)	Eutrofização terrestre (55%)
Eutrofização de água doce (67%),	Uso de Recursos Minerais e Metais (73%)	Material Particulado (55%)
		Acidificação (54%)

Não houve mudança significativa na comparação por kg de PB

Farinha de Vísceras de aves

- **Considerando redução de 30% na produção do frango em MC**





Formulação multifuncional - suínos

Mackenzie et al. (2016)

Table 4
Average environmental impacts per kg for all feed ingredients included in grower/finisher diets in the scenarios tested.

Impact category[a]	Energia ñ renov.	Uso de recursos ñ renov.	Acidificação	Eutrofização	Aquecimento Global
Unit[b]	MJ	kg Sb eq	kg SO_2 eq	kg PO_4 eq	kg CO_2 eq
Canola meal	3.2	1.39E-03	7.97E-03	1.59E-03	0.30
Canola oil	8.9	3.84E-03	2.20E-02	4.40E-03	0.84
Corn	4.0	1.71E-03	5.13E-03	1.11E-03	0.39
Soya meal	1.3	5.70E-04	4.11E-03	8.71E-04	0.15
Wheat	4.2	1.84E-03	1.01E-02	2.04E-03	0.43
Meat (pork) meal	2.4	1.05E-03	2.46E-04	6.16E-05	0.13
Corn DDGS	13.9	6.51E-03	1.13E-03	2.66E-04	0.78
Wheat shorts	1.2	5.12E-04	2.78E-03	5.59E-04	0.12
Bakery meal	1.2	5.17E-04	1.41E-03	2.60E-04	0.08
Animal-vegetable fat blend	5.9	2.57E-03	1.01E-02	2.06E-03	0.49
HCL-Lysine	83.0	3.51E-02	2.12E-02	9.97E-03	4.81
L-Threonine	83.0	3.51E-02	2.12E-02	9.97E-03	4.81
FU-Methionine	80.5	3.64E-02	7.54E-03	1.70E-03	2.95
L-Tryptophan	166.0	7.01E-02	4.24E-02	1.99E-02	9.62
Sodium Chloride	3.1	1.21E-03	8.97E-04	6.68E-04	0.18
Mono-calcium Phosphate	21.5	9.40E-03	2.68E-02	3.63E-04	1.51
Limestone	0.4	1.31E-04	1.03E-04	3.58E-05	0.02

[a] NRE = Nonrenewable energy use, NRRU = Nonrenewable resource use, AP = Acidification Potential EP = Eutrophication Potential, GWP = Global Warming Potential.
[b] eq = equivalent.

Fontes Alternativas

- Insetos alimentícios
- Microalgas
- Proteínas unicelulares

Average global warming potential estimates of select insect-, animal-, and plant-origin ingredients with applications in US pet foods

Ingredient	LCA Study Location[1]	Carbon Footprint (kg CO_2 Eq/kg Functional Unit)	Reference
Insect, origin			
Black soldier fly larvae[a]	DEU	1.36–15.1	Smetana et al,[78] 2016
Animal, origin			
Plains, ranched beef[b]	USA	20.4–23.2	Rotz et al,[79] 2019
Pasture, finished beef[c]	USA	19.2	Pelletier et al,[80] 2010
Feedlot beef[c]	USA	14.8	Pelletier et al,[80] 2010
Grassland, grazed lamb[b]	NZL	19	Ledgard et al,[81] 2011
Hillside, raised lambs[c]	ENG	17.9	Jones et al,[82] 2014
Lowland, raised lambs[c]	ENG	10.9	Jones et al,[82] 2014
Organic farmed salmon[c]	CAN	2.7	Pelletier and Tyedmers,[83] 2007
Farmed salmon[c]	CAN	2.1	Pelletier and Tyedmers,[83] 2007
Pork[c]	USA	2.01–3.02	Thoma et al,[84] 2015
Chicken[c]	USA	1.99	Putman et al,[85] 2017
Poultry by-product meal	PRT	0.73	Campos et al,[86] 2020
Poultry fat	PRT	0.67	Campos et al,[86] 2020
Hydrolyzed feather meal	PRT	0.60	Campos et al,[86] 2020
Rendered animal protein	GBR	0.15	Ramirez et al,[87] 2012
Rendered animal fat	GBR	−0.77 to 0.15	Ramirez et al,[87] 2012
Plant, origin			
Rice	USA	1.41–1.88	Johnson et al,[88] 2016
Potato	FRA	0.10–0.11	Godard et al,[89] 2012
Sorghum	USA	0.60–1.24	Johnson et al,[88] 2016
Wheat	USA	0.45–1.32	Johnson et al,[88] 2016
Soybean	USA	0.34–0.70	Johnson et al,[88] 2016
Oats	FRA	0.31	Wilfart et al,[90] 2016
Corn	USA	0.30–1.68	Johnson et al,[88] 2016
Spring peas	FRA	0.29	Wilfart et al,[90] 2016
Rainfed legumes	ESP	0.23	Aguilera et al,[91] 2015

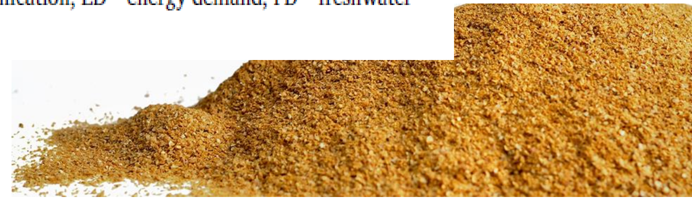
Fontes Alternativas

- Insetos alimentícios
- Microalgas
- Proteínas unicelulares

Environmental impact comparison of main protein sources used for feed and food (per 1 kg of product)

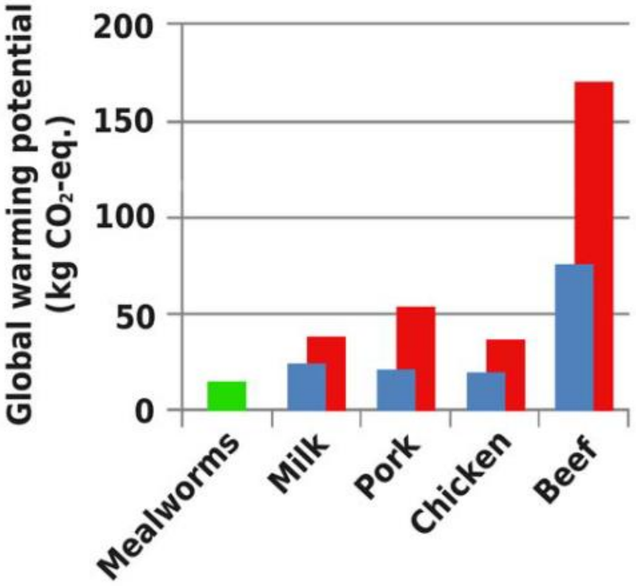
	DM %	Protein, %	GWP, kg CO_2 eq.	OD, mg CFC11 eq.	AC, g SO_2 eq.	EU, g N eq.	ED, MJ	FD, m^3	LU, m^2a
Soybean meal	87.5[1]	49.1[1]	0.34-0.72[1] 6.52[19]	0.2-0.3[1,17]	−1.2 – 3.1[1] 11.4[17]	−81-2[1] (g NO_3 eq.)	5.37[6] 25.5[19]	0.04[6]	3.26[6]
Rapeseed cake	89[1]	34.8[1]	0.37-0.57[6]	0.004-0.05[6]	6.8-7.5[6]	8.9-9.1[6]	3.3-3.8[6]	0.001-0.03[6]	1.5-1.6[6]
Pea protein meal	n/a	n/a	0.44[6] 4-10[8] (pulses)	0.057[6]	21.8[6]	7.94[6]	5.25[6]	0.03[6]	2.85[6]
Fishmeal	90[4]	60-72[5]	0.12-0.58[18]	0.016-0.073[18]	0.12-8.7 [14,18]	−16[4] 0.4-0.87 [3.18]	2.13-17.1[18, 4,3]	0.0002-0.0016[18]	0.0005-0.0052[1] [8,3]
			0.65-1.8[14,3,4,13] 0.48-5.6[15,16] 5.37[17]	0.83[3] 0.947-1.03[17,4]	7.0[13] 15.9-18.0[4.16] 56.7-62.6[19,3]		21[13] 79.8[17] 120[16]	0.0036[3] 0.347[4]	0.6-1.1[14]
HM (this study)	96.6	56	5.3	0.43	21.3	17.9	84.18	0.0028	1.89
HP (this study)	30	17	1.16	0.091	5.3	4.6	17.9	0.0006	0.48
Fresh meat (chicken)	25-30	23-24	1.62-3.12[10]	1.8[10]	44.25[10]	75[10] (g NO_3 eq.)	18.5-65[10]	0.053-0.155[11]	19.5-31.3[11]
Whey concentrate	86-89[3]	60[3,7] 80[11,kp]	7.48[7] 0.8-7.4[6] 12.1[2] 28–43[8,kp] 40.6[11,kp]	0.01-0.06[9] 3.33[7] 3.8[11,kp]	0.05-1.5[6] 56.6[7]	1.14[6] 37.3[2] 3.59-101[9] 229.3[11,kp]	58.1[2] 83.3[7] 10.7-39.4[6]	0.003-0.066[6] 1.45[2] 9.58[7]	0.26-8.27[6]
Egg protein concentrate[9]	85	80	23.4	1.01	4000	139	183	2.65	40.1
Microalgae[9]	96	55	14.7-245.1	0.9-19.8	260.5-1407.5	40.6-105.3	217.1-4181.3	0.3-3.9	1.7-5.4

Sources: [1] – (Dalgaard et al., 2008); [2] – (Kim et al., 2013); [3] – own calculations, [4] – Danish LCA Food Database; [5] – (Hall, 2011); [6] – ecoinvent 3 and Agrifootprint databases; [7] – (Smetana et al., 2016); [8] - (Nijdam et al., 2012); [9] – (Smetana et al., 2017); [10] – (González-García et al., 2014; Weidema et al., 2008); [11] – (Wiedemann et al., 2017); [12] – (Bacenetti et al., 2018); [13] – (Papatryphon et al., 2004); [14] – (Samuel-Fitwi et al., 2013); [15] – (Cashion et al., 2017); [16] – (Smárason et al., 2017); [17] – (Silva et al., 2017); [18] – (Fréon et al., 2017); [kp] – per kg protein. Note: HP – *H. illucens* puree (fresh insect production); HM – *H. illucens* meal (defatted protein concentrate); DM – dry mass, GWP – global warming potential; OD – ozone depletion; AC – acidification; EU – eutrophication; ED – energy demand; FD – freshwater depletion; LU – land use.

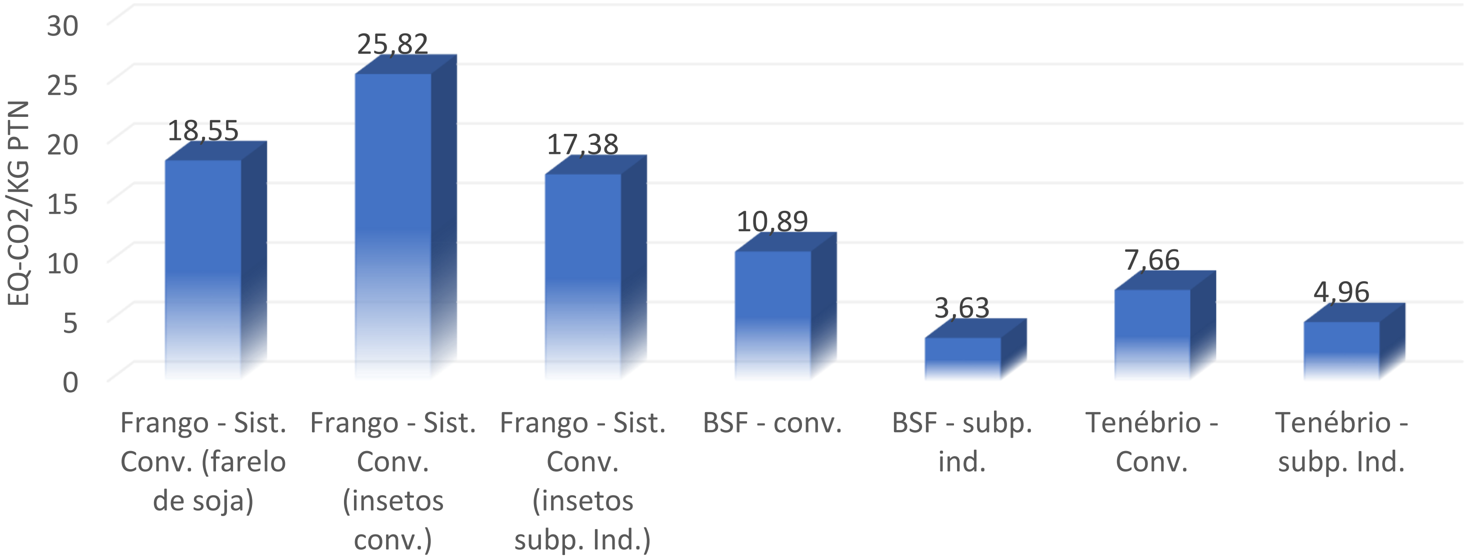


Potencial dos Insetos

- **Aumento da produção tem mostrado resultados relevantes**



Oonincx e De Boer, 2012

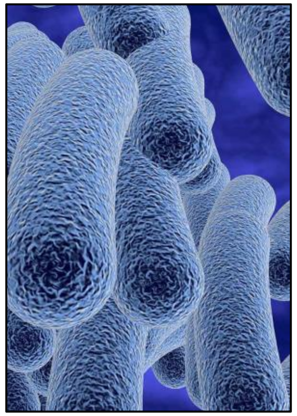


Vauterin et al., 2021

Determinantes qualitativos

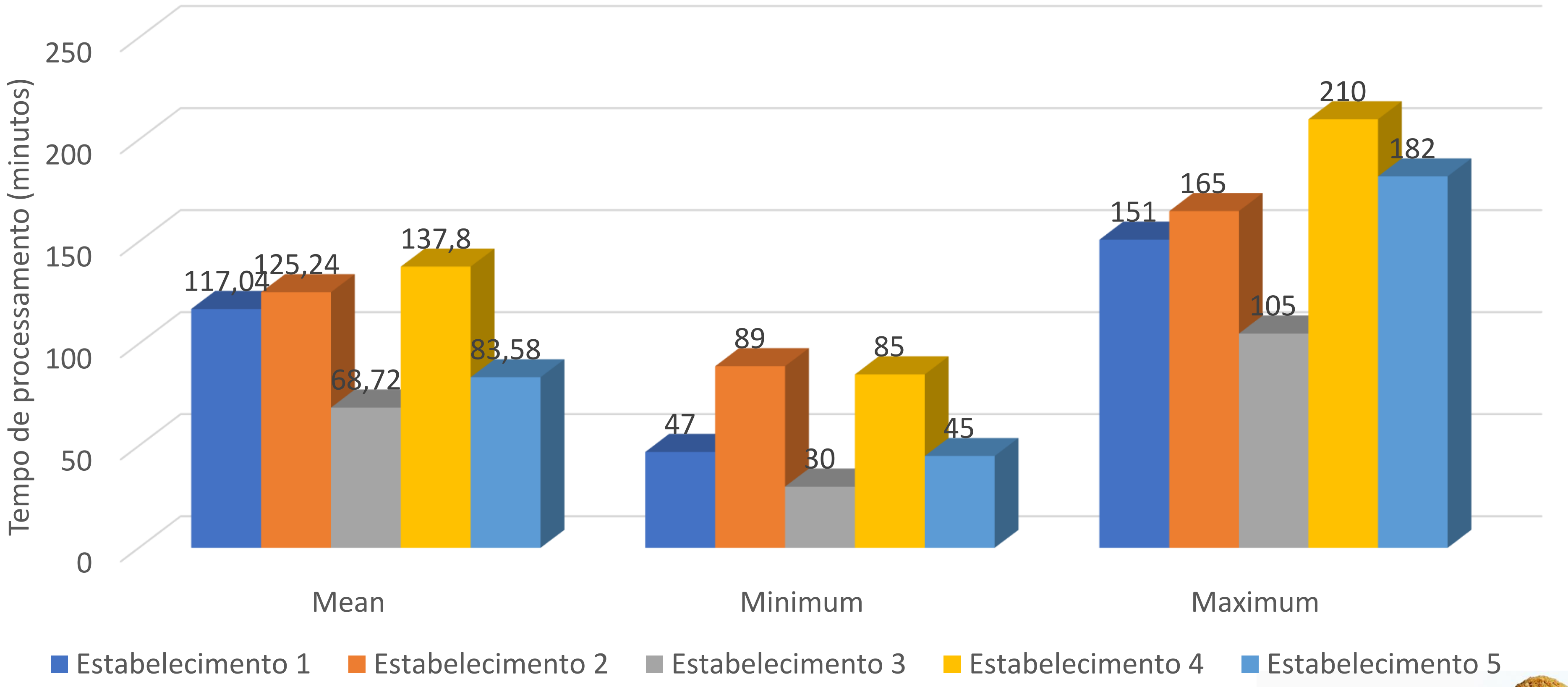
- Composição química
- Processamento
- Oxidação
- Contaminação microbiana
- Aminas biogênicas






Variações no processamento

- Tempo de processamento (min)

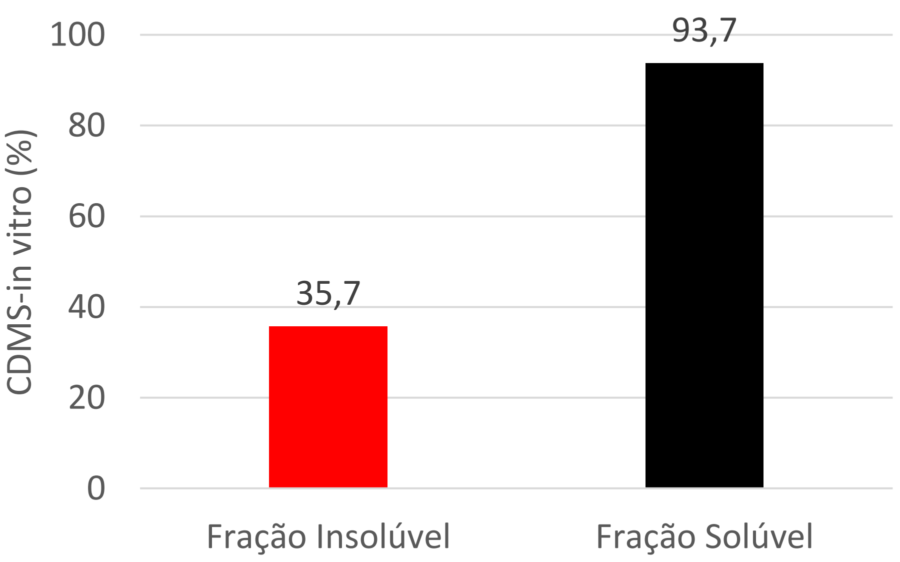


Ribeiro, 2019 e Volpato, 2020

Potencial de melhorias

- Ingredientes Hidrolisados (Miltenburg et al., 2018)

	Dietas			
Item	RR	FPC	FPHE	EPM
Coeficiente de digestibilidade aparente da farinha de penas pelo método de substituição				
Matéria seca	-	70,67ª	66,66ª	1,61
Matéria orgânica	-	73,06ª	69,67ª	1,49
Proteína bruta	-	66,38ᵇ	78,90ª	1,19
Energia digestível (kcal/kg)	-	4361,0ª	3876,1ᵇ	83,34



*Farinha de pena proveniente da Aurora Alimentos

Valor nutricional dos ingredientes

- Disponibilidade do fósforo de Ingredientes de Origem animal

Autor	Fonte	Espécie	Dsiponibilidade
Bunzen et al. (2009)	FVA com penas	Suínos	52,5%
Bunzen et al. (2009)	FCO 42%	Suínos	62,9%
Bunzen et al. (2009)	FP	suínos	88,5%
Brugalli et al. (1999)	FCO	frangos	100%
Xavier 2017	Fosfato bicálcico	Frangos	60%
Xavier 2017	Fosfato monocálcico	Frangos	71%
Jongbloed and Kemme, 1990	FCO	suínos	68-91%

Obrigado

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Professor Adjunto

Universidade Estadual de Maringá (UEM)

34ª Reunião Anual do CBNA - 2023

A Nutrição e as Demandas do Consumidor: Bem-Estar Animal e Meio Ambiente

AVES . SUÍNOS. BOVINOS

21, 22 e 23 de março