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Including protein quality in LCA of novel food products

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Introduction

Novel food products are being developed to achieve a nutritional progression while also providing an ecological advantage to their conventional counterparts. McAuliffe et al. 2022 introduced a method to integrate protein quality in the life cycle assessment (LCA) of food products based on its DIAAS score to make the possible uptake of protein from different sources comparable[1]. For novel food products, however, a DIAAS score is hardly calculatable, as it has to estimated for each ingredient of a commercial food product and therefore, uncertainty is multiplied with each additional ingredient. Thus, a scheme needs to be developed to include protein quality in LCA based on the amino acid composition.

Materials and Methods

To investigate the protein, the sum of Essential Amino Acids is calculated [mg/g of protein] and compared with the EAA of egg protein as reference.
To deeper investigate the adequacy of this protein, the Amino Acid Score (AAS) is assessed for each essential amino acid as the ratio between the single amino acid content [mg/ g of protein] and the corresponding requirement pattern for that specific amino acid [mg/1 g of protein]. The AAS is a measure of the quality of a protein based on its essential amino acid composition. The AAS of each sample can be based on the requirement pattern for two population groups: children (3-18 years old) and adults (18-65 years old), as outlined in FAO/WHO, 2011.[2] The amino acid with the lowest score is identified as the limiting amino acid, which can negatively affect the overall quality of the protein, limiting the usage by the body of the other amino acids for protein synthesis. The AAS of novel food products are set into relation by comparing it to the AAS of egg.
The LCA is conducted following the framework provided according to the norms DIN EN ISO 14040 and 14044. For the calculation of the environmental impact categories, the PEF3.1 rules are applied. The use of the AAS as a factor as a measurement of protein quality was calculated in the manner proposed by McAuliffe et al. 2022, who multiplied the LCA impacts with the DIAAS [%].

As an exemplary case, the intermediate results of the LCA of protein production from tomato pomace is used. The modelling as well as the assessment of the amino acids is conducted with internal data from the ProxIMed project. For now, this data is confidential and is only used as proof-of-concept.

Results

Protein	**Tomato pomace**	
EAA [mg/g protein]	379	512
AAS, based on:	requirements for adults	egg reference protein
His	1.51	1.03
Ile	1.47	0.82
Leu	1.17	0.80
Lys	0.55	0.36
SAA	1.73	0.67
AAA	2.27	0.93
Thr	1.67	0.82
Trp	1.00	0.35
Val	1.27	0.75

Tab. 1 Total amount of essential amino acids and the amino acid score of the essential amino acids and their corresponding requirement patterns for protein from tomato pomace. The marked amounts are used as adjusting factors.

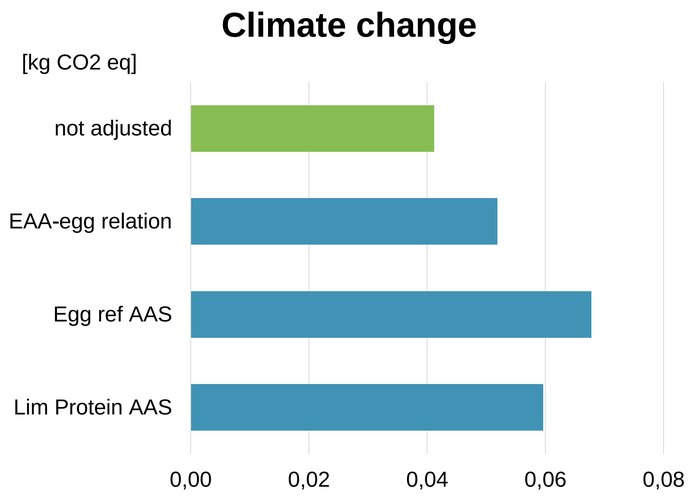

Fig. 1 Effect of the different protein quality factors on the impact factor climate change as an example.

$$Adj.\ Impact = Impact + Impact * (1\text{-}factor_{AA})$$

Form.1 Calculation of the adjusted environmental impacts with the different amino acid scores

The results of the protein analysis are shown in table 1.
The sum of EAA of protein powder from tomato pomace is 379.2 ± 8.2 mg/g of protein. This value was observed to be lower than the sum of EAA estimated for the egg reference protein (512 mg/g of protein). Anyhow the value fulfilled the requirements set by FAO/WHO for both adults and children.[2]
The tomato pomace showed low scores compared to the egg reference proteins, with most of the scores for essential amino acids below 0.80 and the limiting amino acid being tryptophan, which as the score of 0.35. This means that in the human body, when eaten, the protein (if it is 100% digestible) can be utilized at the 35%. Adults appear more representative for the novel food products since the products the developed in ProxIMed are not aimed to fulfill special needs of certain groups of population. All essential amino acids showed values of AAS ≥ 1, with the only exception of lysine. Consequently, Lysine is the limiting amino acid here, having a score of 0.55. This means that eating the tomato protein alone, if it is 100% digestible, 55% of protein can be utilized at max.
The effects of using the results from the protein analysis as a factor for protein quality on LCA results are shown in figure 1. Here the preliminary results for the category of climate change is used.
To include the overall EAA, the relation of EAA of tomato pomace protein and egg protein is used (0.74) Therefore it can be seen that using egg protein as a reference has, using the limiting protein AAS the intermediate and using the overall EAA in relation to egg the lowest the highest increase of the results.
The adjusted impacts are calculated according to [1]. Formula 1 shows their calculation scheme. This is applied for all shown factors (EAA 0.74, AAS_{egg} 0.35 and AAS_{lim} 0.55).

Conclusion

This poster shows the first steps of the intended inclusion of protein quality into Life Cycle assessment.
An evaluation will be made to find the most sensible factor of the proposed three. Furthermore, other novel protein products will be investigated. For this the protein sources within the ProxIMed project will be assessed for EAA, AAS and environmental impacts. This includes- besides protein for tomato pomace – protein from tomato leaves, lentil, duckweed sesame cake, date by-products, microalgae, mycoprotein, sesame, insects, faba beans, chia seed and mallow.
Additionally, the protein products can be improved. E.g, plant-based products are usually made of a mixture of vegetable-based protein sources. Therefore, the score can be improved combining the tomato pomace protein with legume-based products, known to be a good source of lysine. In this way it is possible to achieve a better balance in amino acids and improve the protein usage.

References

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