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Enhancing Cake Nutrition with *Lepidiota mansueta* Flour

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Authors' contributions

This work was carried out in collaboration among all authors. The research was designed and planned by author SB. Author RB carried out research. Authors KS and NSM helped during analysis. Further, authors RB, KS and NSM examined the data. The document was written by author RB. The article was reviewed by all writers. All authors read and approved the final manuscript.

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ABSTRACT

The incorporation of white grub (*Lepidiota mansueta*) flour into cakes was explored to assess its impact on both nutritional composition and sensory attributes. Cakes were prepared with varying ratios of white grub flour to whole wheat flour, ranging from 10% to 30% substitution. Results indicated a progressive increase in moisture, crude protein, crude fat, crude fiber, ash and energy content with higher concentrations of white grub flour, while carbohydrate content exhibited a decreasing trend. Mineral analysis revealed increased levels of sodium, potassium, manganese, zinc, and copper with the increase in white grub flour incorporation. Sensory evaluation demonstrated that cakes with pure wheat flour and those with 10% white grub flour substitution garnered the highest overall acceptability scores, whereas acceptability declined when the white

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grub flour concentration was increased. These findings revealed the potentiality of white grub flour as a nutritious ingredient which could be explored in different baked products maintaining the organoleptic quality.

Keywords: Anthro-entomophagy; malnutrition; Lepidiota mansueta; cakes; food.

1. INTRODUCTION

As the global population is rising, the challenges of ensuring food security has become one of the paramount concerns of humanity. Limited freshwater resources and cultivable land posses a significant barrier to meet the nutritional needs of an expanding global population [1] and approximately about 2 billion people worldwide are of late facing some degree of food insecurity. The food industry and advanced agricultural practices are also on the other hand significantly degrading the environment. Studies indicate that the food industry is accountable for 26-50% of greenhouse gas emissions, while agriculture is responsible for about 80% of the anthropological water footprint [2,3]. Apart from these, protein production, particularly from livestock breeding causes major environmental impact by emitting substantial greenhouse gases. In order to tackle malnutrition and environmental concerns simultaneously, an innovative solution lies in the practice of *anthro-entomophagy* i.e., the consumption of terrestrial and aquatic insects by humans. Compared to livestock, insects are more ecological friendly as they require less water and feed for which they may be regarded as mini-livestock. The entomophagy has ancient roots and is prevalent across various species, notably among our primate predecessors [4]. Based on the insectivory characteristics seen in the chimpanzees, it has been suggested that edible insects may have played a key role in human evolution [5]. The nutritional composition of insects aligns with human dietary needs, containing high-quality protein, diverse carbohydrates, and micronutrients such as vitamin B, E, iron, magnesium and zinc which might be effectively used for malnutrition management [6]. Furthermore, insects demonstrate impressive food conversion efficiency in comparison with mammalian livestock [3]. Their efficiency of conversion of ingested food (ECI) surpasses that of traditional meats, making them an attractive prospect for sustainable food production [7].

An indigenous species of white grub, *L. mansueta*, belonging to the Scarabaeidae family in the order Coleoptera, has been found to be a major pest in diverse agricultural crops such as potato, sugarcane, colocasia, green gram, etc. at Majuli, Assam [8]. Interestingly, despite being a pest, the adults of *L. mansueta* are highly valued delicacies among the local tribal people of Majuli, especially the *Mising* tribe. The beetles were traditionally prepared by removing their hard elytra, membranous wings and legs before frying or roasting. Recognizing the growing interest among the local tribal communities, a study on the nutritional profile of *L. mansueta* beetle powder revealed a considerable amount of crude protein, along with other proximate parameters such as crude fat, crude fiber, total minerals, carbohydrates, and energy [9]. However, the culinary acceptance of *L. mansueta* faces challenges, particularly in terms of storage and consumer reluctance to consume whole cooked beetles [10]. In response to these challenges, the current study aims to explore innovative culinary avenues by developing a recipe for cake based on *L. mansueta* powder. The objective of the study aimed to create value-added food products that could find a place on the global stage by transforming *L. mansueta* into a convenient and palatable form.

2. MATERIALS AND METHODS

The research was conducted during 2020-2021 at All India Network Project on Soil Arthropod Pests Laboratory, Department of Entomology and Laboratory of the Department of Biochemistry and Agricultural Chemistry at Assam Agricultural University, Jorhat, Assam.

2.1 Preparation of *Lepidiota mansueta* Flour

Adult *L. mansueta* beetles from Majuli, Assam, were captured during the month of April using water traps. For euthanization process, beetles were immersed in lukewarm water for 15 minutes. Afterward, wings and legs were removed, and the edible parts were dried and processed into uniform beetle flour with a mechanical grinder. To ensure consistency, the flour was sieved through fine strainers. The powdered beetles were stored in airtight containers in refrigerated condition for further studies.

2.2 Preparation of Cakes

Cakes were prepared by using the methodology as described by Lin et al. [11] with minute modification; where *L. mansueta* powder and wheat flour (WF) were mixed in various proportions viz., 0:100, 10:90, 20:80, and 30:70. The basic elements i.e., wheat flour, milk, butter, sugar, and baking powder were thoroughly mixed, further water was added until the desired consistency required for the batter was achieved, and then batter was baked at 180°C for 30 minutes. After baking, the cakes were sealed in airtight containers and refrigerated for subsequent biochemical evaluation.

2.3 Determination of Proximate and Elemental Composition

The proximate composition of the cakes such as moisture, crude protein, crude ash, crude fat, and crude fiber contents were assessed by following the methodologies recommended by AOAC [12]. While, carbohydrate and energy contents were determined through methodologies followed by Hedge and Hofreiter; FAO methods respectively [13,14]. Additionally, elemental composition, including Mn, Zn, Cu, Na, and K, was assessed using a flame atomic absorption spectrophotometer as methodologies outlined by John and Van; AOAC [15,16].

2.4 Sensory Evaluation

A panel of 10 nonprofessional trained individuals (5 Male and 5 Females; aged more than 25) evaluated the appearance, colour, flavour, taste and overall acceptability of the cakes on a 9-point hedonic scale [17]. The parameter includes: dislike very much (0-2), dislike moderately (2.1-3), dislike slightly (3.1-4), neither like nor dislike (4.1-5), like slightly (5.1-6), like moderately (6.1-7), like very much (7.1-9).

2.5 Statistical Analysis

Biochemical parameters and organoleptic quality were analyzed using ANOVA for Completely Randomized Design (CRD). Significance of variance was assessed at a 5% probability level with 'F' value, following Panse and Sukhatme's method [18].

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of the Cakes

The findings presented in Table 1 provide a comprehensive insight into the proximate composition analysis of *L. mansueta* fortified cakes. The progressive increase in the proportion of *L. mansueta* flour, ranging from 10% to 30%, exhibited a consistent rise in moisture content, reaching values between 23.07% and 25.52%. These levels were notably higher than those found in cakes made solely with wheat flour, which recorded a moisture content of 19.92%. The elevation in moisture content attributed to the hydrophilic nature of *L. mansueta* beetle flour. Elevation of moisture, however, had no influence on shelf stability because it stayed within acceptable ranges as evidenced by Erkmen and Bozoglu's findings [19]. Concurrently, an incremental trend was observed in the percentage of crude protein (13.30% to 26.43%), crude fat (20.10% to 23.06%), crude fibre (0.66% to 0.84%), and ash content (1.31% to 1.96%) with increasing *L. mansueta* flour concentration from 10% to 30% showing noticeably better nutritious contents than cakes made only with wheat flour. Significant levels of crude protein (76.42%), crude fat (4.10%), crude fibre (5.16%), and total minerals (2.90%) were found in *L. mansueta* beetle flour in previous research conducted by Bhattacharyya et al. [9]. The addition of *L. mansueta* flour with wheat flour during the manufacturing of value-added products led to higher levels of crude protein, crude fat, crude fibre, and ash content than those seen in cakes that did not include *L. mansueta* flour. These results are in consistent with the findings of Ayensu et al. [20]; Adeboye et al. [21]. Furthermore, a notable transformation in the carbohydrate content was observed, declining gradually from 61.62% to 44.43% as the percentage of *L. mansueta* flour increased from 10% to 30%. This reduction can be linked to the inherently lower carbohydrate content (9.18%) reported in *L. mansueta* flour by Bhattacharyya et al. [9]. The incorporation of *L. mansueta* flour in cakes not only led to a decrease in sugar intake but also offered the added benefit of higher fiber content. These finding aligns with the findings of Ayensu et al. [20]. Additionally, the energy content analysis revealed a gradual increase in the energy content as the proportion of *L. mansueta* powder increased from 10% to 30%, ranging from 481.94 to 492.67 Kcal. In contrast, cakes made exclusively from 100% wheat flour displayed the lowest energy content at 478.35kcal/100g. This rise in energy content is attributed to the significant fat content present in *L. mansueta* flour. This finding is in consistent with the observations of Zielinska and Pankiewicz [22]; Ogunlakin et al. [23].

Table 1. Proximate composition of cake prepared from *L. mansueta* beetle flour

Treatment	Moisture (%)	Crude Protein	Crude Fat	Crude Fibre	Carbohydrate	Ash	Energy (kcal/100g)
T_1 (10:90)	23.07 ± 0.13	13.30 ± 0.65	20.10 ± 0.60	0.66 ± 0.05	61.62 ± 1.27	1.31 ± 0.20	481.94 ± 8.76
T_2 (20:80)	24.40 ± 0.54	19.34 ± 0.54	21.31 ± 0.33	0.75 ± 0.04	53.13 ± 2.72	1.65 ± 0.09	483.23 ± 9.75
T_3 (30:70)	25.52 ± 0.45	26.43 ± 1.22	23.06 ± 0.48	0.84 ± 0.04	44.43 ± 2.56	1.96 ± 0.278	492.67 ± 15.81
T_4 (0:100)	19.92 ± 0.64	7.00 ± 0.45	17.46 ± 0.55	0.54 ± 0.04	73.02 ± 1.27	0.80 ± 0.10	478.35 ± 9.06
S. Ed (±)	**0.39**	**0.55**	**0.35**	**0.029**	**1.47**	**0.13**	**7.93**
CD (p=0.05)	**0.83**	**1.17**	**0.75**	**0.061**	**3.13**	**0.28**	**16.91**

Table 2. Elemental composition of cake prepared from *L. mansueta* beetle flour

Treatment	Sodium (Na) mg/100g	Potassium (K)	Manganese (Mn)	Zinc (Zn)	Copper (Cu)
T_1 (10:90)	43.183 ± 0.764	41.721 ± 0.249	0.882 ± 0.022	0.701 ± 0.069	0.094 ± 0.029
T_2 (20:80)	45.976 ± 0.108	43.118 ± 0.273	2.293 ± 0.091	1.164 ± 0.073	0.145 ± 0.014
T_3 (30:70)	46.375 ± 0.655	46.676 ± 0.255	3.361 ± 0.029	3.041 ± 0.065	0.394 ± 0.024
T_4 (0:100)	38.795 ± 0.868	40.439 ± 0.509	0.364 ± 0.009	0.263 ± 0.017	0.056 ± 0.009
S. Ed (±)	**0.472**	**0.240**	**0.031**	**0.041**	**0.013**
CD (p=0.05)	**1.004**	**0.511**	**0.063**	**0.083**	**0.034**

Table 3. Organoleptic quality evaluation of the cake prepared from *L. mansueta* beetle flour

Treatment	Appearance	Colour	Flavour	Taste	Overall acceptability
T_1 (10:90)	7.40 ± 0.50	7.30 ± 0.87	7.30 ± 1.12	7.20 ± 0.67	7.50 ± 0.53
T_2 (20:80)	6.80 ± 0.88	6.70 ± 1.00	6.60 ± 1.13	6.80 ± 0.44	6.90 ± 0.86
T_3 (30:70)	6.60 ± 0.50	6.60 ± 0.44	6.50 ± 1.01	6.70 ± 0.71	6.80 ± 0.70
T_4 (0:100)	7.77 ± 0.88	7.50 ± 0.53	7.70 ± 1.13	7.50 ± 0.53	7.80 ± 0.44
S. Ed (±)	**0.39**	**0.36**	**0.52**	**0.26**	**0.29**
CD (p=0.05)	**0.79**	**0.72**	**1.05**	**0.52**	**0.62**

3.2 Elemental Composition of Cakes Prepared from *L. mansueta* Beetle Flour

Table 2 presents a comprehensive overview of the elemental composition of *L. mansueta* enriched cakes, showcasing a remarkable rise in elemental content (mg/100g). The incremental incorporation of *L. mansueta* flour, ranging from 10% to 30% in the cakes, led to a consistent increase in Na (43.183-46.375), K (41.721-46.676), Mn (0.882-3.361), Zn (0.701-3.041), and Cu (0.094-0.394). This substantial augmentation underscores the efficacy of integrating *L. mansueta* flour as a valuable source of essential minerals in value-added cakes compared to 100 percent wheat flour cakes. The observed variations in elemental composition offer crucial insights into the potential nutritional benefits associated with *L. mansueta* flour inclusion. Notably, these findings align with Akullo et al. [17], who reported that increased Fe and Zn in crackers substituting wheat flour with cricket and termite flour, and Ayensu et al. [20], who noted increased Ca, Fe, and Zn in biscuits blending palm weevil larvae flour with wheat flour [17,20].

3.3 Organoleptic Quality Evaluation of Cakes Prepared from *L. mansueta* Beetle Flour

The organoleptic evaluation of cakes made with flour from the *L. mansueta* beetle is detailed in Table 3, revealing the impact of substitution of insect powder on sensory attributes. Cakes prepared solely with wheat flour secured the highest ratings across appearance (7.77), colour (7.50), flavour (7.70), taste (7.50), and overall acceptability (7.80). Notably, a 10% substitution of *L. mansueta* flour fortified cakes exhibited statistically parity ($P \leq 0.05$) for appearance (7.40), colour (7.30), flavour (7.30), taste (7.20), and overall acceptability (7.50). However, cakes with 20% and 30% substitution of *L. mansueta* flour showed statistical inferiority across the parameters with the control group, indicating a decline in organoleptic satisfaction at higher substitution levels. These results align with earlier studies by Simeon et al. [24]; Ogunlakin et al. [23].

4. CONCLUSION

In an effort to prepare cakes enriched with *L. mansueta* flour and assessment of its nutritional quality, we have observed a higher content of proximate components as well as elemental components compared to the cakes prepared solely with wheat flour. However, the sensory analysis results revealed a decrease in the overall acceptance of the cakes with the increase in the proportion of *L. mansueta* flour. Based on these findings, we can conclude that *L. mansueta* flour can be effectively utilized as a supplement for wheat flour, with an optimal ratio of 10:90, in the development of protein-rich value-added food products.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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