DIGESTIBILITY OF INSECT PROTEINS AND INSECT-BASED PRODUCTS

This document is part of our literature review on nutritional quality, processing, functionality and shelf life and storage of insect-based products, and the associated analytical methods.

This literature search was written in context of the Interreg North-West Europe ValuSect project.

Written by:
Isabelle Noyens[1], Sabine Van Miert[1], Christine Brombach[2], Manuela Rossi[2], Nathalie Haas[2], Manfred Beckman[3], Carlos Alvarez[4], Eduarda Neves[4], Natalia Naranjo-Guevara[5], Kim Garrelts[5], Sonja Floto-Stammen[5], Marcel Roosen[5]

[1] Thomas More University of Applied Sciences
[2] Zurich University of Applied Science
[3] Aberystwyth University
[4] Teagasc
[5] Fontys

Contact:
sabine.vanmiert@thomasmore.be

1. Digestibility and protein quality

Digestibility is an indication of the percentage of food absorbed by the gut into the body. It is the amount of food components (e.g. amino acids) absorbed and is generally calculated as the amount of a component consumed (IN) minus the amount of a component retained in the feces (OUT). In 1981, protein quality described by its amino acid score was linked to protein digestibility to reflect digestion and absorption differences between proteins (Blackburn and Southgate 1981). Digestibility had been then calculated by measuring nitrogen intake and fecal nitrogen output as:

Apparent Protein (N) Digestibility (%) = (I – F) / I x 100, and Equation 1

True Protein (N) Digestibility (%) = (I – (F – Fk) / I x 100, Equation 2,

Where I = Nitrogen Intake, F = Fecal Nitrogen output on test diet, and Fk = Fecal Nitrogen output on a non-protein diet.

As a result, the *Protein Digestibility–Corrected Amino Acid Score* (*PDCAAS*) had been adopted by the Food and Agricultural Organisation and World Health Organisation (FAO/WHO) in 1991 (FAO 2013) as the preferred method for the measurement of the protein value in human nutrition (Schaafsma 2000):

PDCAAS(%) = (mg of limiting amino acid in 1 g of test protein / mg of same amino acid in 1 g of reference protein) × fecal true digestibility (%) × 100, Equation 3

To address the limitations of this method, which are apparent after over 20 years of use, the FAO/WHO recommended replacing PDCAAS by the *Digestible Indispensable Amino Acid Score* (DIAAS) in 2013. Highlighting the main difference, the PDCAAS method estimates protein digestibility over the total gut (referred to as 'faecal' protein or digestibility), including microbial activities in the hindgut, whereas DIAAS method determines amino acid digestibility at the end of the small intestine (mouth to terminal ileum; referred to as 'ileal' digestibility). A good introduction showing results for the two methods applied to different protein sources has been contrasted elsewhere (Mathai, Liu et al. 2017). The PDCAAS method can be used on human subjects, but to estimate protein quality, which is meeting the requirements of essential amino acids, as well as the physiological needs, and digestibility for human consumption; rodent or porcine models are recommended. Due to the requirement of measuring amino acid concentrations at the end of the ileum, the DIAAS method is only performed in rats or preferably pigs with the latter having a permanent ileostomy to facilitate collection of *digesta* of individuals in repeated trials. This approach has also been used to measure protein digestibility in human adults and children, where possible, using the indicator amino acid oxidation (IAAO) method (Shivakumar, Jackson et al. 2020).

Although the *in vivo* DIAAS method is now considered the most reliable source for protein digestibility, the main disadvantages are the time and cost associated with conducting animal based studies, as well as the associated ethical considerations. After two decades of using the PDCAAS method, this has also lead to the development of *in vitro* methods simulating digestion processes include the oral, gastric, small intestinal phases, large intestinal fermentation as occasionally realized in artificial rumen, stomach, or gut. This allows the analysis of the products of all sequential processes, or investigations of different phases of digestion, rumen/gut microbial communities and their underlying processes.

The main *in vitro* method referred to in the literature is based on a multienzyme system consisting of trypsin, chymotrypsin and peptidase (Hsu, Vavak et al. 1977). One commercial test patented by Medaillon Labs and distributed by Megazyme is the Animal-Safe Accurate Protein Quality Score (ASAP-Quality Score Method) for determination of the PDCAAS. There is, however, no indication that this kit has been used in primary published literature (PubMed, Scholar) for investigating protein quality. There are various further developments of the widely used Hsu 3-enzyme and pH-drop method as summarized by Butts, Monro et al. (2012) or Qiao, Lin et al. 2004. Developing dynamic and static models of human digestion have led to the COST action INFOGEST an international consortium joined by more than 200 scientists from 32 countries working in the field of digestion (Dupont, Bordoni et al. 2011).

Despite international efforts to identify the best method for defining protein digestibility (*i.e. in vivo* DIAAS, *in-vitro* digestion models) plasma amino acid levels can yield insight into the digestibility of protein products after supplementation (Vangsoe et al., 2018). It could be shown that whey, soy, and insect protein isolate increased the blood concentration of essential amino acids, branched-chain amino acids, and leucine over 120 min period for all protein supplements with whey greater than insect and soy. However, blood amino acid concentrations were highest for insect protein supplementation at 120 min indicating a slower digestion. The same research group also intends to investigate in the inVALUABLE consortium insect proteins and their digestibility using the DIAAS method in pigs to obtain reliable data for correlating *in vitro* and *in vivo* measurements (Heckmann, Andersen et al. 2019).

2. Insect protein products and its digestibility

A partial Google Scholar literature search of ‘digestibility of insects’ combined with a ‘digestibility AND insect’ search (Title/Abstracts) in PubMed resulted in 152 articles related to the subject (see annex in this chapter). Based on the titles, 61 articles describe the effects of general and specific insect products in animal trials compared to usually used feeds evaluating the protein quality based on the results (1-61). A further 73 articles are related to either how insects respond to different feeds (rearing and growth performance of insects), processing of insects, and related product qualities (62-134). The remaining 18 articles explore general aspects or rearing and evaluating insect foods for human consumption (135-152). In the next table, is summarized some of the studies conducted to assess protein digestibility in several species. As it can be seen, the most of the species give values ranging from 66 to 95% of digestibility; however, the methods of determining digestibility are varied and need standardising. In addition to this, no one of the experiment was done in humans, and the results might be slightly different.

Table 1
Digestibility of several edible insect species. Based on Churchward-Venne, Pinckaers et al. (2017).

Edible insects	Digestibility (%)	Comments	Reference
Coleoptera (beetles, grubs)			
Holotrichia parallela	78.4	Assessed in-vitro	(Yang, Liu et al. 2014)
Tenebrio molitor (mixed meal containing 1.5% larvae)	90.3	Assessed in pigs; apparent digestibility	(Jin et al. 2016)
Tenebrio molitor (mixed meal containing 3.0% larvae)	91.3	Assessed in pigs; apparent digestibility	(Jin et al. 2016)
Tenebrio molitor (mixed meal containing 4.5% larvae)	92.2	Assessed in pigs; apparent digestibility	(Jin et al. 2016)
Tenebrio molitor (mixed meal containing 6.0% larvae)	93.0	Assessed in pigs; apparent digestibility	(Jin et al. 2016)
Tenebrio molitor	86.0	Assessed in chickens; apparent digestibility	(De Marco, Martínez et al. 2015)
Tenebrio molitor	91.3	Assessed in-vitro	(Bosch, Zhang et al. 2014)
Tenebrio molitor	66.3	Assessed in-vitro	(Marono, Piccolo et al. 2015)
Tenebrio molitor	66.7	Assessed in-vitro	(Marono, Piccolo et al. 2015)
Tenebrio molitor	65.5	Assessed in-vitro	(Marono, Piccolo et al. 2015)
Tenebrio molitor	66.2	Assessed in-vitro	(Marono, Piccolo et al. 2015)
Tenebrio molitor	65.8	Assessed in-vitro	(Marono, Piccolo et al. 2015)
Tenebrio molitor	66.2	Assessed in-vitro	(Marono, Piccolo et al. 2015)
Zophobas morio	92.0	Assessed in-vitro	(Bosch, Zhang et al. 2014)
Diptera (flies)			
Hermetia illucens	67.1	Assessed in-vitro	(Marono, Piccolo et al. 2015)
Hermetia illucens	68.0	Assessed in chickens; apparent digestibility	(De Marco, Martínez et al. 2015)
Hermetia illucens	67.3	Assessed in-vitro	(Marono, Piccolo et al. 2015)
Hermetia illucens	67.6	Assessed in-vitro	(Marono, Piccolo et al. 2015)
Hermetia illucens	68.7	Assessed in-vitro	(Marono, Piccolo et al. 2015)
Hermetia illucens	66.8	Assessed in-vitro	(Marono, Piccolo et al. 2015)
Hermetia illucens	66.0	Assessed in-vitro	(Marono, Piccolo et al. 2015)
Hermetia illucens (larvae)	89.7	Assessed in-vitro	(Bosch, Zhang et al. 2014)
Hermetia illucens (pupae)	77.7	Assessed in-vitro	(Bosch, Zhang et al. 2014)
Musca domestica (30% of mixed meal)	98.5	Assessed in chickens; apparent digestibility	(Hwangbo et al. 2009)
Musca domestica (pupae)	84.3	Assessed in-vitro	(Bosch, Zhang et al. 2014)
Hemiptera (true bugs)			
Ahuahutle	89.3	Assessed in-vitro	(Ramos-Elorduy, Moreno et al. 1997)
Axayacatl	98.0	Assessed in-vitro	(Ramos-Elorduy, Moreno et al. 1997)
Hymenoptera (ants, bees)			
Apis mellifera (18.8% of mixed meal; whole dried)	62.0	Assessed in rats; apparent digestibility, not corrected for N in chitin	(OZIMEK, SAUER et al. 1985)
Apis mellifera (18.8% of mixed meal; whole dried)	68.5	Assessed in rats; apparent digestibility, corrected for N in chitin	(OZIMEK, SAUER et al. 1985)
Apis mellifera (18.8% of mixed meal; whole dried)	71.5	Assessed in rats; true digestibility, not corrected for N in chitin	(OZIMEK, SAUER et al. 1985)
Apis mellifera (18.8% of mixed meal; whole dried)	79.8	Assessed in rats; true digestibility, corrected for N in chitin	(OZIMEK, SAUER et al. 1985)
Apis mellifera (16.6% of mixed meal; protein concentrate)	87.6	Assessed in rats; apparent digestibility	(OZIMEK, SAUER et al. 1985)
Apis mellifera (16.6% of mixed meal; protein concentrate)	94.3	Assessed in rats; true digestibility	(OZIMEK, SAUER et al. 1985)
Atta mexicana (ants)	87.6	Assessed in-vitro	(Ramos-Elorduy, Moreno et al. 1997)
Brachygastra mellifica	85.2	Assessed in-vitro	(Ramos-Elorduy, Moreno et al. 1997)
Polybia parvulina	86.4	Assessed in-vitro	(Ramos-Elorduy, Moreno et al. 1997)
Vespula squamosa	76.6	Assessed in-vitro	(Ramos-Elorduy, Moreno et al. 1997)
Orthiptera (crickets, hoppers, termites)			
Cricket (Gryllodes sigillatus)	76.2	Assessed in-vitro	(Stone, Tanaka et al. 2019)
Termite (Macrotermes subhylanus)	90.1	Assessed in-vitro	(Kinyuru et al. 2009)
Green grasshopper (Ruspolia differens)	79.6	Assessed in-vitro	(Kinyuru et al. 2009)
Locust (Anacridium melanorhodon)	50	Assessed in-vitro	(Nafisa et al. 2008)
Brown grasshopper (Ruspolia differens)	81.1	Assessed in-vitro	(Kinyuru et al. 2009)

The need to find alternative feeds for animal farming to cope with an increasing global meat demand is a main driver to test insect proteins in poultry (mainly quail, chicken, potentially turkey), pigs and piglets for pork production, for dog and cat food, and even as a protein source in fish farms. Findings so far show that poultry, pork, and fish products after insect diets are at either equal or higher quality compared to those following standard feeds (32; 23; 36; 49).

There is additional research necessary to investigate the use and effects of waste streams on insect products (3). It was concluded that price of insect production and processing were not competitive (in 2015) to compete with conventional protein sources to sustain an increasing demand for protein.

3. References

Blackburn, N. A. and D. A. T. Southgate (1981). PROTEIN DIGESTIBILITY AND ABSORPTION: EFFECTS OF FIBRE, AND THE EXTENT OF INDIVIDUAL VARIATION; joint FAO/WHO/UNU Expert Consultation on Energy and Protein Requirements.

FAO, E. C. (2013). Dietary protein quality evaluation in human nutrition. Auckland, New Zealand.

Shivakumar, N., A. A. Jackson, G. Courtney-Martin, R. Elango, S. Ghosh, S. Hodgkinson, M. Xipsiti, W. T. K. Lee, A. V. Kurpad and D. Tomé (2020). "Protein Quality Assessment of Follow-up Formula for Young Children and Ready-to-Use Therapeutic Foods: Recommendations by the FAO Expert Working Group in 2017." J Nutr **150**(2): 195-201.

Bosch, G., S. Zhang, D. G. A. B. Oonincx and W. H. Hendriks (2014). "Protein quality of insects as potential ingredients for dog and cat foods." Journal of Nutritional Science **3**: e29.

Butts, C. A., J. A. Monro and P. J. Moughan (2012). "In vitro determination of dietary protein and amino acid digestibility for humans." Br J Nutr **108 Suppl 2**: S282-287.

Churchward-Venne, T. A., P. J. M. Pinckaers, J. J. A. van Loon and L. J. C. van Loon (2017). "Consideration of insects as a source of dietary protein for human consumption." Nutrition Reviews **75**(12): 1035-1045.

De Marco, M., S. Martínez, F. Hernandez, J. Madrid, F. Gai, L. Rotolo, M. Belforti, D. Bergero, H. Katz, S. Dabbou, A. Kovitvadhi, I. Zoccarato, L. Gasco and A. Schiavone (2015). "Nutritional value of two insect larval meals (Tenebrio molitor and Hermetia illucens) for broiler chickens: Apparent nutrient digestibility, apparent ileal amino acid digestibility and apparent metabolizable energy." Animal Feed Science and Technology **209**: 211-218.

Dupont, D., A. Bordoni, A. Brodkorb, F. Capozzi, T. Cirkovic Velickovic, M. Corredig, P. D. Cotter, I. De Noni, C. Gaudichon, M. Golding, T. Lea, I. Le Huërou-Luron, A. Mackie, C. Madsen, B. De Meulenaer, Y. Nys, A. Pihlanto, I. Recio, D. Rémond, T. Requena, I. Souchon, D. Swiatecka, S. Turgeon, G. Vegarud, R. Vreeburg, W. Weitschies and M. Wickham (2011). "An International Network for Improving Health Properties of Food by Sharing our Knowledge on the Digestive Process." Food Digestion **2**(1): 23-25.

Heckmann, L. H., J. L. Andersen, J. Eilenberg, J. Fynbo, R. Miklos, A. N. Jensen, J. V. Nørgaard and N. Roos (2019). "A case report on inVALUABLE: insect value chain in a circular bioeconomy." Journal of Insects as Food and Feed **5**(1): 9-13.

HSU, H. W., D. L. VAVAK, L. D. SATTERLEE and G. A. MILLER (1977). "A MULTIENZYME TECHNIQUE FOR ESTIMATING PROTEIN DIGESTIBILITY." Journal of Food Science **42**(5): 1269-1273.

Marono, S., G. Piccolo, R. Loponte, C. Di Meo, Y. A. Attia, A. Nizza and F. Bovera (2015). "In Vitro Crude Protein Digestibility of Tenebrio Molitor and Hermetia Illucens Insect Meals and its Correlation with Chemical Composition Traits." Italian Journal of Animal Science **14**(3): 3889.
Mathai, J. K., Y. Liu and H. H. Stein (2017). "Values for digestible indispensable amino acid scores (DIAAS) for some dairy and plant proteins may better describe protein quality than values calculated using the concept for protein digestibility-corrected amino acid scores (PDCAAS)." Br J Nutr **117**(4): 490-499.
OZIMEK, L., W. C. SAUER, V. KOZIKOWSKI, J. K. RYAN, H. JØRGENSEN and P. JELEN (1985). "Nutritive Value of Protein Extracted from Honey Bees." Journal of Food Science **50**(5): 1327-1329.
Qiao, Y., X. Lin, J. Odle, A. Whittaker and T. A. van Kempen (2004). "Refining in vitro digestibility assays: fractionation of digestible and indigestible peptides." J Anim Sci **82**(6): 1669-1677.
Ramos-Elorduy, J., J. M. P. Moreno, E. E. Prado, M. A. Perez, J. L. Otero and O. L. de Guevara (1997). "Nutritional Value of Edible Insects from the State of Oaxaca, Mexico." Journal of Food Composition and Analysis **10**(2): 142-157.
Schaafsma, G. (2000). "The Protein Digestibility–Corrected Amino Acid Score." The Journal of Nutrition **130**(7): 1865S-1867S.
Shivakumar, N., A. A. Jackson, G. Courtney-Martin, R. Elango, S. Ghosh, S. Hodgkinson, M. Xipsiti, W. T. K. Lee, A. V. Kurpad and D. Tomé (2020). "Protein Quality Assessment of Follow-up Formula for Young Children and Ready-to-Use Therapeutic Foods: Recommendations by the FAO Expert Working Group in 2017." J Nutr **150**(2): 195-201.
Stone, A. K., T. Tanaka and M. T. Nickerson (2019). "Protein quality and physicochemical properties of commercial cricket and mealworm powders." Journal of Food Science and Technology **56**(7): 3355-3363.
Yang, Q., S. Liu, J. Sun, L. Yu, C. Zhang, J. Bi and Z. Yang (2014). "Nutritional Composition and Protein Quality of the Edible Beetle Holotrichia parallela." Journal of Insect Science **14**(1).

4. Annex: Literature research

“A partial Google Scholar literature search of ‘digestibility of insects’ combined with a ‘digestibility AND insect’ search (Title/Abstracts) in PubMed resulted in 152 articles related to the subject”

[1] Insect proteins-a new source for animal feed: The use of insect larvae to recycle food waste in high-quality protein for livestock and aquaculture feeds is held back largely owing to regulatory hurdles.Stamer A.EMBO Rep. 2015 Jun;16(6):676-80. doi: 10.15252/embr.201540528. Epub 2015 May 5.PMID: 25944641 Free PMC article. No abstract available.

[2] Insect Oil as An Alternative to Palm Oil and Poultry Fat in Broiler Chicken Nutrition.Benzertiha A, Kierończyk B, Rawski M, Kołodziejski P, Bryszak M, Józefiak D.Animals (Basel). 2019 Mar 25;9(3):116. doi: 10.3390/ani9030116.PMID: 30934626 Free PMC article.

[3] Insects: a protein-rich feed ingredient in pig and poultry diets. Teun Veldkamp, Guido Bosch, Insects: a protein-rich feed ingredient in pig and poultry diets, Animal Frontiers, Volume 5, Issue 2, April 2015, Pages 45–50, https://doi.org/10.2527/af.2015-0019 https://www.researchgate.net/profile/Teun_Veldkamp/publication/283416380_Insects_a_protein-rich_feed_ingredient_in_pig_and_poultry_diets/links/568151d408ae1975838f76e8.pdf

[4] Animals Fed Insect-Based Diets: State-of-the-Art on Digestibility, Performance and Product Quality.Gasco L, Biasato I, Dabbou S, Schiavone A, Gai F.Animals (Basel). 2019 Apr 16;9(4):170. doi: 10.3390/ani9040170.PMID: 30995783 Free PMC article. Review.

[5] Effect of an insect protein-based diet on clinical signs of dogs with cutaneous adverse food reactions.Böhm TMSA, Klinger CJ, Gedon N, Udraite L, Hiltenkamp K, Mueller RS.Tierarztl Prax Ausg K Kleintiere Heimtiere. 2018 Oct;46(5):297-302. doi: 10.15654/TPK-170833. Epub 2018 Dec 12.PMID: 30541169 English, German.

[6] Potential of Insect Meals as Protein Sources for Meat-Type Ducks Based on In Vitro Digestibility.Kovitvadhi A, Chundang P, Thongprajukaew K, Tirawattanawanich C, Srikachar S, Chotimanothum B.Animals (Basel). 2019 Apr 9;9(4):155. doi: 10.3390/ani9040155.PMID: 30970570 Free PMC article.

[7] The effect of insect or microalga alternative protein feeds on broiler meat quality.Altmann BA, Wigger R, Ciulu M, Mörlein D.J Sci Food Agric. 2020 Aug 30;100(11):4292-4302. doi: 10.1002/jsfa.10473. Epub 2020 Jun 5.PMID: 32378214

[8] Digestibility of Insect Meals for Nile Tilapia Fingerlings.Fontes TV, de Oliveira KRB, Gomes Almeida IL, Maria Orlando T, Rodrigues PB, Costa DVD, Rosa PVE.Animals (Basel). 2019 Apr 20;9(4):181. doi: 10.3390/ani9040181.PMID: 31010009 Free PMC article.

[9] Protein quality of insects as potential ingredients for dog and cat foods.Bosch G, Zhang S, Oonincx DG, Hendriks WH.J Nutr Sci. 2014 Sep 25;3:e29. doi: 10.1017/jns.2014.23. eCollection 2014.PMID: 26101598 Free PMC article.

[10] Evaluation of Some Insects as Potential Feed Ingredients for Ruminants: Chemical Composition, in Vitro Rumen Fermentation and Methane Emissions. Jayanegara, A., et al. "Evaluation of Some Insects as Potential Feed Ingredients for Ruminants: Chemical Composition, in Vitro Rumen Fermentation and Methane Emissions." Journal of Indonesian Tropical Animal Agriculture, vol. 42, no. 4, 19 Dec. 2017, pp. 247-254, doi:10.14710/jitaa.42.4.247-254. https://www.neliti.com/publications/222798/evaluation-of-some-insects-as-potential-feed-ingredients-for-ruminants-chemical

[11] Protein value of two insects, subjected to various heat treatments, using growing rats and the protein digestibility-corrected amino acid score. Poelaert, Christine & Francis, Frédéric & Alabi, T. & Caparros Megido, Rudy & Crahay, B. & Bindelle, J. & Beckers, Yves. (2018). Protein value of two insects, subjected to various heat treatments, using growing rats and the protein digestibility-corrected amino acid score. Journal of Insects as Food and Feed. 4. 1-12. 10.3920/JIFF2017.0003.

[12] Review on the use of insects in the diet of farmed fish: Past and future. Henry, M.A., Gasco, L., Piccolo, G., & Fountoulaki, E. (2015). Review on the use of insects in the diet of farmed fish: Past and future. Animal Feed Science and Technology, 203, 1-22. https://www.sciencedirect.com/science/article/pii/S0377840115000802

[13] Nutritional value of two insect larval meals (Tenebrio molitor and Hermetia illucens) for broiler chickens: Apparent nutrient digestibility, apparent ileal amino acid digestibility and apparent metabolizable energy https://www.sciencedirect.com/science/article/pii/S0377840115300043

[14] Recent advances in role of insects as alternative protein source in poultry nutrition. Khan, S.H. (2018). Recent advances in role of insects as alternative protein source in poultry nutrition. Journal of Applied Animal Research, 46, 1144 - 1157. https://www.tandfonline.com/doi/full/10.1080/09712119.2018.1474743

[15] Comparative Study of the Use of Insect Meal from Spodoptera littoralis and Bactrocera zonata for Feeding Japanese Quail Chicks.Sayed WAA, Ibrahim NS, Hatab MH, Zhu F, Rumpold BA.Animals (Basel). 2019 Mar 31;9(4):136. doi: 10.3390/ani9040136.PMID: 30935161 Free PMC article.
[16] Effect of dietary supplementation with insect fats on growth performance, digestive efficiency and health of rabbits.Gasco L, Dabbou S, Trocino A, Xiccato G, Capucchio MT, Biasato I, Dezzutto D, Birolo M, Meneguz M, Schiavone A, Gai F.J Anim Sci Biotechnol. 2019 Jan 17;10:4. doi: 10.1186/s40104-018-0309-2. eCollection 2019.PMID: 30675348 Free PMC article.
[17] Evaluating the nutritive profile of three insect meals and their effects to replace soya bean in broiler diet.Khan S, Khan RU, Alam W, Sultan A.J Anim Physiol Anim Nutr (Berl). 2018 Apr;102(2):e662-e668. doi: 10.1111/jpn.12809. Epub 2017 Nov 3.PMID: 29098730 Clinical Trial.
[18] In vitro digestibility and fermentability of selected insects for dog foods Bosch, Guido, J. J. M. Vervoort, and W. H. Hendriks. "In vitro digestibility and fermentability of selected insects for dog foods." Animal Feed Science and Technology 221 (2016): 174-184. https://www.sciencedirect.com/science/article/pii/S0377840116305272
[19] Meat Quality Derived from High Inclusion of a Micro-Alga or Insect Meal as an Alternative Protein Source in Poultry Diets: A Pilot Study.Altmann BA, Neumann C, Velten S, Liebert F, Mörlein D.Foods. 2018 Mar 8;7(3):34. doi: 10.3390/foods7030034.PMID: 29518048 Free PMC article.
[20] In vitro evaluation of fermentation characteristics of two types of insects as potential novel protein feeds for pigs. C. Poelaert, Y. Beckers, X. Despret, D. Portetelle, F. Francis, J. Bindelle, In vitro evaluation of fermentation characteristics of two types of insects as potential novel protein feeds for pigs, Journal of Animal Science, Volume 94, Issue suppl_3, September 2016, Pages 198–201, https://doi.org/10.2527/jas.2015-9533 https://academic.oup.com/jas/article/94/suppl_3/198/4731384
[21] Use of a four-parameter logistic model to evaluate the quality of the protein from three insect species when fed to rats.Finke MD, DeFoliart GR, Benevenga NJ.J Nutr. 1989 Jun;119(6):864-71. doi: 10.1093/jn/119.6.864.PMID: 2746371
[22] Comparison of broiler performance and carcass parameters when fed diets containing combined trait insect-protected and glyphosate-tolerant corn (MON 89034 x NK603), control, or conventional reference corn.Taylor M, Lucas D, Nemeth M, Davis S, Hartnell G.Poult Sci. 2007 Sep;86(9):1988-94. doi: 10.1093/ps/86.9.1988.PMID: 17704388 Clinical Trial.
[23] Do dietary soy alternatives lead to pork quality improvements or drawbacks? A look into micro-alga and insect protein in swine diets.Altmann BA, Neumann C, Rothstein S, Liebert F, Mörlein D.Meat Sci. 2019 Jul;153:26-34. doi: 10.1016/j.meatsci.2019.03.001. Epub 2019 Mar 5.PMID: 30861487
[24] Does the Optimal Dietary Methionine to Cysteine Ratio in Diets for Growing Chickens Respond to High Inclusion Rates of Insect Meal from Hermetia illucens?Brede A, Wecke C, Liebert F.Animals (Basel). 2018 Oct 23;8(11):187. doi: 10.3390/ani8110187.PMID: 30360513 Free PMC article.
[25] Cooking Has Variable Effects on the Fermentability in the Large Intestine of the Fraction of Meats, Grain Legumes, and Insects That Is Resistant to Digestion in the Small Intestine in an in Vitro Model of the Pig's Gastrointestinal Tract.Poelaert C, Despret X, Sindic M, Beckers Y, Francis F, Portetelle D, Soyeurt H, Théwis A, Bindelle J.J Agric Food Chem. 2017 Jan 18;65(2):435-444. doi: 10.1021/acs.jafc.6b04599. Epub 2017 Jan 4.PMID: 27997168
[26] N Balance Studies Emphasize the Superior Protein Quality of Pig Diets at High Inclusion Level of Algae Meal (Spirulina platensis) or Insect Meal (Hermetia illucens) when Adequate Amino Acid Supplementation Is Ensured.Neumann C, Velten S, Liebert F.Animals (Basel). 2018 Oct 3;8(10):172. doi: 10.3390/ani8100172.PMID: 30282918 Free PMC article.
[27] Cricket powder as an alternative protein source for broilers based on in vitro digestibility. A. Kovitvadhi, P. Chundang, J. Luapan, P. Amarapitak, P. Sriyaphai, R. Buahom, T. Cham-iam, K. Leelehapongsathon, C. Tirawattanawanich, K. Thongprajukaew. Journal of Insects as Food and Feed, July 2019, Wageningen Academic Publishers. DOI: 10.3920/jiff2018.0043 https://www.ingentaconnect.com/content/wagac/jiff/2019/00000005/00000003/art00004
[28] Protein composition and digestibility of black soldier fly larvae in broiler chickens revisited according to the recent nitrogen-protein conversion ratio. Nery, J., Gasco, L., Dabbou, S., & Schiavone, A. (2018). Protein composition and digestibility of black soldier fly larvae in broiler chickens revisited according to the recent nitrogen-protein conversion ratio. Journal of insects as food and feed, 4, 171-177. doi: 10.3920/JIFF2018.0006
[29] Proximate composition and in vitro protein digestibility of extruded aquafeeds containing Acheta domesticus and Hermetia illucens fractions. Irungu, Francis & Mutungi, Christopher & Faraj, Abdul & Affognon, Hippolyte & Ekesi, Sunday & Nakimbugwe, Dorothy & Fiaboe, Komi. (2018). Proximate composition and in vitro protein digestibility of extruded aquafeeds containing Acheta domesticus and Hermetia illucens fractions.

Journal of Insects as Food and Feed. 4. 1-10. 10.3920/JIFF2017.0089. https://www.wageningenacademic.com/doi/abs/10.3920/JIFF2017.0089
[30] Black soldier fly (Hermetia illucens) pre-pupae meal as a dietary protein source for broiler production ensures a tasty chicken with standard meat quality for every pot.Pieterse E, Erasmus SW, Uushona T, Hoffman LC.J Sci Food Agric. 2019 Jan 30;99(2):893-903. doi: 10.1002/jsfa.9261. Epub 2018 Sep 6.PMID: 30009465
[31] Black Soldier Fly (Hermetia Illucens) as Dietary Source for Laying Quails: Live Performance, and Egg Physico-Chemical Quality, Sensory Profile and Storage Stability.Dalle Zotte A, Singh Y, Michiels J, Cullere M.Animals (Basel). 2019 Mar 25;9(3):115. doi: 10.3390/ani9030115.PMID: 30934616 Free PMC article.
[32] Black soldier fly defatted meal as a dietary protein source for broiler chickens: effects on carcass traits, breast meat quality and safety.Schiavone A, Dabbou S, Petracci M, Zampiga M, Sirri F, Biasato I, Gai F, Gasco L.Animal. 2019 Oct;13(10):2397-2405. doi: 10.1017/S1751731119000685. Epub 2019 May 7.PMID: 31062675
[33] Black soldier fly as dietary protein source for broiler quails: apparent digestibility, excreta microbial load, feed choice, performance, carcass and meat traits.Cullere M, Tasoniero G, Giaccone V, Miotti-Scapin R, Claeys E, De Smet S, Dalle Zotte A.Animal. 2016 Dec;10(12):1923-1930. doi: 10.1017/S1751731116001270. Epub 2016 Jun 24.PMID: 27339654 Clinical Trial.
[34] Black soldier fly as dietary protein source for broiler quails: meat proximate composition, fatty acid and amino acid profile, oxidative status and sensory traits.Cullere M, Tasoniero G, Giaccone V, Acuti G, Marangon A, Dalle Zotte A.Animal. 2018 Mar;12(3):640-647. doi: 10.1017/S1751731117001860. Epub 2017 Jul 24.PMID: 28735587
[35] Impact of black soldier fly larval meal on growth performance, apparent digestibility, haematological and blood chemistry indices of guinea fowl starter keets under tropical conditions.Wallace PA, Nyameasem JK, Adu-Aboagye GA, Affedzie-Obresi S, Nkegbe EK, Karbo N, Murray F, Leschen W, Maquart P-.Trop Anim Health Prod. 2017 Aug;49(6):1163-1169. doi: 10.1007/s11250-017-1312-x. Epub 2017 May 26.PMID: 28550593
[36] Partially defatted black soldier fly larva meal inclusion in piglet diets: effects on the growth performance, nutrient digestibility, blood profile, gut morphology and histological features.Biasato I, Renna M, Gai F, Dabbou S, Meneguz M, Perona G, Martinez S, Lajusticia ACB, Bergagna S, Sardi L, Capucchio MT, Bressan E, Dama A, Schiavone A, Gasco L.J Anim Sci Biotechnol. 2019 Feb 19;10:12. doi: 10.1186/s40104-019-0325-x. eCollection 2019.PMID: 30820321 Free PMC article.
[37] Nutrient and AA digestibility of black soldier fly larvae differing in age using the precision-fed cecectomized rooster assay1.Do S, Koutsos L, Utterback PL, Parsons CM, de Godoy MRC, Swanson KS.J Anim Sci. 2020 Jan 1;98(1):skz363. doi: 10.1093/jas/skz363.PMID: 31781760
[38] Impact of on-range choice feeding with black soldier fly larvae (Hermetia illucens) on flock performance, egg quality, and range use of free-range laying hens.Ruhnke I, Normant C, Campbell DLM, Iqbal Z, Lee C, Hinch GN, Roberts J.Anim Nutr. 2018 Dec;4(4):452-460. doi: 10.1016/j.aninu.2018.03.005. Epub 2018 Apr 4.PMID: 30564767 Free PMC article.
[39] Performances of local poultry breed fed black soldier fly larvae reared on horse manure.Moula N, Scippo ML, Douny C, Degand G, Dawans E, Cabaraux JF, Hornick JL, Medigo RC, Leroy P, Francis F, Detilleux J.Anim Nutr. 2018 Mar;4(1):73-78. doi: 10.1016/j.aninu.2017.10.002. Epub 2017 Oct 26.PMID: 30167487 Free PMC article.
[40] Evaluation of the suitability of a partially defatted black soldier fly (Hermetia illucens L.) larvae meal as ingredient for rainbow trout (Oncorhynchus mykiss Walbaum) diets.Renna M, Schiavone A, Gai F, Dabbou S, Lussiana C, Malfatto V, Prearo M, Capucchio MT, Biasato I, Biasibetti E, De Marco M, Brugiapaglia A, Zoccarato I, Gasco L.J Anim Sci Biotechnol. 2017 Jul 1;8:57. doi: 10.1186/s40104-017-0191-3. eCollection 2017.PMID: 28680591 Free PMC article.
[41] Nutritional value of a partially defatted and a highly defatted black soldier fly larvae (Hermetia illucens L.) meal for broiler chickens: apparent nutrient digestibility, apparent metabolizable energy and apparent ileal amino acid digestibility. Schiavone, A., De Marco, M., Martínez, S. et al. Nutritional value of a partially defatted and a highly defatted black soldier fly larvae (Hermetia illucens L.) meal for broiler chickens: apparent nutrient digestibility, apparent metabolizable energy and apparent ileal amino acid digestibility. J Animal Sci Biotechnol 8, 51 (2017). https://doi.org/10.1186/s40104-017-0181-5. https://jasbsci.biomedcentral.com/articles/10.1186/s40104-017-0181-5
[42] Hermetia illucens Larvae Reared on Different Substrates in Broiler Quail Diets: Effect on Physicochemical and Sensory Quality of the Quail Meat.Cullere M, Woods MJ, van Emmenes L, Pieterse E, Hoffman LC, Dalle Zotte A.Animals (Basel). 2019 Aug 2;9(8):525. doi: 10.3390/ani9080525.PMID: 31382479 Free PMC article.
[43] Replacement of soybean oil by Hermetia illucens fat in turkey nutrition: effect on performance, digestibility, microbial community, immune and physiological status and final product quality.Sypniewski J, Kierończyk B, Benzertiha A, Mikołajczak Z, Pruszyńska-Oszmałek E, Kołodziejski P, Sassek M, Rawski M, Czekała W, Józefiak

D.Br Poult Sci. 2020 Jun;61(3):294-302. doi: 10.1080/00071668.2020.1716302. Epub 2020 Jan 31.PMID: 31955595
[44] Nutritional effects of the dietary inclusion of partially defatted Hermetia illucens larva meal in Muscovy duck.Gariglio M, Dabbou S, Biasato I, Capucchio MT, Colombino E, Hernández F, Madrid J, Martínez S, Gai F, Caimi C, Oddon SB, Meneguz M, Trocino A, Vincenzi R, Gasco L, Schiavone A.J Anim Sci Biotechnol. 2019 May 10;10:37. doi: 10.1186/s40104-019-0344-7. eCollection 2019.PMID: 31168367 Free PMC article.
[45] [Acceptance, tolerance and apparent nutrient digestibility of complete diets based on larvae meal of Hermetia illucens in cats].Paßlack N, Zentek J.Tierarztl Prax Ausg K Kleintiere Heimtiere. 2018 Aug;46(4):213-221. doi: 10.15654/TPK-180372. Epub 2018 Aug 27.PMID: 30149403 German.
[46] Effect of endogenous phenoloxidase on protein solubility and digestibility after processing of Tenebrio molitor, Alphitobius diaperinus and Hermetia illucens.Janssen RH, Vincken JP, Arts NJG, Fogliano V, Lakemond CMM.Food Res Int. 2019 Jul;121:684-690. doi: 10.1016/j.foodres.2018.12.038. Epub 2018 Dec 24.PMID: 31108796
[47] Tenebrio molitor and Zophobas morio Full-Fat Meals in Broiler Chicken Diets: Effects on Nutrients Digestibility, Digestive Enzyme Activities, and Cecal Microbiome.Benzertiha A, Kierończyk B, Rawski M, Józefiak A, Kozłowski K, Jankowski J, Józefiak D.Animals (Basel). 2019 Dec 12;9(12):1128. doi: 10.3390/ani9121128.PMID: 31842397 Free PMC article.
[48] Tenebrio Molitor Meal in Rainbow Trout (Oncorhynchus Mykiss) Diets: Effects on Animal Performance, Nutrient Digestibility and Chemical Composition of Fillets. Belforti, Marco & Gai, Francesco & Lussiana, Carola & Renna, Manuela & Malfatto, Vanda & Rotolo, Luca & Marco, Michele & Dabbou, Sihem & Schiavone, Achille & Ivo, Zoccarato. (2015). Tenebrio molitor meal in rainbow trout (Oncorhynchus mykiss) diets: Effects on animal performance, nutrient digestibility and chemical composition of fillets. Italian Journal of Animal Science. 14. 670-676. 10.4081/ijas.2015.4170. https://www.tandfonline.com/doi/full/10.4081/ijas.2015.4170
[49] Partially Defatted Tenebrio molitor Larva Meal in Diets for Grow-Out Rainbow Trout, Oncorhynchus mykiss (Walbaum): Effects on Growth Performance, Diet Digestibility and Metabolic Responses.Chemello G, Renna M, Caimi C, Guerreiro I, Oliva-Teles A, Enes P, Biasato I, Schiavone A, Gai F, Gasco L.Animals (Basel). 2020 Jan 31;10(2):229. doi: 10.3390/ani10020229.PMID: 32023930 Free PMC article.
[50] Supplementation of Dried Mealworm (Tenebrio molitor larva) on Growth Performance, Nutrient Digestibility and Blood Profiles in Weaning Pigs.Jin XH, Heo PS, Hong JS, Kim NJ, Kim YY.Asian-Australas J Anim Sci. 2016 Jul;29(7):979-86. doi: 10.5713/ajas.15.0535. Epub 2016 Jun 6.PMID: 27282974 Free PMC article.
[51] Graded Incorporation of Defatted Yellow Mealworm (Tenebrio molitor) in Rainbow Trout (Oncorhynchus mykiss) Diet Improves Growth Performance and Nutrient Retention.Rema P, Saravanan S, Armenjon B, Motte C, Dias J.Animals (Basel). 2019 Apr 23;9(4):187. doi: 10.3390/ani9040187.PMID: 31018487 Free PMC article.
[52] Evaluation of Yellow Mealworm Meal as a Protein Feedstuff in the Diet of Broiler Chicks.Elahi U, Wang J, Ma YB, Wu SG, Wu J, Qi GH, Zhang HJ.Animals (Basel). 2020 Jan 30;10(2):224. doi: 10.3390/ani10020224.PMID: 32019216 Free PMC article.
[53] Effects of dietary dried mealworm (Ptecticus tenebrifer) larvae on growth performance and nutrient digestibility in weaning pigs. Ao, X. & Kim, I.H.. (2019). Effects of dietary dried mealworm (Ptecticus tenebrifer) larvae on growth performance and nutrient digestibility in weaning pigs. Livestock Science. 230. 10.1016/j.livsci.2019.09.031. https://www.sciencedirect.com/science/article/pii/S1871141319311400
[54] Effects of dietary replacement of fishmeal by mealworm meal on muscle quality of farmed shrimp Litopenaeus vannamei.Panini RL, Pinto SS, Nóbrega RO, Vieira FN, Fracalossi DM, Samuels RI, Prudêncio ES, Silva CP, Amboni RDMC.Food Res Int. 2017 Dec;102:445-450. doi: 10.1016/j.foodres.2017.09.017. Epub 2017 Sep 13.PMID: 29195971
[55] Cricket (Gryllodes sigillatus) meal fed to healthy adult dogs does not affect general health and minimally impacts apparent total tract digestibility.Kilburn LR, Carlson AT, Lewis E, Serao MCR.J Anim Sci. 2020 Mar 1;98(3):skaa083. doi: 10.1093/jas/skaa083.PMID: 32179914 Free PMC article.
[56] Apparent Digestibility Coefficients and Amino Acid Availability of Cricket Meal, Gryllus bimaculatus , and Fishmeal in African Catfish, Clarias gariepinus , Diet. Taufek, N.M., Muin, H., Raji, A.A., Razak, S.A., Yusof, H.M. and Alias, Z. (2016). J World Aquacult Soc, 47: 798-805. doi:10.1111/jwas.12302 https://onlinelibrary.wiley.com/doi/full/10.1111/jwas.12302
[57] Laying performance, blood profiles, nutrient digestibility and inner organs traits of hens fed an insect meal from Hermetia illucens larvae.Bovera F, Loponte R, Pero ME, Cutrignelli MI, Calabrò S, Musco N, Vassalotti G, Panettieri V, Lombardi P, Piccolo G, Di Meo C, Siddi G, Fliegerova K, Moniello G.Res Vet Sci. 2018 Oct;120:86-93. doi: 10.1016/j.rvsc.2018.09.006. Epub 2018 Sep 28.PMID: 30293041
[58] Evaluation of an insect meal of the Black Soldier Fly (Hermetia illucens) as soybean substitute: Intestinal morphometry, enzymatic and microbial activity in laying hens.Cutrignelli MI, Messina M, Tulli F, Randazzo B,

Olivotto I, Gasco L, Loponte R, Bovera F.Res Vet Sci. 2018 Apr;117:209-215. doi: 10.1016/j.rvsc.2017.12.020. Epub 2017 Dec 27.PMID: 29304440
[59] Growth performance, carcass characteristics, meat quality and serum profile of broiler chicks fed on housefly maggot meal as a replacement of soybean meal.Elahi U, Ma YB, Wu SG, Wang J, Zhang HJ, Qi GH.J Anim Physiol Anim Nutr (Berl). 2020 Jul;104(4):1075-1084. doi: 10.1111/jpn.13265. Epub 2019 Dec 18.PMID: 31854139
[60] Amino acid digestibility of larval meal (Musca domestica) for broiler chickens.Hall HN, Masey O'Neill HV, Scholey D, Burton E, Dickinson M, Fitches EC.Poult Sci. 2018 Apr 1;97(4):1290-1297. doi: 10.3382/ps/pex433.PMID: 29452386
[61] Use of larvae meal as protein source in broiler diet: Effect on growth performance, nutrient digestibility, and carcass and meat traits.Bovera F, Loponte R, Marono S, Piccolo G, Parisi G, Iaconisi V, Gasco L, Nizza A.J Anim Sci. 2016 Feb;94(2):639-47. doi: 10.2527/jas.2015-9201.PMID: 27065134
[62] Insect lipid profile: aqueous versus organic solvent-based extraction methods. Tzompa-Sosa, Daylan & Yi, Liya & Valenberg, Hein J.F. & Boekel, Martinus & Lakemond, Catriona. (2014). Insect lipid profile: Aqueous versus organic solvent-based extraction methods. Food Research International. 62. 1087-1094. 10.1016/j.foodres.2014.05.052. https://www.sciencedirect.com/science/article/pii/S0963996914003676
[63] Insects as an Alternative Protein Source [Chapter: '10 - '] https://www.sciencedirect.com/science/article/pii/B9780081007228000115
[64] Edible insects are the future? https://www.cambridge.org/core/journals/proceedings-of-the-nutrition-society/article/edible-insects-are-the-future/206E43F1C95FCA2E67EF04950321414E/core-reader
[65] Review: Insects and former foodstuffs for upgrading food waste biomasses/streams to feed ingredients for farm animals.Pinotti L, Giromini C, Ottoboni M, Tretola M, Marchis D.Animal. 2019 Jul;13(7):1365-1375. doi: 10.1017/S1751731118003622. Epub 2019 Jan 29.PMID: 30691544 Review.
[66] Consuming insects: are there health benefits? Roos, Nanna & Huis, Arnold. (2017). Consuming insects: Are there health benefits?. Journal of Insects as Food and Feed. 3. 225-229. https://doi.org/10.3920/JIFF2017.x007.
[67] Viruses of insects reared for food and feed.Maciel-Vergara G, Ros VID.J Invertebr Pathol. 2017 Jul;147:60-75. doi: 10.1016/j.jip.2017.01.013. Epub 2017 Feb 9.PMID: 28189501 Review.
[68] Potential of insects as food and feed in assuring food security.van Huis A.Annu Rev Entomol. 2013;58:563-83. doi: 10.1146/annurev-ento-120811-153704. Epub 2012 Sep 27.PMID: 23020616 Review.
[69] Transforming insect biomass into consumer wellness foods: A review.Sun-Waterhouse D, Waterhouse GIN, You L, Zhang J, Liu Y, Ma L, Gao J, Dong Y.Food Res Int. 2016 Nov;89(Pt 1):129-151. doi: 10.1016/j.foodres.2016.10.001. Epub 2016 Oct 5.PMID: 28460898 Review.
[70] Quality Aspects of Insects as Food-Nutritional, Sensory, and Related Concepts.Elhassan M, Wendin K, Olsson V, Langton M.Foods. 2019 Mar 12;8(3):95. doi: 10.3390/foods8030095.PMID: 30871008 Free PMC article. Review.
[71] BOOK: The Role of Edible Insects in Diets and Nutrition in East Africa. Kinyuru J.N. et al. (2018) The Role of Edible Insects in Diets and Nutrition in East Africa. In: Halloran A., Flore R., Vantomme P., Roos N. (eds) Edible Insects in Sustainable Food Systems. Springer, Cham. https://doi.org/10.1007/978-3-319-74011-9_6 https://link.springer.com/chapter/10.1007/978-3-319-74011-9_6
[72] Selected species of edible insects as a source of nutrient composition. Zielińska, Ewelina & Baraniak, Barbara & Karaś, Monika & Rybczyńska-Tkaczyk, Kamila & Jakubczyk, Anna. (2015). Selected species of edible insects as a source of nutrient composition. Food Research International. 77. 10.1016/j.foodres.2015.09.008. https://www.sciencedirect.com/science/article/pii/S0963996915301824
[73] Nutritional Value of Edible Insects from the State of Oaxaca, Mexico. Ramos-Elorduy, J.P.no-Moreno, J.; Escamilla-Prado, E.A.varado-Perez, M.L.gunez-Otero, J.L.dron-De-Guevara, O. Journal of food composition and analysis: an official ciation of the United Nations University International Network of Food Data Systems 10(2): 142-157. (1997). https://eurekamag.com/research/002/908/002908815.php https://www.sciencedirect.com/science/article/pii/S0889157597905305
[74] Estimate of chitin in raw whole insect https://onlinelibrary.wiley.com/doi/abs/10.1002/zoo.20123
[75] The nutritional value of edible insects. To cite this article: Sandra G.F. Bukkens (1997) The nutritional value of edible insects, Ecology of Food and Nutrition, 36:2-4, 287-319, DOI: 10.1080/03670244.1997.9991521 https://www.tandfonline.com/doi/abs/10.1080/03670244.1997.9991521#aHR0cHM6Ly93d3cudGFuZGZvbmx pbmUuY29tL2RvaS9wZGYvMTAuMTA4MC8wMzY3MDI0NC4xOTk3Ljk5OTE1MjE/bmVlZEFjY2Vzcz10cnVlQEBA MA==
[76] Opportunities and hurdles of edible insects for food and feed. Dobermann, D., Swift, J.A., & Field, L.M. (2017). Opportunities and hurdles of edible insects for food and feed. Nutrition Bulletin, 42, 293–308.

https://onlinelibrary.wiley.com/doi/abs/10.1111/nbu.12291@10.1111/(ISSN)1467-3010.fashionable_ingredients_the_facts
[77] Nutritional and sensory quality of edible insects. Kouřimská, Lenka & Adámková, Anna. (2016). Nutritional and sensory quality of edible insects. NFS Journal. 4. 10.1016/j.nfs.2016.07.001. https://www.sciencedirect.com/science/article/pii/S2352364616300013#bb0130
[78] Comparison of functional properties of edible insects and protein preparations thereof. EwelinaZ ielińska, Monika Karaś, Barbara Baraniak. LWT, Volume 91, (2018), 168-174. https://www.sciencedirect.com/science/article/pii/S002364381830080X
[79] The high level of protein content reported in insects for food and feed is overestimated.
[80] A Comprehensive Look at the Possibilities of Edible Insects as Food in Europe – a Review. Mlcek, Jiri & Rop, Otakar & Borkovcová, Marie & Bednářová, Martina. (2014). Polish Journal of Food and Nutrition Sciences. 64. 10.2478/v10222-012-0099-8.
[81] Functional Properties of Extracted Protein from Edible Insect Larvae and Their Interaction with Transglutaminase.Kim TK, Yong HI, Jang HW, Kim YB, Choi YS.Foods. 2020 May 6;9(5):591. doi: 10.3390/foods9050591.PMID: 32384629 Free PMC article.
[82] Nitrogen-to-Protein Conversion Factors for Three Edible Insects: Tenebrio molitor, Alphitobius diaperinus, and Hermetia illucens. Janssen RH, Vincken JP, van den Broek LA, Fogliano V, Lakemond CM. Nitrogen-to-Protein Conversion Factors for Three Edible Insects: Tenebrio molitor, Alphitobius diaperinus, and Hermetia illucens. J Agric Food Chem. 2017;65(11):2275-2278. doi:10.1021/acs.jafc.7b00471. https://pubs.acs.org/doi/10.1021/acs.jafc.7b00471
[83] Fortification of traditional egg pasta (erişte) with edible insects: nutritional quality, cooking properties and sensory characteristics evaluation.Çabuk B, Yılmaz B.J Food Sci Technol. 2020 Jul;57(7):2750-2757. doi: 10.1007/s13197-020-04315-7. Epub 2020 Mar 9.PMID: 32549625
[84] Consumer Acceptance of Biscuits Supplemented with a Sorghum-Insect Meal.Awobusuyi TD, Pillay K, Siwela M.Nutrients. 2020 Mar 25;12(4):895. doi: 10.3390/nu12040895.PMID: 32218250 Free PMC article.
[85] Chitosan production with larval exoskeletons derived from the insect protein production.Hahn T, Roth A, Ji R, Schmitt E, Zibek S.J Biotechnol. 2020 Feb 20;310:62-67. doi: 10.1016/j.jbiotec.2019.12.015. Epub 2019 Dec 23.PMID: 31877336
[86] Extraction and characterisation of protein fractions from five insect species.Yi L, Lakemond CM, Sagis LM, Eisner-Schadler V, van Huis A, van Boekel MA.Food Chem. 2013 Dec 15;141(4):3341-8. doi: 10.1016/j.foodchem.2013.05.115. Epub 2013 Jun 6.PMID: 23993491
[87] Feed Conversion, Survival and Development, and Composition of Four Insect Species on Diets Composed of Food By-Products. Oonincx, Dennis & Broekhoven, Sarah & Huis, Arnold & van Loon, Joop. (2015). Feed Conversion, Survival and Development, and Composition of Four Insect Species on Diets Composed of Food By-Products. PloS one. 10. e0144601. 10.1371/journal.pone.0144601. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0144601
[88] Fatty acids and proximate composition of eight Thai edible terricolous insects. Raksakantong, P., Meeso, N., Kubola, J., & Siriamornpun, S. (2010). Fatty acids and proximate composition of eight Thai edible terricolous insects. Food Research International, 43(1), 350–355. doi:10.1016/j.foodres.2009.10.014 https://www.sciencedirect.com/science/article/pii/S0963996909003317
[89] Benefits and food safety concerns associated with consumption of edible insects. Samuel Imathiu, NFS Journal, Volume 18, (2020), 1-11 https://www.sciencedirect.com/science/article/pii/S235236461930046X
[90] In Vitro Crude Protein Digestibility of Tenebrio Molitor and Hermetia Illucens Insect Meals and its Correlation with Chemical Composition Traits. Marono, S., Piccolo, G., Loponte, R., Meo, C.D., Attia, Y.A., Nizza, A., & Bovera, F. (2015). In Vitro Crude Protein Digestibility of Tenebrio Molitor and Hermetia Illucens Insect Meals and its Correlation with Chemical Composition Traits. Italian Journal of Animal Science, 14. https://www.tandfonline.com/doi/full/10.4081/ijas.2015.3889
[91] Nutritional evaluation of protein from Clanis bilineata (Lepidoptera), an edible insect.Xia Z, Wu S, Pan S, Kim JM.J Sci Food Agric. 2012 May;92(7):1479-82. doi: 10.1002/jsfa.4730. Epub 2011 Dec 22.PMID: 22189909
[92] Technical Functional Properties of Water- and Salt-soluble Proteins Extracted from Edible Insects.Kim TK, Yong HI, Jeong CH, Han SG, Kim YB, Paik HD, Choi YS.Food Sci Anim Resour. 2019 Aug;39(4):643-654. doi: 10.5851/kosfa.2019.e56. Epub 2019 Aug 31.PMID: 31508594 Free PMC article.
[93] Influence of Freeze-Drying and Oven-Drying Post Blanching on the Nutrient Composition of the Edible Insect Ruspolia differens.Fombong FT, Van Der Borght M, Vanden Broeck J.Insects. 2017 Sep 16;8(3):102. doi: 10.3390/insects8030102.PMID: 28926949 Free PMC article.
[94] Effects of formulation and process conditions on microstructure, texture and digestibility of extruded insect-riched snacks. Azzollini, Domenico & Derossi, Antonio & Fogliano, Vincenzo & Lakemond, Catriona & Severini,

Carla. (2017). Effects of formulation and process conditions on microstructure, texture and digestibility of extruded insect-riched snacks. Innovative Food Science & Emerging Technologies. 45. 10.1016/j.ifset.2017.11.017. https://www.sciencedirect.com/science/article/pii/S1466856416307755
[95] Effects of Traditional Processing Techniques on the Nutritional and Microbiological Quality of Four Edible Insect Species Used for Food and Feed in East Africa.Nyangena DN, Mutungi C, Imathiu S, Kinyuru J, Affognon H, Ekesi S, Nakimbugwe D, Fiaboe KKM.Foods. 2020 May 4;9(5):574. doi: 10.3390/foods9050574.PMID: 32375385 Free PMC article.
[96] On printability, quality and nutritional properties of 3D printed cereal based snacks enriched with edible insects.Severini C, Azzollini D, Albenzio M, Derossi A.Food Res Int. 2018 Apr;106:666-676. doi: 10.1016/j.foodres.2018.01.034. Epub 2018 Feb 8.PMID: 29579973
[97] Effect of domestic cooking methods on protein digestibility and mineral bioaccessibility of wild harvested adult edible insects.Manditsera FA, Luning PA, Fogliano V, Lakemond CMM.Food Res Int. 2019 Jul;121:404-411. doi: 10.1016/j.foodres.2019.03.052. Epub 2019 Mar 27.PMID: 31108764
[98] Straightforward extraction and selective bioconversion of high purity chitin from Bombyx eri larva: Toward an integrated insect biorefinery.Huet G, Hadad C, Husson E, Laclef S, Lambertyn V, Araya Farias M, Jamali A, Courty M, Alayoubi R, Gosselin I, Sarazin C, Van Nhien AN.Carbohydr Polym. 2020 Jan 15;228:115382. doi: 10.1016/j.carbpol.2019.115382. Epub 2019 Sep 28.PMID: 31635752
[99] Identification of antioxidant and anti-inflammatory peptides obtained by simulated gastrointestinal digestion of three edible insects species (Gryllodes sigillatus , Tenebrio molitor , Schistocerca gragaria). Zielińska, E., Baraniak, B. and Karaś, M. (2018), Identification of antioxidant and anti-inflammatory peptides obtained by simulated gastrointestinal digestion of three edible insects species (Gryllodes sigillatus, Tenebrio molitor, Schistocerca gragaria). Int J Food Sci Technol, 53: 2542-2551. doi:10.1111/ijfs.13848 https://ifst.onlinelibrary.wiley.com/doi/full/10.1111/ijfs.13848
[100] Agri-Food Side-Stream Inclusions in the Diet of Alphitobius diaperinus Part 1: Impact on Larvae Growth Performance Parameters.Gianotten N, Soetemans L, Bastiaens L.Insects. 2020 Jan 23;11(2):79. doi: 10.3390/insects11020079.PMID: 31979388 Free PMC article.
[101] Larval nutrition affects lipid storage and growth, but not protein or carbohydrate storage in newly eclosed adults of the grasshopper Schistocerca americana.Hahn DA.J Insect Physiol. 2005 Nov;51(11):1210-9. doi: 10.1016/j.jinsphys.2005.06.011. Epub 2005 Aug 11.PMID: 16098985
[102] Role of temperature on growth and metabolic rate in the tenebrionid beetles Alphitobius diaperinus and Tenebrio molitor.Bjørge JD, Overgaard J, Malte H, Gianotten N, Heckmann LH.J Insect Physiol. 2018 May-Jun;107:89-96. doi: 10.1016/j.jinsphys.2018.02.010. Epub 2018 Mar 15.PMID: 29477466
[103] Effect of Dietary Protein and Carbohydrates on Survival and Growth in Larvae of the Henosepilachna vigintioctopunctata (F.) (Coleoptera: Coccinellidae).Wang ZL, Wang XP, Li CR, Xia ZZ, Li SX.J Insect Sci. 2018 Jul 1;18(4):3. doi: 10.1093/jisesa/iey067.PMID: 29982810 Free PMC article.
[104] Growth performance and feed conversion efficiency of three edible mealworm species (Coleoptera: Tenebrionidae) on diets composed of organic by-products.van Broekhoven S, Oonincx DG, van Huis A, van Loon JJ.J Insect Physiol. 2015 Feb;73:1-10. doi: 10.1016/j.jinsphys.2014.12.005. Epub 2015 Jan 7.PMID: 25576652
[105] Ontogenic Development of Digestive Enzymes in Mealworm Larvae (Tenebrio molitor) and Their Suitable Harvesting Time for Use as Fish Feed.Rodjaroen S, Thongprajukaew K, Khongmuang P, Malawa S, Tuntikawinwong K, Saekhow S.Insects. 2020 Jun 26;11(6):393. doi: 10.3390/insects11060393.PMID: 32604741 Free PMC article.
[106] Use of black soldier fly larvae (Hermetia illucens) to substitute soybean meal in ruminant diet: An in vitro rumen fermentation study.Jayanegara A, Novandri B, Yantina N, Ridla M.Vet World. 2017 Dec;10(12):1439-1446. doi: 10.14202/vetworld.2017.1439-1446. Epub 2017 Dec 10.PMID: 29391684 Free PMC article.
[107] Estimating black soldier fly larvae biowaste conversion performance by simulation of midgut digestion.Gold M, Egger J, Scheidegger A, Zurbrügg C, Bruno D, Bonelli M, Tettamanti G, Casartelli M, Schmitt E, Kerkaert B, Smet J, Campenhout LV, Mathys A.Waste Manag. 2020 Jul 1;112:40-51. doi: 10.1016/j.wasman.2020.05.026. Epub 2020 Jun 1.PMID: 32497900
[108] Modeling the Growth of Black Soldier Fly Hermetia illucens (Diptera: Stratiomyidae): An Approach to Evaluate Diet Quality.Sripontan Y, Chiu CI, Tanansathaporn S, Leasen K, Manlong K.J Econ Entomol. 2020 Apr 6;113(2):742-751. doi: 10.1093/jee/toz337.PMID: 31836886
[109] A survey of the mycobiota associated with larvae of the black soldier fly (Hermetia illucens) reared for feed production.Varotto Boccazzi I, Ottoboni M, Martin E, Comandatore F, Vallone L, Spranghers T, Eeckhout M, Mereghetti V, Pinotti L, Epis S.PLoS One. 2017 Aug 3;12(8):e0182533. doi: 10.1371/journal.pone.0182533. eCollection 2017.PMID: 28771577 Free PMC article.

[110] Killing method affects the browning and the quality of the protein fraction of Black Soldier Fly (Hermetia illucens) prepupae: a metabolomics and proteomic insight.Leni G, Caligiani A, Sforza S.Food Res Int. 2019 Jan;115:116-125. doi: 10.1016/j.foodres.2018.08.021. Epub 2018 Aug 8.PMID: 30599922
[111] Impact of Thermal and High-Pressure Treatments on the Microbiological Quality and In Vitro Digestibility of Black Soldier Fly (Hermetia illucens) Larvae.Campbell M, Ortuño J, Stratakos AC, Linton M, Corcionivoschi N, Elliott T, Koidis A, Theodoridou K.Animals (Basel). 2020 Apr 14;10(4):682. doi: 10.3390/ani10040682.PMID: 32295154 Free PMC article.
[112] Influence of larval density and dietary nutrient concentration on performance, body protein, and fat contents of black soldier fly larvae (Hermetia illucens).Barragan-Fonseca KB, Dicke M, van Loon JJA.Entomol Exp Appl. 2018 Sep;166(9):761-770. doi: 10.1111/eea.12716. Epub 2018 Sep 3.PMID: 30449896 Free PMC article.
[113] Impact of substrate contamination with mycotoxins, heavy metals and pesticides on the growth performance and composition of black soldier fly larvae (Hermetia illucens) for use in the feed and food value chain.Purschke B, Scheibelberger R, Axmann S, Adler A, Jäger H.Food Addit Contam Part A Chem Anal Control Expo Risk Assess. 2017 Aug;34(8):1410-1420. doi: 10.1080/19440049.2017.1299946.PMID: 28278126
[114] Nutrient Composition of Selected Whole Invertebrates. Barker, D., Fitzpatrick, M.P., & Dierenfeld, E. (1998). Nutrient composition of selected whole invertebrates. https://onlinelibrary.wiley.com/doi/pdf/10.1002/(SICI)1098-2361(1998)17:2%3C123::AID-ZOO7%3E3.0.CO;2-B
[115] Extraction and physicochemical characterization of Tenebrio molitor proteins.
[116] Essential dietary amino acids for growth of larvae of the yellow mealworm, Tenebrio molitor L.Davis GR.J Nutr. 1975 Aug;105(8):1071-5. doi: 10.1093/jn/105.8.1071.PMID: 1142013
[117] A novel clean production approach to utilize crop waste residues as co-diet for mealworm (Tenebrio molitor) biomass production with biochar as byproduct for heavy metal removal.Yang SS, Chen YD, Zhang Y, Zhou HM, Ji XY, He L, Xing DF, Ren NQ, Ho SH, Wu WM.Environ Pollut. 2019 Sep;252(Pt B):1142-1153. doi: 10.1016/j.envpol.2019.06.028. Epub 2019 Jun 8.PMID: 31252112
[118] Addition of Olive Pomace to Feeding Substrate Affects Growth Performance and Nutritional Value of Mealworm (Tenebrio Molitor L.) Larvae. Ruschioni, Sara & Loreto, Nino & Foligni, Roberta & Mannozzi, C. & Raffaelli, Nadia & Zamporlini, Federica & Pasquini, Marina & Roncolini, Andrea & Cardinali, Federica & Osimani, Andrea & Aquilanti, Lucia & Isidoro, Nunzio & Riolo, Paola & Mozzon, Massimo. (2020). Foods. 9. 317. 10.3390/foods9030317.
[119] Effect of household cooking techniques on the microbiological load and the nutritional quality of mealworms (Tenebrio molitor L. 1758).Caparros Megido R, Poelaert C, Ernens M, Liotta M, Blecker C, Danthine S, Tyteca E, Haubruge É, Alabi T, Bindelle J, Francis F.Food Res Int. 2018 Apr;106:503-508. doi: 10.1016/j.foodres.2018.01.002. Epub 2018 Jan 6.PMID: 29579954
[120] Food Value of Mealworm Grown on Acrocomia aculeata Pulp Flour. Alves AV, Sanjinez-Argandoña EJ, Linzmeier AM, Cardoso CA, Macedo ML. Food Value of Mealworm Grown on Acrocomia aculeata Pulp Flour. PLoS One. 2016;11(3):e0151275. Published 2016 Mar 14. doi:10.1371/journal.pone.0151275 https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0151275
[121] Metabolic response of yellow mealworm larvae to two alternative rearing substrates. Melis R, Braca A, Sanna R, et al. Metabolic response of yellow mealworm larvae to two alternative rearing substrates. Metabolomics. 2019;15(8):113. Published 2019 Aug 17. doi:10.1007/s11306-019-1578-2 https://link.springer.com/article/10.1007/s11306-019-1578-2
[122] Growth performance and nutritional profile of mealworms reared on corn stover, soybean meal, and distillers' grains. Zhang, Xia & Tang, Huaijian & Chen, Gaowei & Qiao, Linran & Li, Jinlong & Liu, Bosh & Liu, Zhongdong & Li, Mengxing & Liu, Xu. (2019). Growth performance and nutritional profile of mealworms reared on corn stover, soybean meal, and distillers' grains. European Food Research and Technology. 10.1007/s00217-019-03336-7. https://link.springer.com/article/10.1007/s00217-019-03336-7
[123] Degree of Hydrolysis Affects the Techno-Functional Properties of Lesser Mealworm Protein Hydrolysates.Leni G, Soetemans L, Caligiani A, Sforza S, Bastiaens L.Foods. 2020 Mar 25;9(4):381. doi: 10.3390/foods9040381.PMID: 32218377 Free PMC article.
[124] Protein quality and physicochemical properties of commercial cricket and mealworm powders.Stone AK, Tanaka T, Nickerson MT.J Food Sci Technol. 2019 Jul;56(7):3355-3363. doi: 10.1007/s13197-019-03818-2. Epub 2019 Jun 10.PMID: 31274903 Free PMC article.
[125] Lowering Chitin Content of Cricket (<I>Gryllus assimilis</I>) Through Exoskeleton Removal and Chemical Extraction and its Utilization as a Ruminant Feed <I>in vitro</I>Jayanegara A, Sholikin MM, Sabila DAN, Suharti S, Astuti DA.Pak J Biol Sci. 2017;20(10):523-529. doi: 10.3923/pjbs.2017.523.529.PMID: 30187729

[126] Sex-specific interactions of microbial symbioses on cricket dietary selection.Schmid RB, Lehman RM, Lundgren JG.Environ Entomol. 2014 Aug;43(4):896-902. doi: 10.1603/EN13311. Epub 2014 Jun 9.PMID: 24914929
[127] Effect of Diet on the Growth Performance, Feed Conversion, and Nutrient Content of the House Cricket
[128] Effect of traditional processing methods on chemical composition and in vitro true dry matter digestibility of the Mophane worm (Imbrasia belina). Force Tefo, Thema. (2007). Effect of traditional processing methods on chemical composition and in vitro true dry matter digestibility of the Mophane worm (Imbrasia belina). Journal of Arid Environments. 492-500. https://www.sciencedirect.com/science/article/pii/S0140196306002072
[129] Effects of Diet on the Chemical Composition of Migratory Locusts (Locusta migratoria). Oonincx DG, van der Poel AF. Effects of diet on the chemical composition of migratory locusts (Locusta migratoria). Zoo Biol. 2011;30(1):9-16. doi:10.1002/zoo.20308
[130] The Effect of Diet Quality on δ(13)C and δ(15)N in the Tissues of Locusts, Locusta migratoria L.Webb SC, Simpson SJ, Hedges RE.Isotopes Environ Health Stud. 1997 Jul;33(1-2):43-51. doi: 10.1080/10256019708036330.PMID: 22087480
[131] Protein-induced mass increase of the gastrointestinal tract of locusts improves net nutrient uptake via larger meals rather than more efficient nutrient absorption.Clissold FJ, Brown ZP, Simpson SJ.J Exp Biol. 2013 Jan 15;216(Pt 2):329-37. doi: 10.1242/jeb.076489. Epub 2012 Sep 20.PMID: 22996444
[132] Does dietary P affect feeding and performance in the mixed-feeding grasshopper (Acrididae) Melanoplus bivitattus?Loaiza V, Jonas JL, Joern A.Environ Entomol. 2008 Apr;37(2):333-9. doi: 10.1603/0046-225x(2008)37[333:ddpafa]2.0.co;2.PMID: 18419904
[133] The population growth, development and metabolic enzymes of the white-backed planthopper, Sogatella furcifera (Hemiptera: Delphacidae) under the sublethal dose of triflumezopyrim.Chen L, Wang X, Zhang Y, Yang R, Zhang S, Xu X, Zhu M, Gong C, Hasnain A, Shen L, Jiang C.Chemosphere. 2020 May;247:125865. doi: 10.1016/j.chemosphere.2020.125865. Epub 2020 Jan 8.PMID: 31962223
[134] Effect of Processing Methods on the In Vitro Protein Digestibility and Vitamin Content of Edible Winged Termite (Macrotermes subhylanus) and Grasshopper (Ruspolia differens). Kinyuru, J.N., Kenji, G.M., Njoroge, S.M. et al. Effect of Processing Methods on the In Vitro Protein Digestibility and Vitamin Content of Edible Winged Termite (Macrotermes subhylanus) and Grasshopper (Ruspolia differens). Food Bioprocess Technol 3, 778–782 (2010). https://doi.org/10.1007/s11947-009-0264-1 https://link.springer.com/article/10.1007/s11947-009-0264-1
[135] Chitin digestibility is dependent on feeding behaviors, which determine acidic chitinase mRNA levels in mammalian and poultry stomachs.Tabata E, Kashimura A, Kikuchi A, Masuda H, Miyahara R, Hiruma Y, Wakita S, Ohno M, Sakaguchi M, Sugahara Y, Matoska V, Bauer PO, Oyama F.Sci Rep. 2018 Jan 23;8(1):1461. doi: 10.1038/s41598-018-19940-8.PMID: 29362395 Free PMC article.
[136] Protein Digestibility and Quality in Products Containing Antinutritional Factors Are Adversely Affected by Old Age in Rats https://academic.oup.com/jn/article/133/1/220/4687670
[137] High-yield production of a chitinase from Aeromonas veronii B565 as a potential feed supplement for warm-water aquaculture.Zhang Y, Zhou Z, Liu Y, Cao Y, He S, Huo F, Qin C, Yao B, Ringø E.Appl Microbiol Biotechnol. 2014 Feb;98(4):1651-62. doi: 10.1007/s00253-013-5023-6. Epub 2013 Jun 18.PMID: 23775269
[138] Chitosan and its oligosaccharide derivatives (chito-oligosaccharides) as feed supplements in poultry and swine nutrition.Swiatkiewicz S, Swiatkiewicz M, Arczewska-Wlosek A, Jozefiak D.J Anim Physiol Anim Nutr (Berl). 2015 Feb;99(1):1-12. doi: 10.1111/jpn.12222. Epub 2014 Jul 12.PMID: 25041091 Review.
[139] Digestibility of nitrogen and amino acids in selected protein sources fed to mice. Murray O. Keith, J. Milton Bell, Digestibility of Nitrogen and Amino Acids in Selected Protein Sources Fed to Mice, The Journal of Nutrition, Volume 118, Issue 5, May 1988, Pages 561–568, https://doi.org/10.1093/jn/118.5.561 https://academic.oup.com/jn/article-abstract/118/5/561/4737959?redirectedFrom=fulltext
[140] Chitin utilisation by broilers and its effect on body composition and blood metabolites.Hossain SM, Blair R.Br Poult Sci. 2007 Feb;48(1):33-8. doi: 10.1080/00071660601156529.PMID: 17364538
[141] Insect food for astronauts: gas exchange in silkworms fed on mulberry and lettuce and the nutritional value of these insects for human consumption during deep space flights.Tong L, Yu X, Liu H.Bull Entomol Res. 2011 Oct;101(5):613-22. doi: 10.1017/S0007485311000228. Epub 2011 May 4.PMID: 21554801
[142] Insect cells for human food.Verkerk MC, Tramper J, van Trijp JC, Martens DE.Biotechnol Adv. 2007 Mar-Apr;25(2):198-202. doi: 10.1016/j.biotechadv.2006.11.004. Epub 2006 Nov 23.PMID: 17197149 Review.
[143] Ingestion of Insect Protein Isolate Enhances Blood Amino Acid Concentrations Similar to Soy Protein in A Human Trial.Vangsoe MT, Thogersen R, Bertram HC, Heckmann LL, Hansen M.Nutrients. 2018 Sep 22;10(10):1357. doi: 10.3390/nu10101357.PMID: 30248987 Free PMC article. Clinical Trial.

[144] Consideration of insects as a source of dietary protein for human consumption.Churchward-Venne TA, Pinckaers PJM, van Loon JJA, van Loon LJC.Nutr Rev. 2017 Dec 1;75(12):1035-1045. doi: 10.1093/nutrit/nux057.PMID: 29202184 Review.
[145] Optimisation of a cheap and residential small-scale production of edible crickets with local by-products as an alternative protein-rich human food source in Ratanakiri Province, Cambodia.Caparros Megido R, Alabi T, Nieus C, Blecker C, Danthine S, Bogaert J, Haubruge É, Francis F.J Sci Food Agric. 2016 Jan 30;96(2):627-32. doi: 10.1002/jsfa.7133. Epub 2015 Mar 23.PMID: 25683556
[146] Microbial Dynamics during Industrial Rearing, Processing, and Storage of Tropical House Crickets (Gryllodes sigillatus) for Human Consumption.Vandeweyer D, Wynants E, Crauwels S, Verreth C, Viaene N, Claes J, Lievens B, Van Campenhout L.Appl Environ Microbiol. 2018 May 31;84(12):e00255-18. doi: 10.1128/AEM.00255-18. Print 2018 Jun 15.PMID: 29625988 Free PMC article.
[147] Effect of different killing methods on physicochemical traits, nutritional characteristics, in vitro human digestibility and oxidative stability during storage of the house cricket (Acheta domesticus L.) https://www.sciencedirect.com/science/article/pii/S1466856420303908 Y.Singh, M.Cullere, A.Kovitvadhi ,P.Chundang , A.Dalle Zotte Innovative Food Science & Emerging Technologies, Volume 65, October 2020, 102444
[148] Food Proteins and Bioactive Peptides: New and Novel Sources, Characterisation Strategies and Applications.Hayes M.Foods. 2018 Mar 14;7(3):38. doi: 10.3390/foods7030038.PMID: 29538293 Free PMC article.
[149] [Negative effects of anti-nutritional factors in animal feed on nitrogen burden of the environment and possibilities of its reduction. Nutritional physiology effects].Huisman J.Tijdschr Diergeneeskd. 1991 Apr 15;116(8):391-5.PMID: 1882367 Dutch.
[150] Emergent food proteins - Towards sustainability, health and innovation.Fasolin LH, Pereira RN, Pinheiro AC, Martins JT, Andrade CCP, Ramos OL, Vicente AA.Food Res Int. 2019 Nov;125:108586. doi: 10.1016/j.foodres.2019.108586. Epub 2019 Jul 29.PMID: 31554037 Review.
[151] Food Proteins: Technological, Nutritional, and Sustainability Attributes of Traditional and Emerging Proteins.Loveday SM.Annu Rev Food Sci Technol. 2019 Mar 25;10:311-339. doi: 10.1146/annurev-food-032818-121128. Epub 2019 Jan 16.PMID: 30649962 Review.
[152] Impact of Antinutritional Factors in Food Proteins on the Digestibility of Protein and the Bioavailability of Amino Acids and on Protein Quality Sarwar Gilani G, Wu Xiao C, Cockell KA. Impact of antinutritional factors in food proteins on the digestibility of protein and the bioavailability of amino acids and on protein quality. Br J Nutr. 2012;108 Suppl 2:S315-S332. doi:10.1017/S0007114512002371
https://www.cambridge.org/core/journals/british-journal-of-nutrition/article/impact-of-antinutritional-factors-in-food-proteins-on-the-digestibility-of-protein-and-the-bioavailability-of-amino-acids-and-on-protein-