

Research Article

Krzysztof Smarzyński, Paulina Sarbak, Szymon Musiał, Paweł Jeżowski, Michał Piątek, Przemysław Łukasz Kowalczewski*

Nutritional analysis and evaluation of the consumer acceptance of pork pâté enriched with cricket powder - preliminary study

<https://doi.org/10.1515/opag-2019-0015>

received December 28, 2018; accepted February 26, 2019

Abstract: The growing interest in insects as food ingredients on the one hand is controversial, on the other is in line with the recommendations of international organizations, such as the Food and Agriculture Organization of the United Nations. Crickets, as well as cricket powder (CP), are a source of high quality protein, fat, vitamins and minerals. This paper analyzes the impact of CP additive (2%, 6% and 10%) on the nutritional value and consumer acceptance of enriched pâtés. It was shown that the CP additive significantly increases the content of protein, fat and minerals. It also changes the color of the product, which is darker (lower L* value), and the color balance is shifted towards the blue. Consumer assessment showed that the 2% CP additive allows to obtain a product of high attractiveness for consumers.

Keywords: insect; novel food; cricket powder; consumer acceptance; pâté

1 Introduction

Food production in a sustainable way is undoubtedly one of the greatest challenges of our time. It is estimated that by 2050, the world's population will increase to 9 billion (FAO 2012). Producing the right amount of food, including animal origin, for such a large population will be a huge challenge for agriculture. Even today, due to rational feeding of animals, very large production results can be achieved, however, it carries a huge burden on the environment. Producing one kilogram of meat requires an investment of 5,000 to 10,000 liters of water, and simultaneously from one ton of produced food, 4.2 tonnes of carbon dioxide are produced (Hilborn et al. 2018). Globalization changes have led to the spread of many new technologies, but in developing countries access to animal protein is significantly reduced due to rising prices (Ivanic and Martin 2018).

Insects are increasingly seen as a potentially important source of cheap protein that can supplement conventional protein sources, such as meat, without overcharging the environment (Kulma et al. 2019; van Huis 2013; Tan et al. 2017). It is worth noting that the production of insects for edible purposes is relatively easy and cheap, and the obtained protein has a high nutritional value (Caparros et al. 2015). For a long time, insects have been food for people from Africa, Australia and Latin America (Ramos-Elorduy 1997). The use of insects as food can help to meet the challenge of the need for a source of cheap protein. In addition, crickets are a valuable source of not only protein, but also dietary fiber, unsaturated fatty acids, vitamins and minerals (Ayieko et al. 2016; Caparros et al. 2015). The cricket powder obtained from them is a very valuable product in terms of nutritional value and contains even three times more protein than sirloin, and also twice as much as chicken breast, thus it is an interesting addition to enriching food (Duda et al. 2019; Pauter et al. 2018). In addition, 100 g of this flour can cover 1/3 of the daily iron demand (Finke 2007; van Huis 2013).

*Corresponding author: Przemysław Ł. Kowalczewski, Institute of Food Technology of Plant Origin, Poznań University of Life Sciences; 31 Wojska Polskiego Str., Poznań, Poland; E-mail: przemyslaw.kowalczewski@up.poznan.pl

Krzysztof Smarzyński, Paulina Sarbak, Szymon Musiał, Students' Scientific Club of Food Technologist, Faculty of Food Science and Nutrition, Poznań University of Life Sciences, Poznań, Poland

Paweł Jeżowski, Institute of Chemistry and Technical Electrochemistry, Poznań University of Technology, Poznań, Poland

Michał Piątek, Department of Meat Technology, Poznań University of Life Sciences, Poznań, Poland

Przemysław Ł. Kowalczewski (orcid: 0000-0001-9088-5153);

Krzysztof Smarzyński (orcid: 0000-0001-9088-5153);

Paulina Sarbak (orcid: 0000-0002-5873-108X);

Paweł Jeżowski (orcid: 0000-0001-9869-0641);

Michał Piątek (orcid: 0000-0001-6558-4092)

The FAO recommends the use of insects as food, due to the easily digestible protein (FAO 2013). Due to the growing costs of animal protein production (Ivanic and Martin 2008), it seems particularly interesting to use insect protein in the production of food for athletes. Such snacks can be purchased in Great Britain, France or the Netherlands. Unfortunately, for cultural reasons, the inhabitants of most Western European countries are reluctant to eat insects and products made from them.

Greater availability of information on the potential nutritional benefits of using edible insects would allow the development of new products and thus the fulfillment of consumer preferences in this direction (House 2016; Pambo et al. 2018). Additives used to improve the nutritional value of pâtés or give them new health-promoting properties may, however, change its physicochemical characteristics (Baranowska 2011; Baranowska et al. 2018), and this may lead to changes in the attractiveness of enriched products. Therefore, the aim of this work was to evaluate the impact of cricket powder addition on the sensory attractiveness of pork pâté, as well as its nutritional value.

2 Materials and methods

2.1 Pâté manufacturing

Cricket powder (CP) was bought from Crunchy Critters (United Kingdom) and it contained 56.8% protein, 29.3% fat, 5.5% carbohydrates and 2.3% fiber. Pâtés were prepared using meat, liver and fat from pork (Mas-Pol, Poland), CP and a mix of spices consisting of pepper, dried onion, marjoram (McCormick Polska S.A., Poland). Pork meat (38.96%) and fat (24.35%) were boiled in water until tender. The material prepared in this way was pre-grated in a PT-98 type mincer (Mainca, Spain) using a 3 mm mesh. After that, the meat was combined with the hot broth (19.48%) obtained during cooking of meat and spice mix (2.60%) and mixed in a bowl cutter (CR-22, Mainca, Spain) at 55°C. Homogenized pork liver (14.61%) was added to the minced meat and the grinding operation was continued until homogeneous consistency was obtained. Finally, the mass was placed in 200 mL jars and cooked at 70°C for 40 minutes. Thus prepared pâtés were cooled with cold water and stored in a refrigerator prior to the analyses. The pâté formulations contained 2%, 6% and 10% addition of cricket powder (added together with spice mix), and were termed CP2, CP6 and CP10, respectively. Pâté without CP addition was used as a reference (R).

2.2 Nutritional composition and energy value

The ash content was determined according to ISO 936, total water content – according to ISO 1442, fat content (Soxhlet method) was determined according to ISO 1444. Total nitrogen content was determined by the Kjeldahl method according to ISO 8968 and was used to calculate the protein content by multiplying the result by the conversion factor of 6.25. Moreover, the proximate carbohydrate content was estimated by subtracting the total fat, protein, ash and moisture content from 100%. The energy value [kcal/100 g] was calculated with the following formula: energy value = $4 \times \text{protein (\%)} + 4 \times \text{carbohydrate (\%)} + 9 \times \text{fat (\%)}$.

2.3 Color measurements

The color of the pâté was measured using a Chroma Meter CR-410 (Konica Minolta Sensing Inc., Japan) color meter. Differences were recorded in CIE L*a*b* scale in terms of lightness (L*) and color (a* – redness; b* – yellowness) (Kowalczewski et al. 2018). Moreover, the total color difference (ΔE) was calculated using the formula:

2.4 Consumer acceptance

Thirty untrained panelists for organoleptic assessment (basic flavors, color vision, odor detection, tactile sensitivity), as well as the ability to communicate sensory product descriptions in accordance with the recommendations of ISO 8589 were invited to participate in this study. Consumer rating was evaluated according to a 10-cm linear scale (Villanueva et al. 2000). Consumers, in the age between twenty and forty-five, were asked to evaluate the color on the cross-section: intensity (from light to dark), uniform; texture: consistency, uniform, spreadability; flavor: meat, fat, salty, liver, bitter, other; odor: meat, liver, other; and overall rating as well.

2.5 Statistical analysis

All the measurements were repeated three times, unless stated otherwise. One-way analysis of variance (ANOVA) was carried out independently for each dependent variable. A post-hoc Tukey HSD multiple comparison test was used to identify statistically homogeneous subsets $\alpha = 0.05$. Statistical analysis was performed with Statistica 13

software (Dell Software Inc., USA).

Ethical approval: The conducted research is not related to either human or animal use.

3 Results and discussion

The interest in using insects for food production is rising in Europe. Edible insects, as well as products obtained from them, including cricket powder, are a good source of high quality protein, but also fat and vitamins (Ayieko et al. 2016). Moreover, the main advantage of farming edible insects is that they do not have to be fed on grains, thus saving agricultural land for growing crops for human consumption (van Huis 2013). The use of CP for food production can, on the one hand, reduce production costs, and on the other, provide many nutrients. Unlike other proteins of animal origin (poultry, pork or beef), the production of an insect protein has a smaller ecological footprint (Dobermann et al. 2017). Another advantage is the possibility of using waste from the agri-food industry as feed for insects. It enables reduction of production costs and makes the process independent of the raw material used as food by people (Lundy et al. 2015). All these advantages make the cricket additions not only an additive that is cheap, healthy and functional, but also environmentally friendly. According to the assumptions, the CP additive caused a significant increase in the protein

content in the obtained pâtés (Table 1). Analogous results were observed in the case of fat content. Crickets contain also microelements (Finke 2007; Stull et al. 2018; van Huis 2013), thus the addition of CP caused a significant increase in mineral content. Due to the high fat content in CP, the effect of using the additive on the energy value of pâtés was also observed.

The lightness (L^*) was reduced in pâtés containing CP therefore they were darker (Table 2). There were slight changes in the value of parameter a^* , but the blue/yellow balance, which represents parameter b^* , has shifted toward blue in CP2, CP6 and CP10. Also, total color differences (ΔE) were calculated for pâtés with cricket powder. Mokrzycki and Tatol (2011) proved that an experienced observer may visually detect color deviation when ΔE is greater than 3.5 between 2 objects. The results obtained ($\Delta E = 5.50, 10.53$ and 17.10 for CP2, CP6 and CP10, respectively) allow a statement that pâtés with CP deviated very much from reference samples. The color of food products is one of the key parameters on the basis of which consumers choose the product. Thus, it is extremely important that the additives used do not cause significant color changes in relation to the conventional product (Grunert 1997).

Changes in the proximate composition has a significant impact on the quality of products, understood not only as physicochemical but also as sensory properties (Jin et al. 2014; Steen et al. 2014). Moreover, commercial success of

Table 1: Nutritional content and characteristics of pâtés

Parameter	R	CP2	CP6	CP10
Water content [%]	43.64 ± 3.02 ^a	44.96 ± 3.40 ^a	43.54 ± 2.30 ^a	44.12 ± 3.01 ^a
Protein content [%]	15.97 ± 0.25 ^d	17.45 ± 0.23 ^c	19.02 ± 0.09 ^b	21.01 ± 0.09 ^a
Fat content [%]	27.46 ± 1.02 ^c	28.89 ± 0.99 ^{bc}	30.68 ± 1.28 ^b	31.11 ± 0.78 ^a
Ash content [%]	1.80 ± 0.03 ^d	1.95 ± 0.04 ^c	2.02 ± 0.06 ^b	2.17 ± 0.04 ^a
Carbohydrate ¹ [%]	11.13 ± 1.02 ^a	7.35 ± 0.68 ^b	4.54 ± 0.43 ^c	1.59 ± 0.22 ^d
Energy value ² [kcal/100 g]	355.54	359.21	370.36	370.39

¹The carbohydrate content was estimated by subtracting the average content of ash, fat and protein from 100%.

²Energy value was calculated based on average protein, fat and carbohydrate content.

Mean values denoted by different letters differ statistically significantly ($p < 0.05$).

Table 2: Color parameters of pâtés with cricket powder

Parameter	R	CP2	CP6	CP10
L^*	66.54 ± 0.94 ^a	61.50 ± 0.34 ^b	56.74 ± 0.84 ^c	50.11 ± 0.66 ^d
a^*	3.38 ± 0.13 ^a	3.08 ± 0.18 ^{ab}	2.98 ± 0.24 ^b	2.87 ± 0.16 ^b
b^*	17.16 ± 0.43 ^a	14.98 ± 0.29 ^b	13.34 ± 0.33 ^c	12.44 ± 0.11 ^d
ΔE	-	5.50	10.53	17.10

Mean values denoted by different letters differ statistically significantly ($p < 0.05$).

new ingredients, and thus products, relies on consumer acceptance (Sun-Waterhouse and Wadhwa 2013). The analytically determined differences between reference pâté and pâtés with cricket powder were reflected in the consumer assessment (Table 3). One of the most important features influencing the consumer's decision to buy a product is appearance, taste and flavour. It was shown that the CP additive affects the sensory characteristics of the enriched pâté. The reference product had the highest rating in terms of appearance, compared to all enriched pâtés. The CP additive changed the color, which resulted in worse acceptance among consumers. A negative effect of the additive on the taste and flavor assessment was also observed. With the increase in the amount of CP additive, the palatability of meat and liver in taste and flavor decreased, while the saltiness and palpability of others taste and flavor increased. Surprisingly, however, it turned out that the addition of CP improves the texture according to consumer ratings. The CP10 and CP6 variants received significantly higher texture ratings for consistency (7.7 and 7.5, respectively) and uniform (5.1 and 4.8, respectively) compared to the reference sample (4.9 for consistency and 3.2 for uniform). At the same time, a reduction in the spreadability rating was noted.

4 Conclusion

It was found that the addition of cricket powder influences the proximate composition, increasing the content of ash, fat and protein in the final product. The additive used also changed color determinants. It caused reduction in lightness of pâtés and shifted color balance toward blue. Taking into account the slight change in sensory acceptance, a small amount of cricket powder additive can be used in the production of sensitively attractive pâté. Nevertheless, further studies on the impact of cricket powder additive on the texture, structure and properties of pâtés are needed to explain the changes in the attractiveness of enriched products observed in this work.

Acknowledgements: The authors thank Dr. Mirosława Krzywdzińska-Bartkowiak (Poznań University of Life Sciences, Poznań, Poland) for her help with the analyzes.

Funding: The authors received no financial support for the research, authorship, and/or publication of this article.

Conflicts of Interest: On behalf of all authors, the

Table 3: Results of sensory study

Parameter	R	CP2	CP6	CP10
<i>Color on the cross-section</i>				
Intensity	1.7 ± 0.8 ^d	4.1 ± 1.2 ^c	6.7 ± 1.3 ^b	8.9 ± 1.1 ^a
Uniform	7.4 ± 0.8 ^a	6.2 ± 0.7 ^b	6.1 ± 0.9 ^b	5.2 ± 0.4 ^c
<i>Texture</i>				
Consistency	4.9 ± 1.2 ^b	6.3 ± 1.1 ^{ab}	7.5 ± 0.9 ^a	7.7 ± 1.3 ^a
Uniform	3.2 ± 0.7 ^b	4.1 ± 1.1 ^a	4.8 ± 1.1 ^a	5.1 ± 1.2 ^a
Spreadability	7.2 ± 1.0 ^a	5.6 ± 1.1 ^b	3.8 ± 1.2 ^c	1.1 ± 0.6 ^d
<i>Flavor</i>				
Meat	6.6 ± 0.8 ^a	6.3 ± 0.9 ^a	6.1 ± 1.0 ^a	4.8 ± 0.4 ^b
Other	1.6 ± 0.5 ^d	2.7 ± 0.4 ^c	4.7 ± 1.1 ^b	7.6 ± 0.6 ^a
Fat	3.4 ± 0.4 ^a	3.3 ± 0.9 ^a	2.6 ± 0.5 ^b	2.2 ± 0.5 ^b
Salty	5.2 ± 1.1 ^a	4.5 ± 1.2 ^b	4.5 ± 0.9 ^b	4.5 ± 0.8 ^b
Liver	4.1 ± 0.7 ^a	2.9 ± 1.1 ^b	2.3 ± 1.2 ^b	1.2 ± 0.5 ^c
Bitter	1.4 ± 0.4 ^c	2.2 ± 0.8 ^b	2.3 ± 0.7 ^b	4.1 ± 0.9 ^a
<i>Odor</i>				
Meat	6.0 ± 1.0 ^a	4.1 ± 0.6 ^b	3.6 ± 1.2 ^{bc}	2.1 ± 1.1 ^c
Liver	5.4 ± 1.3 ^a	5.3 ± 0.8 ^a	4.6 ± 1.1 ^{ab}	3.2 ± 0.7 ^b
Other	1.1 ± 0.6 ^c	2.5 ± 0.5 ^{bc}	3.9 ± 0.9 ^b	7.1 ± 1.2 ^a
<i>Overall rating</i>				
Final Score	8.1 ± 0.7 ^a	7.8 ± 0.5 ^a	6.7 ± 0.3 ^b	4.4 ± 0.4 ^c

Mean values denoted by different letters differ statistically significantly ($p < 0.05$).

corresponding author states that there is no conflict of interest.

References

- Ayieko M.A., Ogola H.J., Ayieko I.A., Introducing rearing crickets (*Gryllids*) at household levels: adoption, processing and nutritional values. *J. Ins. Food Feed*, 2016, 2(3), 203-211. <https://doi.org/10.3920/JIFF2015.0080>
- Baranowska H.M. Water Molecular Properties in Forcemeats and Finely Ground Sausages Containing Plant Fat. *Food Biophys*, 2011, 6(1), 133-137, <https://doi.org/10.1007/s11483-010-9190-z>
- Baranowska H.M., Masewicz Ł., Kowalczewski P.Ł., Lewandowicz G., Piątek M., Kubiak P., Water properties in pâtés enriched with potato juice. *Eur Food Res Technol*, 2018, 244, 387-393, <https://doi.org/10.1007/s00217-017-2965-4>
- Caparros Megido R., Alabi T., Nieuw C., Blecker C., Danthine S., Bogaert J., et al., 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. *J. Sci. Food Agric.*, 2016, 96, 627-632. <https://doi.org/10.1002/jsfa.7133>

- Dobermann D., Swift J.A., Field L.M. Opportunities and hurdles of edible insects for food and feed. *Nutr Bull.*, 2017, 42, 293-308. <https://doi.org/10.1111/nbu.12291>
- Duda A., Adamczak J., Chelmińska P., Juszkiewicz J., Kowalczewski, P. Quality and Nutritional/Textural Properties of Durum Wheat Pasta Enriched with Cricket Powder. *Foods*, 2019, 8, 46. <https://doi.org/10.3390/foods8020046>
- Finke M.D., Estimate of chitin in raw whole insects. *Zoo Biol*, 2007, 26(2), 105-115, <https://doi.org/10.1002/zoo.20123>
- Food and Agriculture Organization of the United Nations (FAO). Assessing the Potential of Insects as Food and Feed in Assuring Food Security. Presented at Tech. Consult. Meet., 23-25 January, 2012, Rome, Italy.
- Food and Agriculture Organization of the United Nations (FAO). Edible insects. Future prospects for food and feed security. FAO Forestry Paper 171, 2013, Rome, Italy.
- Grunert K.G., What's in a steak? A cross-cultural study on the quality perception of beef. *Food Qual Prefer*, 1997, 8(3), 157-174
- Hilborn R., Bonabi J., Hall S.J., Pucylowski T., Walsworth T.E., The environmental cost of animal source foods. *Front. Ecol. Environ.*, 2018, 16(6), 329-335. <https://doi.org/10.1002/fee.1822>
- House J., Consumer acceptance of insect-based foods in the Netherlands: Academic and commercial implications. *Appetite*, 2016, 107, 47-58.
- Ivanic M., Martin W., Implications of higher global food prices for poverty in low-income countries. *Agricultural Economics*, 2008, 39, 405-416. <https://doi.org/10.1111/j.1574-0862.2008.00347.x>
- ISO 936:1998 Meat and meat products - Determination of total ash
- ISO 1442:1997 Meat and meat products - Determination of moisture content (Reference method)
- ISO 1444:1996 Meat and meat products - Determination of free fat content
- ISO 8589:2007 Sensory analysis - General guidance for the design of test rooms
- ISO 8968-1:2014 Milk and milk products - Determination of nitrogen content - Part 1: Kjeldahl principle and crude protein calculation
- Jin S.K., Park J.H., Hur S.J., Effect of substituting surimi with spent laying hen meat on the physicochemical characteristics of fried fish paste. *Food Bioproc Technol*, 2014, 7, 901-908, <https://doi.org/10.1007/s11947-013-1137-1>
- Kowalczewski P., Różańska M., Makowska A., Jeżowski P., Kubiak P. Production of wheat bread with spray-dried potato juice: Influence on dough and bread characteristics. *Food Sci. Technol. Int.*, 2018. <https://doi.org/10.1177/1082013218814605>
- Kulma M., Kouřimská L., Plachý V., Božik M., Adámková A., et al., Effect of sex on the nutritional value of house cricket, *Acheta domestica* L. *Food Chem*, 2019, 272, 267-272, <https://doi.org/10.1016/j.foodchem.2018.08.049>
- Lundy M.E., Parrella M.P. Crickets are not a free lunch: protein capture from scalable organic side-streams via highdensity populations of *Acheta domestica*. *PLoS ONE*, 2015, 10, 1-12. <https://doi.org/10.1371/journal.pone.0118785>
- Mokrzycki W., Tatol M., Color difference ΔE - a survey. *Mach Graphics Vis*, 2011, 20, 383-411
- Pambo K.O., Okello J.J., Mbeche R.M., Kinyuru J.N., Alemu M.H., The role of product information on consumer sensory evaluation, expectations, experiences and emotions of cricket-flour-containing buns. *Food Res Int*, 2018, 16, 532-541. <https://doi.org/10.1016/j.foodres.2018.01.011>
- Pauter P., Różańska M., Wiza P., Dworzak S., Grobelna N., Sarbak P., et al., Effects of the replacement of wheat flour with cricket powder on the characteristics of muffins. *Acta Sci Pol Technol Aliment*, 2018, 17(3), 227-233, <https://doi.org/10.17306/J.AFS.2018.0570>
- Ramos-Elorduy J. Insects: A sustainable source of food?. *Ecol. Food Nutr.*, 1997, 36(2-4), 247-276. <https://doi.org/10/d94v5q>
- Steen L., Fraeye I., De Mey E., Goemaere O., Paelinck H., Foubert I., Effect of salt and liver/fat ratio on viscoelastic properties of liver paste and its intermediates. *Food Bioproc Technol*, 2014, 7, 496-505, <https://doi.org/10.1007/s11947-012-1038-8>
- Stull V.J., Finer E., Bergmans R.S., Febvre H.P., Longhurst C., Manter D.K., et al., Impact of Edible Cricket Consumption on Gut Microbiota in Healthy Adults, a Double-blind, Randomized Crossover Trial. *Sci Rep*, 2018, 8, 10762, <https://doi.org/10.1038/s41598-018-29032-2>
- Sun-Waterhouse D., Wadhwa S.S., Industry-relevant approaches for minimising the bitterness of bioactive compounds in functional foods: a review. *Food Bioproc Technol*, 2013, 6, 607-627, <https://doi.org/10.1007/s11947-012-0829-2>
- Tan H., Fischer A., Tinchan P., Stieger M., Steenbekkers L., et al. Insects as food: Exploring cultural exposure and individual experience as determinants of acceptance. *Food Qual. Prefer.*, 2015, 42, 78-89. <https://doi.org/10.1016/j.foodqual.2015.01.013>
- van Huis A., Potential of insects as food and feed in assuring food security. *Annu Rev Entomol*, 2013, 58, 563-583
- Villanueva N.D.M., Petenate A.J., Da Silva M.A.A.P., Performance of three affective methods and diagnosis of the ANOVA model. *Food Qual Prefer*, 2000, 11, 363-370