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# Cricket *(Acheta domesticus*) valorization in muffins manufacturing

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***Abstract***

Cricket (*Acheta domesticus)* flour represent a sustainable unexploited source of protein, minerals, fat, amino-acids, polysaturated fatty acid, B group vitamins, total phenols and antioxidant activity that recently drawn mainstream attention. The main goal of the present research was to valorize cricket flour into the muffins manufacturing. The results showed that insect flour addition increased muffins protein, ash, fat, total phenols and antioxidant activity, meantime, sensorial attributes such as taste, and flavor slightly decreased. Addition of 10% insect flour could be considered optimum for muffins production, reaching a final hedonic score of 8.5.

***Keywords:*** *Acheta domesticus*, insect flour, sustainability, sensory evaluation, chemical composition

## 1.Introduction

From the ancient times till nowadays edible insects have been use as a worldwide source of food in continents such as Asia, Africa and America. In Europe, the consumption of insects was limited by the regulatory issues, till January 2018, when EFSA (European Food Safety Authority) approved the use of insect-based food [1]. The most commonly used species are *Tenebrio molitor* and *Acheta domesticus* (*A. domesticus*) with high nutritional value such as crude protein, bioactive peptides, B-group vitamins and low crude fat [2] together with field cricket (*Gryllus bimaculatus)* with a high protein content ranging between 55% to 75%, higher amino-acids digestibility (92.9%) compared even with fish meal with a digestibility value of 91.3%) [3]. For instance, in the case of field cricket (*Gryllus bimaculatus*) from the essential amino acid group, lysine was identified in a value content of 4.58 g/100g, tyrosine registered a value of 2.62 g/100g, leucine 2.61 g/100g, and from the nonessential amino-acids, the biggest values were displayed by glutamic acid (2.50 g/100g), aspartic acid (1.51 g/100g) and arginine (1.09 g/100g) [3].

With respect to *A. domesticus* protein content, [1] reported a value of 67.48% protein, whilst, [4] reported a value of 72.60% protein [1]. showed that polysaturated fatty acid content of *A. domesticus* could range between 44.98% to 30.18%, meantime, monosaturated fatty acid ranged between a maximum value of 38.90% and a minimum value of 20.47%. The bioactive compounds identified in different insect species could be able to display different properties such as antioxidant activity, antidiabetic, antithrombotic or even immunomodulatory effect, as reported by [5].

The insect consumption was surrounded by several negative factors such as unpleasant consumers perception, safety and hygiene regulations and also religion concerns [2]. To overcome the perception of processed insect foods and to improve their bioactive compounds, fermentation is considered a promising tool. Also, through fermentation taste and textural characteristics of insect products could highly improve [5]. Recently, [4] showed that *Lactobacillus plantarum* ATCC 8014 strain is able to grow and to develop on *A. domesticus* flour through controlled fermentation, increasing its bioactive compounds such as amino-acids, minerals,

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fatty acids but also aroma volatile compounds. Moreover, during fermentation, some antimicrobial compounds such as organic acids (lactic, acetic) could be released due to the action of different lactic acid bacteria [5].

From the sustainability point of view, insects are considered a sustainable protein source mainly because of their less water and soil used for grow compared with domestic animals, less greenhouse gas emissions, being more efficient for the feed conversion point of view [1]. The increasing number of global populations over 9.6 billion in 20150 with an increased food demand by 56% arise the need to identify other protein sources

Cricket *(A. domesticus)* based products registered an increased rapid demand because of their important potential for food and feed [6]. reported that in cricket flour could have a protein content of 70g/100g, fat (mainly polysaturated fatty acids), minerals such as selenium, iron, zinc, fiber but also vitamins. Therefore, the goal of the present research was to optimize the maximum addition of cricket *(A. domesticus)* flour into the muffins manufacturing. Moisture, protein, ash, lipid, color, total phenols and antioxidant activity followed by sensorial analysis of the final baked goods was analysed.

## 2. Materials and method

### *2.1. Materials*

Insect flour was purchased from Cluj-Napoca supermarket store and manufactured in Thailand (JR Unique company Foods Ltd., Udon Thani, Thailand). Wheat flour, eggs, sugar, butter, milk, vegetable oil (sunflower) baking powder were achieved from specialized local store from the same city.

### *2.2. Muffins manufacturing*

As presented in Figure 1., wheat and insect flour were mixed with baking powder. Afterward, eggs were sterilized, and white egg was whipped and mixed with a part of the sugar, whilst egg yolk was mixed with sunflower oil. Butter was mechanically mixed with sugar and all the ingredients were mixed till a homogenized dough muffins was obtained (Figure 1).

The muffins recipe is displayed in Table 1. Wheat flour was replaced with 5, 10 and 15% insect flour and the rest of the ingredients remained in the same amount.

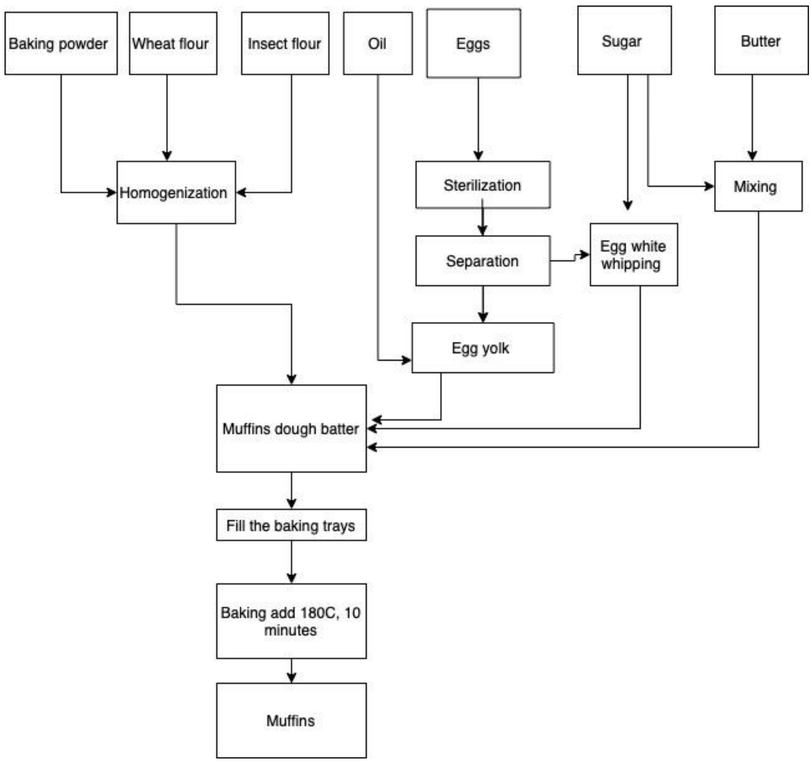


***Figure 1***. Muffins flow diagram production

***Table 1.*** Muffins recipe with different insect flour addition

| **Raw materials, g** | **Almond flour and lucerne powder addition** | | |
|---|---|---|---|
| Wheat flour | 95 | 90 | 85 |
| Insect flour | 5 | 10 | 15 |
| Sugar | 50 | | |
| Butter | 60 | | |
| Eggs | 100 | | |
| Sunflower oil | 5 | | |
| Baking powder | 4 | | |

***Table 2.*** Chemical and physical characteristics of muffins

| **Samples** | **Moisture (%)** | **Ash (%)** | **Protein (%)** | **Fat (%)** | **Height (cm)** | **Specific Volume ($cm^3/g$)** |
|---|---|---|---|---|---|---|
| M5 | $14.40 \pm 0.43^a$ | $2.04 \pm 0.11^a$ | $12.03 \pm 0.17^a$ | $20.66 \pm 0.42^a$ | $3.70 \pm 0.22^a$ | $3.25 \pm 0.07^a$ |
| M10 | $15.41 \pm 0.31^b$ | $2.30 \pm 0.55^{ab}$ | $13.94 \pm 0.22^b$ | $22.51 \pm 0.77^b$ | $3.50 \pm 0.07^{ab}$ | $3.10 \pm 0.12^{ab}$ |
| M15 | $16.02 \pm 0.37^c$ | $2.54 \pm 0.24^b$ | $16.41 \pm 0.09^c$ | $23.82 \pm 0.55^c$ | $3.41 \pm 0.21^b$ | $2.93 \pm 0.21^b$ |

[*] M5= 95 % wheat flour +5 % insect flour; M10 = 90 % wheat flour + 10 % insect flour; M15= 85 % wheat flour + 15% insect flour. *All analyses were made in triplicate and mean value ± standard deviation was recorded.*
** data followed by different small letters in a column are significantly different ($p<0.05$)

*2.2. Physico-chemical characterization of the final baked goods*

Moisture, protein, total ash, and lipid were analyzed through AOAC approved methods, as follows: 925.09, 950.48, 923.03 and 969.24, respectively. With respect to the moisture content, samples were dried in an oven at a temperature of 105°C for 3 h, protein was quantified through Kjeldahl method (%N X 5.33, according to [7], ash was determined upon incineration in a furnace at a temperature of 550°C for 12 h and lipid was measured by Soxhlet extraction using as a solvent diethyl ether. Muffins weight and specific volume were measured according to the method described by [8].

An NH 300 portable colorimeter (Shenzhen Threenh Technology Co., Ltd., Shenzhen, China), was used to determine *L** (lightness*)*, *a** (red/green coordinate*)*, *b** (yellow/blue coordinate) color coordinates, according to the method described by [9]. Folin Ciocalteu method was used to determine total phenols content, as mentioned by [10] and antioxidant activity was measured through DPPH (1,1-Diphenyl-2-picrylhydrazyl) method, as mentioned by (Chiș et al. 2020). Nine hedonic test was used for the sensorial analysis of muffins, ranging from 1 (extremely dislike) to 9 (extremely like, based on the next attributes: taste, color, odor, texture, overall acceptability, as described by our research group, [12]. A total number of 40 panelist were subjected to the sensorial analysis.

*2.6. Statistical analysis*

Duncan multiple comparation test was used to statistically analyze the obtained results, according to [13]. Results were expressed as mean value followed by standard deviation. All samples were analyzed in triplicates.

## 3. Results and Discussion

*3.1. General composition and physical characteristics of insect muffins*

Moisture increased as the insect flour addition increased and this could be explained by the high content of insect flour in protein and fiber, which are able to better capture water during the baking process, as mentioned by [14]. The high protein content of *Acheta domesticus* flour was highlighted by [15] with a value of 72.55 %, whilst, [4] reported a similar value protein content of 72.60%. Regarding the fiber content, [16] reported a value of 7.64% meantime, [3] mentioned a value of 7.37 g/100g. Leucine was identified in a value of 72.09 mg/g protein, isoleucine reached a value of 40.91 mg/g protein, 59.48 mg/g protein and 55.84 mg/g protein were displayed for valine and lysine, respectively [17].

Ash content increased as insect flour percentages increased, probably because its high ash content, as mentioned by 4.77 g/100g [15].

In the light of this affirmation, from the mineral group significant values of potassium (352 mg/100g dry weight), sodium (135 mg/100g dry weight), phosphor (225 mg/100g dry weight) and calcium (27.5 mg/100g dry weight) were displayed by [18].

The differences in minerals content could varied mainly because of climatic and geographic conditions, seasonal influence, but also on the type of species and the insect food intake [19], [20]. Fat content of the insect flour is relatively high as mentioned by a large body of literature. For example, [18] displayed a fat content of *Acheta domesticus* between 22.1 and 14.4% for adult and nymph, whilst, [19] mentioned a value for insect flour of 20%. Increasing addition of insect flour influenced in a positive way the fat muffin content, insect flour being mainly rich in polysaturated fatty acids such as linoleic, ω -3 and α-linolenic, [15].

With respect to the physical characteristics of the obtained muffins, height value and specific volume are presented in Table 2. Both parameters are essential in evaluating the quality of bakery products, in general [8]. Height registered a small decrease together with specific volume, and this could be justified by insect flour lack of gluten resulting in a weakening crumb network structure, as explained by [8]. Our results is in line with those of [17] who showed that insect flour increased the nutritional value of the final baked products, but could have a negative influence on the volume and texture parameters.

Color represent one of the main key features of bakery products with a great impact on the acceptance of the final product. There are several factors involved in the final color of the products such as technological baking parameters (time, temperature), chemical and color of the main ingredients [17]. Nonetheless, it is important to mention the reaction between amino groups and carbonyl compounds such as reducing sugars, entitled Maillard reaction.

With respect to color coordinates, addition of insect flour decreases *L** value, probably because insect flour has a darkness color compared with wheat flour, as previously mentioned by [21] but, on the other hand, the higher protein content of insect flour could lead to an intensification of the Maillard reaction, as showed by [17]. The redness and yellowness color parameters registered a small increase value, mainly because of insect flour addition. The results are in line with those reported by [22].

Regardless the total phenols and antioxidant activity content their value increased as insect flour addition increase (Figure 2), and this could likely be mainly because of insect flour composition. In line with this, [15] showed that *Acheta domesticus* flour is an important source in total phenols and antioxidant activity and, in a recent study of [21], authors showed that increasing insect flour addition on the muffins manufacturing influence the increasing values of total phenols and antioxidant activity.

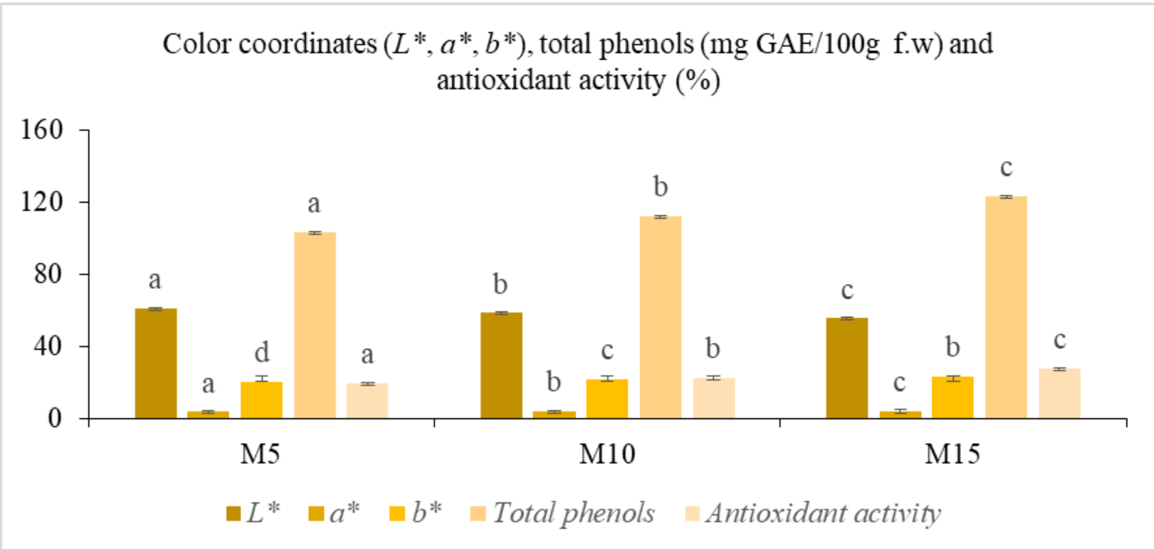


***Figure 2***. Color parameters of final baked products (*l** (lightness), *a** (red/green coordinate), *b** (yellow/blue coordinate)), total phenols and antioxidant activity; f.w. – fresh weight

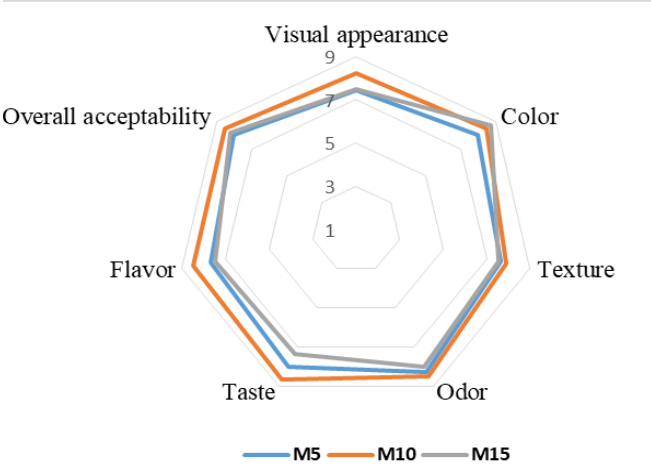


***Figure 3.*** Muffins sensorial analysis

## 4.Conclusions

This study sought to bridge the gap of insect flour consuming by highlighting it big impact on the nutritional profile of the final products. Therefore, protein, ash, fat, total phenols, and antioxidant activity were analyzed. Moreover, heigh and specific volume together with sensorial analysis were displayed, emphasizing that a 10% addition of *Acheta domesticus* flour could be successfully accepted by consumers. This result will definitely pave the way for new research aiming to develop new insect flour products.

**Compliance with Ethics Requirements.** Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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