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Research Application Summary

Nutritional and sensory quality of complementary foods developed from Ethiopian staple grains and insect bee larvae (*Apis mellifera*)

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Abstract

Complementary feeding could be a method of providing different foods when breast milk alone is not any longer enough to satisfy the nutritional demand of the infant, and so food and liquids other than breast milk are needed. The objective of this study was to assess the nutritional and sensory quality of complementary foods formulated from a mixture of staple grains with *Apis mellifera*. Individual ingredients of protein (g/100g) ranged from 9.79-50.5 g/100g, highest in soybean and low in teff. Also, the fat contents of ingredients were recorded as 2.65-24.98 g/100g, highest in bee larvae. The formulated foods were CF001 (Maize, Teff, Soybean; 57:29:14, respectively) and CF002 (Maize, Teff, Bee larvae; 58:29:13, respectively) using Nutrisurvey software (version, 2007). Standard methods were used to analyze the nutritional, microbiological, and sensory components of the flour mixture developed. The developed and control foods had significantly different proximate compositions. Insect bee larvae base CF002 recorded the highest fat, energy, Vitamin A, Niacin, and folate contents which were 14.3 g/100g, 427.18 Kcal/100g, 706 µg/100g, 8.2 mg/100g, and 86.7 mg/100g. Minerals (mg/100g) Fe (40.94) and Ca (68.20) were highest in CF002. The sensory evaluation showed that all the foods were above the minimum threshold. Hence, *A. mellifera* can be used as a complementary food ingredient in conventional cereal foods.

Key words: *Apis mellifera*, complementary foods, infants, nutrients

Résumé

L'alimentation complémentaire pourrait être une méthode de fourniture d'aliments différents lorsque le lait maternel seul ne suffit plus à satisfaire les besoins nutritionnels du nourrisson, et que des aliments et des liquides autres que le lait maternel sont alors nécessaires. L'objectif de cette étude était d'évaluer la qualité nutritionnelle et sensorielle d'aliments complémentaires formulés à partir d'un mélange de céréales de base avec Apis mellifera. Les ingrédients individuels de protéines (g/100g) variaient de 9,79 à 50,5 g/100g, le plus élevé dans le soja et le plus faible en teff. En outre, la teneur en matières grasses des ingrédients a été enregistrée entre 2,65 et 24,98 g/100 g, la plus élevée chez les larves d'abeilles. Les aliments formulés étaient CF001 (Maïs, Teff, Soja ; 57:29:14, respectivement) et CF002 (Maïs, Teff, Larves d'abeille ; 58:29:13, respectivement) en utilisant le logiciel Nutrisurvey (version, 2007). Des méthodes standard ont été utilisées pour analyser les composants nutritionnels, microbiologiques et sensoriels du mélange de farine développé. Les aliments développés et témoins avaient des compositions approximatives significativement différentes. La base de larves d'abeilles d'insectes CF002 a enregistré les teneurs les plus élevées en matières grasses, en énergie, en vitamine A, en niacine et en folate, soit 14,3 g/100 g, 427,18 Kcal/100 g, 706 µg/100 g, 8,2 mg/100 g et 86,7 mg/100 g. Les minéraux (mg/100g) Fe (40,94) et Ca (68,20) étaient les plus élevés dans CF002. L'évaluation sensorielle a montré que tous les aliments étaient au-dessus du seuil minimum. Par conséquent, A. mellifera peut être utilisé comme ingrédient alimentaire complémentaire dans les aliments céréaliers conventionnels.

Mots clés : Apis mellifera, aliments complémentaires, nourrissons, nutriments

Introduction

Nutrition is a principal focus of the 2030 Agenda (WHO, 2020). The current world's total population exceeds 7.71 billion people and by 2030, will exceed 8.6 billion (UN, 2017). Malnutrition is a worldwide problem of infants and children which affects the world population. Ethiopia's malnutrition rate ranks second in Sub-Saharan Africa (SSA), a form of chronic malnutrition, with a stunting rate of 38% (USAID, 2018). Although the causes of malnutrition and inadequate intake of foods and essential nutrients are many and the major contributory factor to under-five malnutrition has been reported (Chaturvedi *et al.,* 2017). Therefore, complementary foods (CFs) of adequate nutrient densities are needed for infant growth and development.

In developing countries, commercial infant food is very expensive and may not be available to low-income families. Although cereals' nutritional protein content is generally low, the addition of protein-rich legumes to cereals increases their protein content can help (Abdulkadir and Danjuma, 2015). However, these plant diets are inadequate in terms of protein quality hence the need to include animal proteins (Henchion *et al.,* 2017). Also, owing to the high cost of animal proteins, food insecurity, increment of population, and increasing demand for protein-rich food (Tiencheu and Womeni, 2017), other options should be found. Edible insects are a good source of protein with the potential for use in CFs (Kinyuru *et al.,* 2015; Adámková *et al.,* 2017). Insect protein processing is similar to legume protein processing (Gravel and Doyen, 2020). However, the utilization of edible insects in CF production is not studied. Honey bee larvae (*Apis mellifera*) are a very promising food resource among insects since honey bees are kept all over the world and consumed as a delicacy in many cultures. (Jensen *et al.,* 2019). Although the protein content of cereals is generally low, adding protein-rich legumes to cereals will increase the protein content of the cereal and pulse mixture (Konyole *et al.,* 2012). This study, therefore, was designed to evaluate the nutritional composition, and sensory acceptability of CFs developed from blends of insect bee larva (*Apis mellifera*) and Ethiopian staple grains.

Materials and Methods

Sample collection and preparation. Insect *A. mellifera* was collected from modern beehives. Soybean (*Glycine* max), Red teff (Eragrostis tef (Zucc.), and maize (*Zea mays*) were purchased from the local market and Gondar Agricultural Research Center, Ethiopia. *Apis mellifera* were oven-dried at 60 C for 24h and ground to powder. Teff grains were cleaned with foreign materials, washed with tap water, and dried using sunlight, and grounded to a fine flour (Tenagashaw *et al.,* 2017). Maize grains and soybeans were processed according to Tona *et al.* (2015); Tenagashaw *et al.,* 2017; Forsido *et al.,* 2019. Finally, all the samples of food flours were packaged and labeled into polyethylene bags and stored until extrusion was carried out at room temperature.

Complementary foods formulation and extrusion cooking. Two different ratios of CFs for infants and young children were formulated using Nutrisurvey software (version, 2007) and according to the guidelines of WFP (2018). The first CF CF001 included 57% maize, 29% teff, and 14% Soya bean flours, and CF002 consisted of 58% maize, 29% teff, and 13% Bee larva flours. Then extrusion cooking was at 17 % moisture content, 150 °C barrel temperature, and with a feed rate of 1.74 kg/hr screw speed. After drying the products at ambient temperatures, grounded and packaged in HDPE. The products were stored at dry room temperature until laboratory analyses were carried out. Commercial wean food used as a control food was bought from the supermarket and used as a control.

Nutritional analysis of raw flours and developed CFs. The nutritional composition of each raw flours, the extruded CFs, and commercial food was analyzed according to the AOAC (2005). Moisture, ash, crude protein, crude fat, and crude fiber content were determined by method #925.09, method # 923.03, method #979.09, method #930.09, and method #962.09, respectively. Carbohydrate content was calculated according to Atwater's calorie conversion factors (FAO, 2003). The mineral Fe, Zn, and Ca of CFs were determined using AOAC method 985.35 (AOAC, 2005) of a flame AAS (Shimadzu AA-6200; Shimadzu, Tokyo, Japan). The ß- carotene content was determined according to Biswas *et al.,* (2011). Vitamin B-complex was determined using HPLC (Shimadzu, RID-6A) (Oladejo and Kayode, 2016).

Sensory evaluation. Gruel was made according to the instructions of WFP, (2018) for sensory evaluation of each developed food. A total of 30 semi-trained healthy and positive attitudes mothers were selected. For the evaluation, a five-point hedonic scale was used (Meilgaard *et al.,* 2006; Forsido *et al.,* 2019).

Statistical Analysis. Data were analysed using one-way ANOVA and LSD tests were used to determine the differences among means between the CFs using SPSS for Windows Version, 23. The level of significant difference at $P<0.05$ was considered.

Results and Discussion

Nutritional composition of individual flours. The proximate composition of each food ingredient is presented in Figure 1. The moisture (g/100g) contents of individual food ingredients ranged from 6.04 -13.36 with the highest moisture content recorded for maize. High protein (g/100g) was recorded on soybean (50.50) and low in maize, and teff 10.10, 9.79, respectively. The soybean protein content reported by Tenagashaw *et al.* (2017) was 35.59 g/100g and 27 g/100g (Menure, 2017), which were lower than in the present finding. In addition, the soybean fat content was higher than the value reported by Tenagashaw *et al.* (2017) and slightly similar to values reported by Menure (2017). *Apis mellifera*, protein, and fat content values in the present study were different from those reported by Ghosh *et al.* (2016) who reported lower 35.3 g/100g protein and 14.5 g/100g fat. High COH contents of teff (69.55 g/100g), followed by maize (72.44 g/100g), soybean (14.34 g/100g), and bee larvae (14.24 g/100g) were recorded.

Proximate composition of Cfs and control food. Table 1 shows the proximate composition of extruded CFs and controls food and energy content. Moisture, ash, protein, fat, fiber, carbohydrate, and energy (kcal) content of the developed CFs and control food met the requirements of Codex (Codex, 2017). The ash contents were statistically significantly different (P<0.05) between the foods and CF001 (2.09 g/100g). The highest moisture (5.72 g/100g) content was recorded on CF002. The protein content of CF001 (12.56 g/100g) and CF002 (11.75 g/100g) were higher than for the control food (10.78 g/100g). The fiber (4.52 g/100g) content on CF001 was higher than in the control food (2.82 g/100g). The highest fat (14.3 g/100g), and energy (427.18 g/100g) contents were observed in CF002, while the least 2.82 g/100g fat, and 385.25 g/100g energy were observed in control food.

In developing countries, micronutrient deficiencies are a common public health problem, especially in the first two years of infant life (Eichler *et al.*, 2012). Minerals, i.e., Fe and Ca contents were significantly different (P 0.001) between the develsoped foods and control food (Table 2). There were high contents of Ca (68.20 mg/100g) and Fe (40.94 mg/100g) in CF002 compared to in the control food. This findings are consisten with that of Dewey and Brown, (2003) that the iron and calcium levels in the two developed CFs are on average higher than recommended levels. This may be due to the inclusion of the larvae of insect bees in the CF, which are rich in minerals (Ghosh *et al.*, 2016). However, the mineral content of Zn did not satisfy the recommended value in all foods.

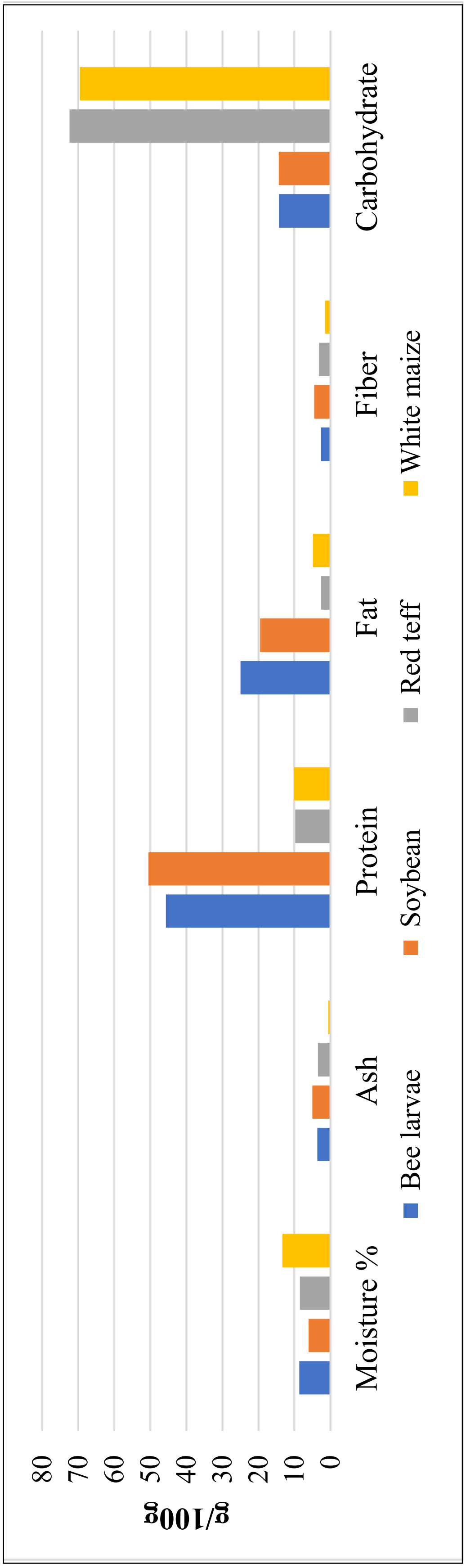


Figure 1. Proximate composition of individual food ingredients

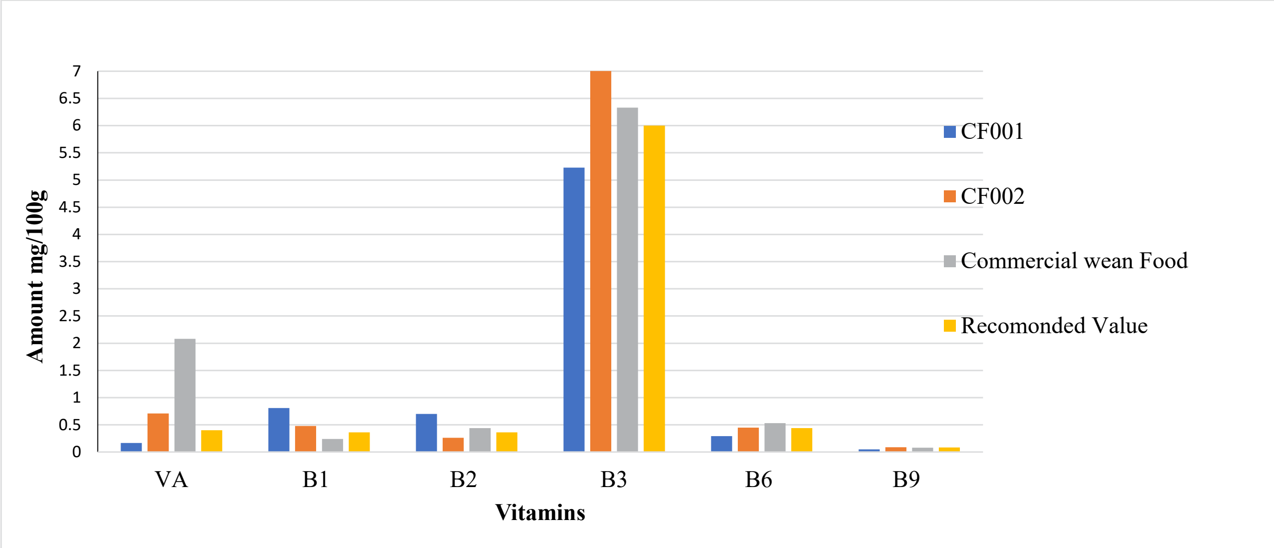
Table 1. Proximate (g/100g) and mineral (mg/100g) composition of control food and extruded CFs

Parameters	CF_{001}	CF_{002}	Control food	RV^{+}	P-Value
Moisture	4.41 ± 0.19^{b}	5.72 ± 0.17^{a}	2.46 ± 0.39^{c}	10	***
Ash	2.09 ± 0.09^{a}	1.88 ± 0.04^{b}	2.01 ± 0.08^{ab}	<4	*
Crude Protein	12.56 ± 0.17^{a}	11.75 ± 0.15^{b}	10.78 ± 0.29^{c}	15+	**
Crude Fat	12.4 ± 0.1^{b}	14.3 ± 0.1^{a}	2.82 ± 0.36^{c}	10-25+	***
Crude Fiber	4.52 ± 0.04^{a}	3.47 ± 0.08^{b}	2.75 ± 0.17^{c}	<5+	***
Carbohydrate	64.02 ± 0.41^{b}	62.87 ± 0.23^{c}	79.19 ± 0.55^{a}	60-75	***
Energy	417.93 ± 3.23^{b}	427.18 ± 2.42^{a}	385.25 ± 1.77^{c}	400-425+	***
Fe	40.17 ± 0.38^{b}	40.94 ± 0.29^{a}	5.79 ± 0.16^{c}	9.3*	***
Zn	2.84 ± 0.18^{a}	2.92 ± 0.16^{a}	2.32 ± 0.11^{b}	4.1*	**
Ca	31.78 ± 0.11^{c}	44.34 ± 0.49^{b}	68.20 ± 0.12^{a}	0.40*	***

Means with different superscripts in the same row are significantly different (P<0.05); RV= Recommended Value; *sources: (Dewey and Brown, 2003; FAO/WHO, 2002); + source (Codex, 2017); (WFP, 2013); The codex standard; *=P<0.05; **=P<0.01; ***=P<0.001;

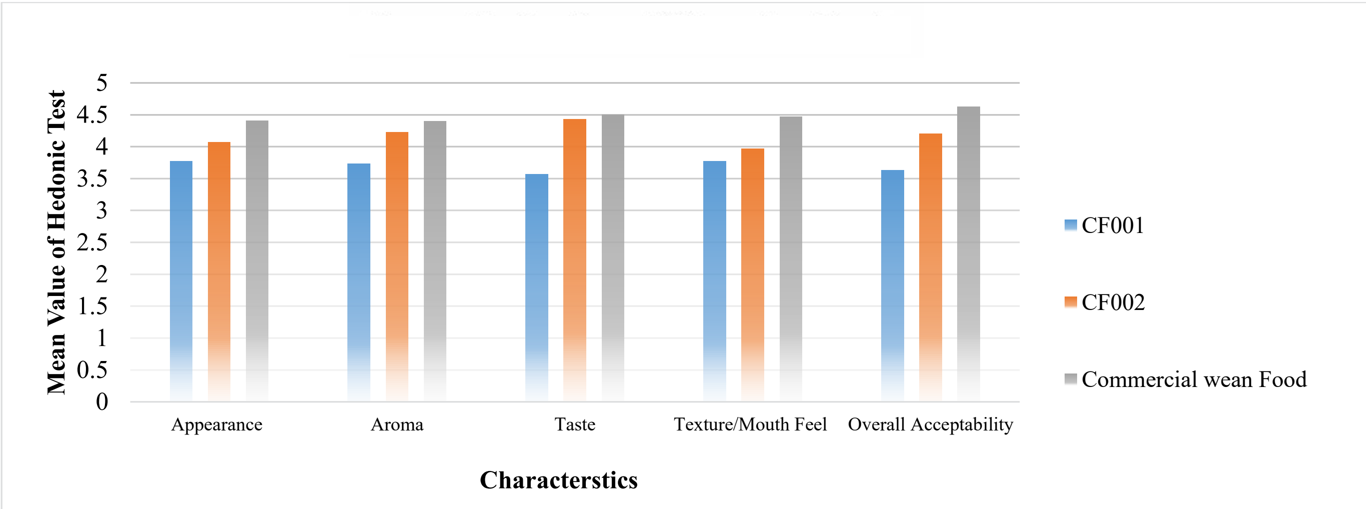
Vitamins composition of the developed and control food. The vitamin composition of the developed CFs and control food is indicated in Figure 2. Vitamin composition of developed CFs and control food were statistically significantly different (P≤0.001). Vitamin A results showed that CF002 and control food fulfilled the RV (FAO/WHO, 2002). Vitamin A content of control food (2.08 mg/100g) were higher than CF001 (0.16 mg/100g) and CF002 (0.71 mg/100g), respectively. Vitamins B1 (0.81 mg/100g) and B2 (0.70 mg/100g) value of CF001 were the highest values, however, with lower records of B6 (0.29 mg/100g) and B9 (51 µg/100g). Also, B3 (8.20 mg/100g) and B9 (86.7 µg/100g) in CF002 were high but did not meet the recommended value of riboflavin.

Sensory evaluation. Sensory evaluation of the developed CFs compared to control food is shown in Figure 3. Parent compassion is important in assessing whether a particular CF matches their children's preferences (Madrelle *et al.,* 2017). The appearance and aroma of the developed CFs and control food were statistically significantly different (P<0.01). Appearance is an important attribute when choosing and eating food (Muhimbula *et al.,* 2011). Sensory evaluation showed that samples CF001 and CF002 were similar in appearance, while commercial weaning was significantly different. However, CF001 had a lower score of overall acceptance than CF002. There was a highly significant difference (P≤0.001) between the foods of taste, texture, and overall acceptability. The CF002 was more liked by the panelists as compared to CF001 but had lower acceptable than the control food as also reported by Ikpeme-Emmanuel and Okoi (2009).



The results are presented as the means. CF001= Complementary Foods 001; CF002= Complementary Foods 02; comercial wean food (control food)

Figure 2. Vitamins composition of complementary foods and control foods



The results are presented as the means. CF001= Complementary Foods 001 (white maize + Red teff + Soybean); CF002= Complementary Foods 002 (white maize + Red teff +Insect bee larvae); Control food

Figure 3. Sensory evaluation of the developed complementary Foods compared to control food

Conclusions

The study showed that the developed CFs fulfilled the recommended nutritional quality, and sensory acceptability. The nutritional composition of the developed CFs met the Codex Alimentarius Standard of the recommended dietary allowance for infants.

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