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THE EFFECT OF THE CRICKET POWDER ADDITION (*ACHETA DOMESTICUS*) ON THE QUALITY OF PORK PÂTÉS

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ABSTRACT

The increasing global demand for sustainable protein sources highlights the need to explore alternative ingredients in food systems. This study evaluated the effect of incorporating varying levels (2.5%, 5%, and 7.5%) of cricket powder (*Acheta domesticus*) into pork pâté formulations on their chemical composition (moisture, protein, fat, and cholesterol), amino acid and fatty acid profiles, colour characteristics, and sensory properties. The enrichment with cricket powder significantly increased total protein content (up to 19.39%). The fat content decreased with increasing cricket powder content, and the values ranged from 12.80% (E3) to 13.95% (E1). The cholesterol content ranged from 1.52 (E2) to 1.61% (E1). The water content ranged from 66 (E1) to 67.25% (E3) and increased with increasing amounts of cricket powder. The addition of cricket powder significantly increased amino acid, particularly threonine and cysteine and monounsaturated fatty acids (MUFA), while simultaneously reducing lightness (L^*), redness (a^*), and yellowness (b^*) values. Despite the improved nutritional quality, higher insect powder levels negatively impacted sensory acceptability, with the 2.5% enrichment yielding the most favourable balance between nutritional enhancement and consumer perception. These findings suggest that moderate incorporation of cricket powder can improve the nutritional value of meat products while maintaining acceptable sensory characteristics, supporting its potential as a functional ingredient in reformulated meat-based foods.

Keywords: edible insect, meat product, pâté, quality

INTRODUCTION

The global population is projected to reach 8.5 billion by 2030, 9.7 billion by 2050, and 10.4 billion by 2100 **(United Nation, n.d.).** With the world's population growing, securing sufficient food is one of the most pressing challenges of our time **(Raheem *et al.*, 2018; Siddiqui *et al.*, 2022; Kasza *et al.*, 2023).** Meat is a staple food consumed by humans. Due to its appropriate and balanced amino acid content, meat is a significant source of protein **(van der Weele *et al.*, 2019; Wu, 2022)**, as well as an important source of minerals and vitamins, including iron, zinc, and vitamin B_{12} **(Huang *et al.*, 2018)**. A growing number of meat producers are interested in enhancing their products with ingredients that benefit human health and function **(Jiang & Xiong, 2016)**. One such ingredient may be the use of edible insects.

According to the Novel Foods Regulation 2015/2283 **(European Union, 2015),** novel foods containing certain specific insect species (namely *Acheta domesticus*, *Tenebrio molitor larva*, *Locusta migratoria*, and *Alphitobius diaperinus*) are currently permitted.

Since edible insects are known to contain more than 50% protein, they are often recommended as an alternative to animal protein **(Caparros *et al.*, 2015; Ayieko *et al.*, 2016)**. In addition to being rich in monounsaturated and polyunsaturated fatty acids, they are a good source of micronutrients such as iron (Fe) and copper (Cu) **(Rumpold & Schlüter, 2013)**.

From a commercial perspective, the integration of insect proteins into traditional meat products such as pork pates represents a promising strategy for product innovation in the functional food sector. The growing demand for sustainable and high-protein food alternatives has created new market opportunities for insect-enriched products, especially if they can be presented as nutritious and environmentally friendly. Consumer reluctance towards insect-based foods in Europe is mainly due to psychological and cultural barriers such as food neophobia and aversion **(Verbeke, 2015; Hartmann & Siegrist, 2016; Guiné *et al.*, 2024).** Pilot studies in the European market show that consumer acceptance increases significantly with informative labelling, brand transparency and culinary knowledge **(Tan *et al.*, 2016; Menozzi *et al.*, 2017).**

However, adding edible insects to pâtés to increase their nutritional content or provide additional health benefits may alter their physicochemical properties **(Baranowska, 2010; Baranowska *et al.*, 2017)**, which may affect their consumption. There are several studies that address the acceptability of insect-based foods by consumers **(Caparros Megido *et al.*, 2015; Orsi *et al.*, 2019; Barton *et al.*, 2020; Junges *et al.*, 2021)**. Higher education, gender, age, place of residence, prior knowledge of insect food consumption, prior insect consumption, curiosity, ethical motivation, and environmental and dietary benefits are associated with better acceptance of edible insects. Unlike plant-based foodse, e.g., **Pauter *et al.* (2018), Duda *et al.* (2019)** only a small number of studies report the effects of adding insects to meat products **(Smarzyński *et al.*, 2019; Zhang *et al.*, 2022; Cavalheiro *et al.*, 2023).**

Based on these considerations, this study hypothesizes that incorporating edible insect powder into conventional meat products, pork pâté, will improve their proximate composition (moisture, protein, fat, and cholesterol), amino acid and fatty acid profiles, colour characteristics, and sensory properties, leading to improved nutritional value.

The aim of this study was to evaluate the effects of adding cricket powder as an alternative protein source on the chemical, physical, and sensory properties of pork pâtés.

MATERIALS AND METHODS

Raw materials

Cricket powder was purchased from SENS Food Ltd. (London, UK). According to the producer it was made from 100% domestic crickets (*Acheta domesticus*). It was free from artificial colours, flavouring, preservatives, monosodium glutamate, gluten, and dairy. The nutritional composition of the cricket powder was as follows: protein (70 g/100 g), fat (20 g/100 g), saturated fatty acids (SFA; 5.2 g/100 g), fibre (9.5 g/100 g), carbohydrates (0.5 g/100 g), salt (0.8 g/100 g), iron 5.67 mg/100 g and vitamin B_{12} 5.76 µg/100 g. The colour parameters were L^* (64.54), a^* (5.38), and b^* (16.56).

Mixture of pork meat (pork flank and pork shoulder), pork back fat, pork liver, and other ingredients were purchased from a commercially available chain of stores (Nitra, Slovakia).

The experiment was conducted under the same conditions in 3 replicates. No ethical approval was required.

Pork pâtés manufacturing

Pork pâté was made according to an experimental recipe at the Institute of Food Sciences, SPU Nitra. Four different pork pâtés formulations were manufactured under the same conditions in 3 replicates. All pork meat was boiled in water until tender. The material prepared in this manner was pre-grated in a PT-98 type mincer (Mainca, Spain) using a 3 mm mesh. The meat was then combined with the hot broth obtained during cooking of the meat and spice mix and mixed in a bowl cutter (CR-22, Mainca, Spain) at 55 °C. Homogenized pork liver 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 min. The prepared pâtés were cooled with cold water and stored in a refrigerator prior to analysis. The experimental groups contained 2.5%, 5%, and 7.5% cricket powder added per kg of meat mass and were designated as E1, E2, and E3, respectively. Pâté without cricket powder (C-control group) was used as a reference. A total of 80 pork pates (1 pâté = 125 g) were produced, which were divided into 20 pieces in each experimental group in 1 experiment. A total of 3 replications were performed.

The recipe for producing experimental pork pâté per 100 kg of meat is as follows:

- fried onion 20 kg
- pork flank 35 kg
- pork shoulder 15 kg
- pork liver 20 kg
- broth 10 kg
- ground black pepper 200 g
- allspice 50 g
- ground cinnamon 50 g
- ginger powder 50 g
- nutmeg 30 g
- nitrite salting mixture 1.75 kg.

Composition

Chemical composition

The chemical composition of pork sausage samples, including moisture, crude protein, crude fat and cholesterol, was determined using an INFRATEC 1265 spectrometer (Germany) in transmittance mode in the wavelength range of 850–1050 nm with 2 nm intervals. Homogenized 50 g samples were placed in glass jars (90 × 90 × 15 mm) and scanned in duplicate. For each sample, the spectrum was calculated as the average of five scanning points and recorded as log 1/T (T = transmittance). The results are expressed in g per 100 g sample. All measurements were performed in triplicate.

Amino acid composition

Amino acid profiles were obtained following acid hydrolysis in 6 N HCl at 110 °C for 24 h, using an Automatic Amino Acid Analyzer AAA 400 (Ingos a.s., Prague, Czech Republic). Quantification relied on the ninhydrin-based colour reaction, as described by **Straková *et al.* (2015)**. Values were recalculated to dry matter basis and expressed as grams of amino acid per 100 g of muscle tissue. Analyses were performed in duplicate.

Fatty acid composition

Total lipid content was determined via Soxhlet extraction with petroleum ether according to ISO 12966–2:2017 and **Bobková *et al.* (2022)**, followed by preparation of fatty acid methyl esters (FAMEs). Fatty acid profiles were analysed by gas chromatography with flame ionization detection (GC-FID) using an Agilent 6890 system equipped with a DB-23 capillary column (60 m × 250 µm × 0.15 µm, Agilent 122–2361). Analytical conditions included: injector temperature 250 °C; injection volume 1 µL; split ratio 1:10; helium carrier gas at 238.96 kPa (2.225 mL/min); oven program 50 °C for 1 min, ramp 25 °C/min to 175 °C, then 2 °C/min to 230 °C; detector temperature 280 °C; hydrogen 35 mL/min; air 350 mL/min; nitrogen as make-up gas 30 mL/min. Fatty acids were identified by comparison with a 42-component FAME standard (10 mg/mL in methylene chloride, C4–C24, 2–4% relative concentration; Supelco, catalog no. 47885-U, Sigma-Aldrich, Steinheim, Germany). Analyses were conducted in triplicate.

Determination of colour

The colour parameters (L*: lightness, a*: redness, and b*: yellowness) of pork pâté were measured on the surface at 20±1 °C using a Konica Minolta CM-2600d spectrophotometer. 3 measurements in 5 replicates were performed for each sample. The study was performed using a D65 light source, a 10° observer with a port diameter of 8 mm and a SCI (Specular Component Included) configuration. The pork pâté was exposed to atmospheric air for 10 minutes before colour measurement. In the case of colour analysis of pâté with the addition of cricket powder, we used the L*, a* and b* values without gloss (SCE) in the results.

Sensory analysis

Sensory evaluation was performed by eleven trained evaluators according to ISO 8586:2012 (males and females, age range 24–47 years) at the Institute of Food Science of the Slovak University of Agriculture in Nitra. Colour, aroma, taste, texture and overall impression were evaluated. Pork pâtés were sensory evaluated using a 5-point system. A score from 1 to 5 expresses how much the trained evaluator likes the tested sample: 1 – extremely dislike; 2 – moderately dislike; 3 – neither like nor dislike; 4 – somewhat; 5 – extremely. Sensory evaluation was performed after 1 week of storage at 4 °C. Each evaluated sample (10 g, 20 °C) was coded with a random three-digit number and served on a white plate. Drinking water and white bread were given to the evaluators as neutralizers between tastings of the samples. A standard sensory laboratory equipped with sensory cabins meeting the requirements of ISO 8589:2007 (normal lighting conditions, temperature 20±2 °C) was used for sensory evaluation.

Statistical analysis

All analyses were performed in triplicate unless otherwise indicated. Results are reported as mean ± standard deviation of measurements. Data were analysed using one-way ANOVA analysis of variance, followed by Tukey's post hoc test at a significance level of p≤0.05 to test for differences between mean values. Data were analyses using XLSTAT software (version 2018.5.52280, Addinsoft, New York).

RESULTS AND DISCUSSION

Composition

Proximate composition

The proximate composition of pork pâté is showed in Table 1. The average water content in the samples with the addition of cricket powder ranged from 66.99 to 67.25%, and compared with the control group (65.69%), it regularly increased with the addition of cricket powder. The statistically significant differences were found between the experimental groups (p≤0.05). **Smarzyński *et al.* (2019)** found a lower water content in pâté s (44.96%; 43.54%, and 44.11%) in samples with 2; 6, and 10% cricket powder, and comparable results were also found by **Walkowiak *et al.* (2019)** from 43.54 to 44.96% (6 and 2% cricket powder).

Table 1 Chemical composition of pork pâté with the cricket powder addition (g/100 g)

Parameter/Group	Control	E1	E2	E3	p-value
Water	65.69±0.43^{ab}	66.99±0.29^{b}	67.19±0.72^{a}	67.25±0.06^{a}	0.029
Total Protein	17.91±0.40^{ab}	18.67±0.43^{b}	18.80±0.39^{ab}	19.39±0.67^{a}	0.036
Crude Fat	11.82±0.79^{b}	12.80±0.71^{a}	12.94±0.55^{a}	13.95±0.23^{a}	0.018
Cholesterol (mg/100 g)	151.70±0.60	160.70±0.40	152.00±0.55	155.00±0.20	0.129

Notes: Mean±SD. Different superscript letter in rows (a, b) indicate statistically significant differences (p≤0.05). Abbreviations: Control = pork pâté without addition of cricket powder; E1 = pork pâté with 2.5% cricket powder addition; E2 = pork pâté with 5% cricket powder addition; E3 = pork pâté with 7.5% cricket powder addition.

The protein content of all experimental groups was higher than that of the control group. The highest protein content of 19.39% was found in the experimental group E3. Statistically significant differences were found between the experimental samples (E1 and E3 group) (p≤0.05). **Smarzyński *et al.* (2019)** noted a linear proportionality with the increase in the concentration of cricket powder with a subsequent increase in the protein content in pork pâté samples. **Walkowiak *et al.* (2019)** found a similar protein content from 17.45 to 19.22%. Lower values of protein content in pork pâté s (14–15.56%) were found by **Cunningham *et al.* (2015)**. The fat content ranged between 12.80 and 13.95% and compared with the control group, it gradually increased (p≤0.05) with the addition of cricket powder. Similar results recorded other author **Smarzyński *et al.* (2019)**, in contrast, authors **Choi *et al.* (2017)** found fat content decreased with increasing mealworm concentration. **Cavalheiro *et al.* (2023)** found that the fat content was not significantly affected by the addition of cricket powder as a lean meat substitute. The average cholesterol content determined in the control group of pork pâté was 151.70 mg/100 g and was similar in the experimental groups (E1 – 160.70; E2 – 152.00, and E3 – 155.00 mg/100 g), without significant differences (p≥0.05) between experimental groups. Owing to the growing search for healthier food products, high cholesterol content is considered the most important disadvantage of meat products **(Echarte *et al.*, 2004)**. For this purpose, the pâté with the addition of cricket flour meets the demands of consumers as a product with a lower cholesterol content if we consider the liver pâté traditionally sold on the market.

Amino acid composition

Table 2 presents the results of the amino acid composition. The amino acid content prevailed in the tested samples of pork pâté, which was made with the addition of 5 and 7.5% cricket powder, followed by the control group. Significantly higher (p≤0.05) contents of threonine and cysteine were found in groups E2 and E3 than in the control group. The most abundant amino acids observed in all groups were lysine (2.45–2.58 mg/g), leucine (2.22–2.35 mg/g), and arginine (1.80–1.90 mg/g).

Table 2 Effect of cricket powder on amino acid pork pâté composition (g/100 g)

Parameter/Group	C	E1	E2	E3	*p*-value
Threonine	1.21±0.02^{b}	1.22±0.01^{b}	1.30±0.04^{a}	1.30±0.01^{a}	0.003
Valine	1.06±0.01	1.05±0.01	1.09±0.03	1.07±0.01	0.247
Methionine	0.99±0.02	0.98±0.03	1.01±0.03	1.02±0.02	0.215
Isoleucine	1.13±0.02	1.09±0.03	1.15±0.05	1.15±0.03	0.123
Leucine	2.28±0.04	2.22±0.05	2.35±0.08	2.35±0.05	0.066
Phenylalanine	1.18±0.02	1.14±0.03	1.20±0.04	1.20±0.02	0.119
Lysine	2.52±0.06	2.45±0.06	2.58±0.09	2.57±0.05	0.163
Cysteine	0.47±0.02^{c}	0.49±0.01^{bc}	0.50±0.01^{ab}	0.51±0.01^{a}	0.006
Histidine	1.19±0.02	1.17±0.01	1.22±0.03	1.20±0.01	0.086
Arginine	1.86±0.04	1.80±0.05	1.90±0.07	1.90±0.04	0.130

Notes: Mean±SD. Different superscript letter in rows (a-c) indicate statistically significant differences (p≤0.05). Abbreviations: Control = pork pâté without addition of cricket powder; E1 = pork pâté with 2.5% cricket powder addition; E2 = pork pâté with 5% cricket powder addition; E3 = pork pâté with 7.5% cricket powder addition.

In comparison with **Kabdylzhar *et al.* (2022),** who added meat-bone paste to the meat pâté, we found significantly higher values of all monitored amino acids in the experiment, which was verified by the addition of cricket powder. Similarly, lower values of amino acids have been reported by **Amaral *et al.* (2013)** in sheep liver pâtés and by **Berisha *et al.* (2023)** in beef sausages.

Fatty acid composition

Pork pâté has a high proportion of monounsaturated fatty acids (61.57 - 63.52 g/100 g) mainly due to oleic acid **(Table 3)**, which is characterized by a high concentration in pork meat and pork fat **(Bragagnolo & Rodriguez-Amaya, 2002)**, where its content in our experiment was between 54.12 - 57.97 g/100 g. These values are like those reported by several authors who used natural antioxidants in the preparation of pork liver pâté **(Estévez *et al.*, 2007; Pateiro *et al.*, 2014; Pateiro *et al.*, 2015)**. Among the polyunsaturated fatty acids, linoleic acid stood out with a higher representation in the experimental groups with the addition of cricket powder at 2; 5, and 7.5% (4.81 to 5.49 g/100 g) than in the control group (4.40 g/100 g). **Estévez & Cava (2004)** reported a lower percentage of polyunsaturated fatty acids in pork liver pâté, especially with respect to the concentration of linoleic acid. Linoleic acid is considered essential for the human body because of its specific physiological functions. It is an essential compound in the tissue that forms the central nervous system and plays a vital role in the prevention of cardiovascular, autoimmune, and inflammatory diseases **(Trautwein, 2001)**. The content of omega 3 fatty acids was comparable, but the content of omega 6 fatty acids increased in the experimental groups with the addition of cricket powder. **Amaral *et al.* (2013)** found comparable contents of stearic acid and arachidonic acid, lower content of palmitic acid, oleic acid, α-linolenic acid, and MUFA, and higher content of myristic acid, linoleic acid, SAFA, and MUFA compared to our results. Lower values of fatty acid content were found in their experiment by **Martins *et al.* (2020)**, who enriched meat-based pâté s with oleogels as fat substitutes.

Table 3 Effect of cricket powder on fatty acid pork pâté composition (g/100 g)

Fatty acid/Group	C	E1	E2	E3	*p*-value
Lauric	0.04±0.01	0.03±0.01	0.02±0.01	0.01±0.01	0.620
Myristic	1.27±0.01	1.27±0.01	1.26±0.01	1.26±0.01	0.332
Palmitic	24.06±0.04	24.02±0.03	24.18±0.15	24.14±0.04	0.136
Heptadecanoic	0.15±0.03	0.15±0.01	0.15±0.02	0.16±0.01	0.875
Stearic	10.99±0.17	10.98±0.06	11.05±0.05	11.02±0.05	0.830
Oleic	56.48±0.80^{ab}	57.99±0.86^{a}	55.98±0.62^{b}	54.12±1.22^{c}	0.005
Vaccenic	4.47±0.07	4.43±0.01	4.38±0.01	4.43±0.03	0.109
Linoleic	4.40±0.50^{bc}	4.81±0.50^{c}	4.99±0.46^{ab}	5.49±0.72^{a}	0.027
Conjugated Linoleic	0.08±0.01	0.08±0.01	0.07±0.01	0.08±0.01	0.835
α-Linolenic	0.29±0.01^{b}	0.29±0.01^{b}	0.34±0.03^{a}	0.34±0.01^{a}	0.009
Eicosenoic	0.69±0.03^{c}	0.76±0.03^{b}	0.81±0.01^{ab}	0.82±0.04^{a}	0.003
Arachidonic	0.37±0.23	0.27±0.11	0.24±0.14	0.38±0.10	0.595
Eicosapentaenoic	0.02±0.02	0.02±0.01	0.02±0.01	0.02±0.01	0.526
Docosapentaenoic	0.11±0.01	0.12±0.01	0.12±0.01	0.12±0.01	0.609
Docosahexaenoic	0.04±0.01	0.04±0.01	0.04±0.01	0.04±0.001	0.525
Omega 3	0.83±0.02	0.80±0.05	0.83±0.02	0.83±0.02	0.416
Omega 6	2.06±1.17	2.62±0.55	2.67±0.40	3.56±0.87	0.079
∑ SAFA	28.95±0.38	29.06±0.37	29.31±1.05	29.34±0.63	0.879
∑ MUFA	61.57±0.81^{b}	63.52±0.75^{a}	62.74±0.32^{a}	62.73±0.43^{ab}	0.029
∑ PUFA	3.78±0.97	3.68±0.76	3.72±0.69	4.35±1.04	0.276

Notes: Mean±SD. Different superscript letter in rows (a-c) indicate statistically significant differences (p≤0.05). Abbreviations: Control = pork pâté without addition of cricket powder; E1 = pork pâté with 2.5% cricket powder addition; E2 = pork pâté with 5% cricket powder addition; E3 = pork pâté with 7.5% cricket powder addition.

Determination of colour

Colour is a key attribute of meat products as it is linked to consumer acceptance. The colour determination results showed that the L^*, a^*, and b^* values decreased with increasing levels of cricket powder **(Table 4)**, were found to be significantly changed with cricket powder addition (p≤0.05). The control group showed the highest L^* value (62.99), and the E3 group with 7.5% addition of cricket powder showed the lowest L^* value (56.48), pork pâté samples with addition of cricket powder showed a darker colour compared to the control group.

Table 4 Colour evaluation of pork pâté

Group/Parameter	*L**	*a**	*b**
C	62.99±1.94^{a}	8.59±0.47^{a}	15.49±1.13^{a}
E1	60.06±1.91^{b}	7.36±0.71^{b}	15.12±0.53^{b}
E2	58.61±0.91^{c}	6.90±0.58^{c}	14.69±0.66^{b}
E3	56.48±0.96^{d}	6.19±0.28^{d}	14.18±0.44^{c}
p-value	0.001	0.001	0.001

Notes: Mean±SD. Different superscript letter in rows (a-d) indicate statistically significant differences ($p \leq 0.05$). Abbreviations: Control = pork pâté without addition of cricket powder; E1 = pork pâté with 2.5% cricket powder addition; E2 = pork pâté with 5% cricket powder addition; E3 = pork pâté with 7.5% cricket powder addition.

These findings are in line with those of other investigators who discovered that adding more edible insects to reformed meat products reduced their lightness **(Kim *et al*., 2016; Kim *et al*., 2017; Smarzyński *et al*., 2019; Cruz-López *et al*., 2022; Cavalheiro *et al*., 2023)**.

Fernández-López *et al*. (2019) stated that *a** values usually refer to the red components of meat (hem pigments) and their interconversions as well as oxidation processes that can affect both hem pigments and fat. The average values of the colour spectrum *a** in the pork pâté samples were from 6.19 (E3) to 8.59 (C) and were in the red colour region of the spectrum. Although there was no clear significant trend, in general, the addition of cricket powder decreased the *a** values of the pork pâté. **Smarzyński *et al*. (2019)** reported slight changes in the value of the *a** parameter for samples of pork pâté enriched with cricket powder. In contrast, **Ho *et al*. (2022)** found that, in raw sausage samples, the addition of cricket powder significantly reduced the *a** value to -2.08, which is in the green region of the colour spectrum. The average parameters of the colour spectrum *b** decreased proportionally with increasing amounts of cricket powder. **Kim *et al.* (2016)** claimed that the *L**, *a**, and *b** colour characteristics of insect powders can be significantly influenced by the way they are treated.

Sensory evaluation

The average results of the sensory analysis of pork pâté s with the addition of cricket powder are shown in **Table 5**. The inclusion of cricket powder as an ingredient intended to enrich pork pâté had different effects on the sensory scores, depending on the concentration level. Statistically significant differences ($p \leq 0.05$) were observed between the evaluated samples in the sensory analysis. The highest average point scores in all evaluation indicators were obtained for the control samples of pork pâté without the addition of cricket protein powder. A comparison of the mean results of the sensory analysis between the pork pâté samples with different concentrations of cricket powder showed that the acceptance by the evaluators decreased significantly with increasing levels of cricket powder. Furthermore, the study showed that the sensory attributes gradually deteriorated with the addition of higher concentrations of edible insects, a finding that was also reported by another study **(Choi *et al*., 2017)**. In samples of pork pâté with the addition of cricket powder was best evaluated in group E1 with 2.5% addition of cricket powder, suggesting that a lower addition of cricket powder could generate a better substitute effect in terms of sensory characteristics. The average smell results show that as the concentration of cricket powder increases, the consumer acceptability of the evaluators decreases. They stated that the typical liver smell of pâté gradually disappeared, which was replaced by another unspecified smell, reminding them of the spices. The taste in the experimental groups was the best among the samples of group E1 (3.93 points). As stated by the evaluators, the samples with 5% cricket powder showed a pleasant nutty taste. In the sensory evaluation of the samples with 7.5% cricket powder, the evaluators reported that they perceived a bitter taste; therefore, these samples received a lower score. Similar results were reported in their studies by **Zhang *et al*. (2022)**, **Gomes Martins *et al*. (2024)**.

In case of texture, the best was evaluated experimental group E1, where these samples had a fine, smooth texture without the presence of foreign parts. In contrary, samples with addition 5 and 7.5% of cricket powder, the panellists described as pâté the grainy to sandy texture

Cavalheiro *et al*. (2023) used cricket powder as a meat substitute for Frankfurt sausages and reported that all sensory parameters were affected by its addition. Changes in the proximal composition have a significant impact on product quality, understood not only as physicochemical properties but also as sensory properties **(Steen *et al*., 2013; Jin *et al*., 2014)**. Moreover, the commercial success of new ingredients, and therefore products, depends on their acceptance by consumers **(Sun-Waterhouse & Wadhwa, 2012)**. One of the most notable features that influences a consumer's decision to buy a product is its appearance, taste, and aroma. Like our experiment, **Smarzyński *et al*. (2019)** reported that the addition of cricket powder affects the sensory properties of pâtés.

Table 5 Sensory analysis of pork pâté (points)

Parameter/Group	C	E1	E2	E3	*p*-value
Colour	4.07±0.87^{a}	3.90±0.55^{ab}	3.43±0.44^{bc}	3.33±0.67^{c}	0.010
Smell	4.23±0.57^{a}	3.90±0.71^{a}	3.30±0.96^{b}	3.17±0.77^{b}	0.001
Taste	4.43±0.65^{a}	3.93±0.77^{a}	3.27±0.68^{b}	3.20±0.68^{b}	0.001
Texture	4.00±0.73^{a}	4.00±0.48^{a}	3.47±0.50^{b}	2.70±0.44^{c}	0.001
Overall impression	4.20±0.68^{a}	4.17±0.65^{a}	3.53±0.43^{b}	3.23±0.63^{b}	0.001

Notes: Mean±SD. Different superscript letter in rows (a-c) indicate statistically significant differences ($p \leq 0.05$). Abbreviations: Control = pork pâté without addition of cricket powder; E1 = pork pâté with 2.5% cricket powder addition; E2 = pork pâté with 5% cricket powder addition; E3 = pork pâté with 7.5% cricket powder addition.

CONCLUSION

The addition of cricket powder to pork pâtés demonstrably enhanced their nutritional profile by increasing total protein content, improving the amino acid spectrum, and enriching the fatty acid composition with health-promoting monounsaturated fatty acids. However, the addition also induced measurable changes in colour and sensory attributes. While all levels of cricket powder improved nutritional characteristics, only the 2.5% addition maintained a favourable sensory profile in terms of texture, taste, and overall consumer acceptance. These findings indicate that cricket powder can serve as a viable functional ingredient in processed meat products, provided its concentration is carefully optimized to balance nutritional benefits and sensory quality. Future research should investigate strategies to improve the sensory profile of higher-concentration formulations and assess consumer acceptance across different demographics and product types.

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