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MANUFACTURE OF BISCUIT FROM THE FLOUR OF WHEAT AND LENTIL SEEDS AS A FOOD SUPPLEMENT

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ABSTRACT: *For 4-5 months-old babies in developing countries, breast milk alone no longer suffices to satisfy the needs for energy, proteins and micronutrients such as calcium, iron, and vitamin A. To solve this crucial problem, breast feeding needs to be associated with a food sup plement that is able to compensate for these deficiencies. In this study, the feasibility of manufacturing wheat flour-based biscuits, supplemented with lentil seed flour, for babies and young children was demonstrated. Biochemical characterization of the biscuits manufactured showed that incorporation of lentil seed flour into wheat flour (used as control) significantly (P <0.05) improved the protein (6.88–11.45%), lipid (22.86–25.41%), moisture (5.13–7.17%), and cellulose (2.16–3.84%) contents. Also, their energy value was significantly increased (P <0.05) from 461.2 to 541.5 kcal/ 100 g, and values of pH and acidity varied from 5.24 to 6.01 and from 3.33 to 2.33 meq /100 g, respectively; from biscuits* BL_0 *(100% of wheat flour, control) to* BL_{20} *(80% of wheat flour + 20 % of lentil seed flour).Sensory analysis of biscuits revealed a clear preferential acceptance of trained panelists for biscuits with 20% incorporation of lentil seed flour into wheat flour. In the light of the results obtained, the lentil seed flour-incorporated wheat-based biscuits, especially* BL_{20}, *were found to fulfill the chemical and sensory quality characteristics to be consumed as food supplements by young children.*

KEYWORDS: Breast milk, Food Supplement, Micronutrients

INTRODUCTION

Protein-energy malnutrition is common in developing countries, especially rural areas [1]. This protein malnutrition, which may cause diseases such as kwashiorkor, marasmus, and immune deficiencies, can be explained by several factors, the main one being the lack of quantitative and qualitative protein intake [2]. For young children and babies from 4th to 6th month, these conditions are usually due to the fact that breast milk no longer meets the needs for energy, protein, and micronutrients including calcium, iron, and vitamin A [3]. It is, therefore, necessary to associate, to breast milk, a food supplement that can compensate for deficiencies. In rural areas of developing countries where the income of famers are very limited, complementary foods traditionally used to tentatively circumvent these conditions are gruels composed of cereals, roots and/or tubers depending on the geographic (savannah or forest) regions. These supplements are known to be rich in starch but poor in proteins and essential micronutrients. Thus, the diet does not sufficiently contain the micronutrients required for healthy conditions. As a consequence, many babies and young children suffer from protein malnutrition and/or avitaminosis [4]. The fortification of staples, widely

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consumed and accessible by this class of population, with food materials rich in proteins and micronutrients, is one of the main strategies adopted for the improvement of the nutritional quality of people in rural areas in developing countries [5, 6]. For the young children, fortified biscuits and cookies are largely used as a way of solving the crucial problem of malnutrition. Biscuits are indeed very popular and delighted by children worldwide owing to their sweet taste.

Therefore, in this study, the feasibility of supplementing wheat flour-based biscuit with protein-rich flour from green lentil (*Lens culinaris*) seeds, in order to improve the nutritional value of this food type, was examined. A peculiar feature of green lentil seed is a thin skin that enables one to readily cook it without the need for pre-soaking. Moreover, its cellulose content is considerably lower than that of other legumes, a result of which is a better digestibility. In addition, it is a dietary fiber-rich product which may help to lower serum cholesterol and balance blood glucose, thereby protecting against arterial diseases, diabetes, and cancer [7].

The goal of this work is to formulate protein-rich lentil seed flour-incorporated wheat flour-based biscuits which can be consumed as protein, dietary and micronutrient supplement required for the normal and healthy growth of young children. In this connection, wheat-flour based-biscuits, containing varying proportions (between 0 and 20%) of protein and dietary fiber-rich lentil seed flour were prepared and their quality (physicochemical and sensory) characteristics were appraised by conventional analytical techniques (for eatability and acceptability).

EXPERIMENTAL

Raw materials

Green lentil (*L. culinaris*) seeds, wheat flour type 45 "Elephantine", olive oil, vanilla essence "Gyan's", instant yeast "Saf-yeast" and sucrose "SUCAF" were purchased at a local supermarket (Adjamé, Abidjan, Côte d'Ivoire).

Production of lentil seed flour

The green lentil seeds were sorted on appropriate sorter to remove degraded grains and other impurities. The seeds were extensively washed with tap water until the washing was colorless. The seeds were soaked in 10% (v/v) beach for 10 minutes to eliminate germs, washed with water (to remove bleach remnant) and spread on metal tray and dried in a vacuum-oven at 45 °C for 72 h. The green seeds were roasted to golden brown colour and were finely ground to pass through two sifters of different diameters (sieve 1 # 200 μm; sieve 2 # 100 μm), which gave very fine particle flours (Figure 1). Experiments were performed at least in three independent runs.

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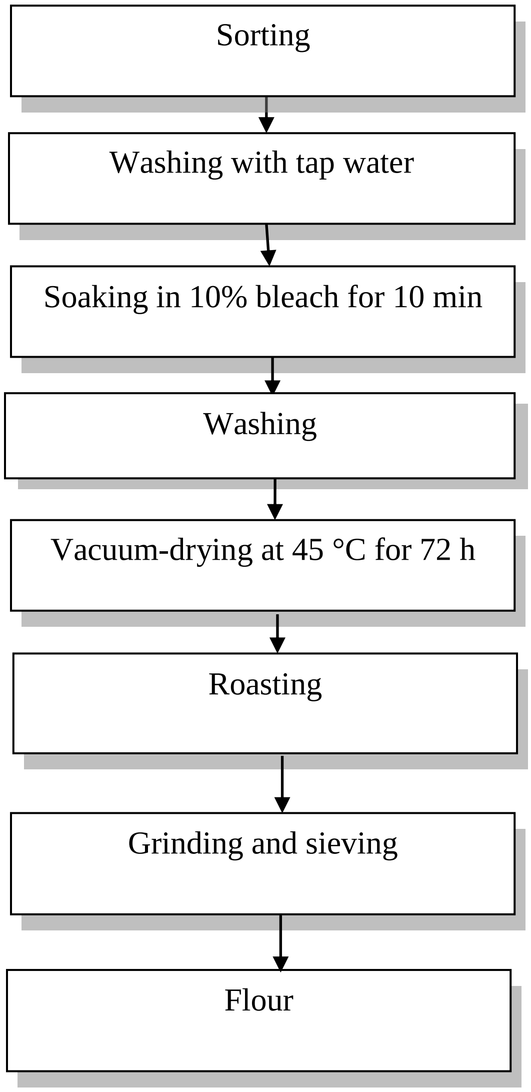

Figure1: Scheme of production of lentil seed flour

Preparations of wheat flour / lentil grain flour

Wheat flour and lentil seed flour (LSF) were mixed at different proportions to obtain various flour preparations as follows:
BL_0 = 100 % of wheat flour (sample control)
BL_5 = 95% of wheat flour + 5% of LSF
BL_{10} = 90 % of wheat flour + 10% of LSF
BL_{15} = 85 % of wheat flour + 15% of LSF
BL_{20} = 80 % of wheat flour + 20% of LSF

Formulation and preparation of biscuits

The different ingredients used in the formulation of biscuits are presented in Table 1.
Table 1. The different types of ingredients used for making biscuits

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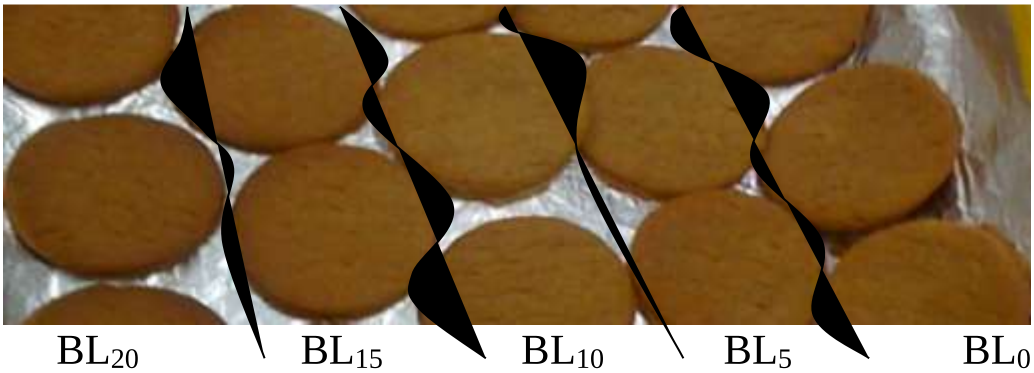
Ingredients	BL$_0$	BL$_5$	BL$_{10}$	BL$_{15}$	BL$_{20}$
Wheat Flour (g)	225	214.8	202.5	191.3	180
Lentil seed flour (g)	0.0	11.3	22.5	33.8	45
Olive oil (g)	66	66	66	66	66
Baking powder (g)	0.5	0.5	0.5	1.0	1.0
Vanilla (g)	13.5	13.5	13.5	13.5	13.5
Water (g)	70	75	80	85	90
Sugar (g)	56	56	56	56	56
Dough total weight (g)	432	437	442	449	458

For the preparation of biscuits, **t**he (composed) flour was mixed with sugar in a blender and the whole was put in a kneading trough to which water and yeast were added. After a few minutes of kneading, oil and vanilla essence were added. The process was stopped when the dough no longer stuck on the sleeves of the kneading apparatus. The dough was spread on the pastry board, previously covered with aluminum foil, and was flatten to 3–5 mm using the pastry rolling wood. The flattened dough was round-shaped in several small pastries with the help of a rounded-edged glass and allowed to ferment for 20–30 min. After that, the rounded-shape dough of biscuits were introduced in the oven at a temperature of 180 °C for 45–50 min. After baking, the cookies were removed from the oven and were allowed to cool down to ambient temperature (Figure 2). The cookies were finally packaged in cleaned plastic jars, labeled (date and formulation type), and appropriately stored pending analysis.

The different formulations were as follows:
BL$_0$ = biscuit made of 100% of wheat flour, sample control;
BL$_5$ = biscuit made of 95 % of wheat flour + 5 % of flour of lentils;
BL$_{10}$ = biscuit made of 90 % of wheat flour + 10 % of flour of lentils;
BL$_{15}$ = biscuit made of 85 % of wheat flour + 15 % of flour of lentils;
and
BL$_{20}$ = biscuit made of 80% of wheat flour + 20 % of flour of lentils.



Bic

Figure 2. Photogragh of the different biscuits formulated

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The moisture, dry matter, protein, lipid and ash contents, titratable acidity and pH of samples were determined by the standard AOAC methods [8]. Crude protein was calculated by multiplying the nitrogen content with a factor of 6.25. Total ash was determined by incinerating samples in a muffle furnace at 550° for 24 h. Crude lipid was determined by with a Soxhlet apparatus using hexane solvent. The moisture content and dry matter were estimated by drying samples at 105 °C to constant weight.
The total carbohydrate content was calculated by difference as follows:
% Total carbohydrate = 100% - (% Crude lipid + % Crude protein + % Ash + % Moisture) and the energy value (EV), in kilocalorie (kcal), was also calculated as follows:
% EV = (% Protein × 4) + (% Lipid × 9) + (% Carbohydrate × 4).

Physical characterization of wheat flour-based biscuits

The physical characteristics of the biscuits were analyzed the AOAC method [8]. Their diameter and thickness were measured with using a rule and then the average ratio of diameter to thickness was calculated. The weight of the biscuits was determined with the aid of a precision balance (± 0.01). All the experiments were performed in three independent runs.

Sensory analysis of biscuits

The sensory properties, namely color, flavor, texture, taste, appearance and overall acceptability of the biscuits made were appraised as reported elsewhere [9]. Acceptance testing was used to determine how much each sample was liked based on a 8-point hedonic scale (8 = very, very good, 7 = very good, 6 = moderately good, 5 = neither good nor bad, 4 = slightly bad, 3 = moderately bad, 2 = very bad, and 1 = extremely bad) for the set of attributes, according to the standards NF ISO 5492 and V 09-001 [9]. Thirty student panelists (men and women), well-trained in sensory evaluation, were selected following a pretest to determine their ability to discriminate between graded concentrations of sugar and citric acid solutions. The codified biscuits were served to the panelists, isolated from any visual and auditory disturbances, in a smell-free airy room. The codified samples were presented to consumers who evaluated samples in individual testing booths under white lighting. In every booth (partitioned for privacy), each consumer used a paper ballot where he/she completed his/her observations. The data were then collected and computerized for statistical analysis.

Statistical analysis

All the experiments were carried out in three independent runs and analysis of variance (ANOVA) was conducted on the sample means for overall liking, flavor, and texture. Statistically significant attributes were further analyzed to see where mean differences existed using the Duncan's test at the 95% confidence interval (P <0.05). Analysis was performed with the software SPSS version 19.

RESULTS

Biochemical characteristics of wheat flour-based biscuits supplemented with LSF

The biochemical characteristics of LSF-fortified wheat flour-based biscuits are shown in Table 2. Incorporation of LSF in wheat flour had a significant effect on the biochemical composition of the biscuits formulated. Indeed, the protein and lipid contents of biscuits

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increased significantly (P <0.05) from 6.88 to 11.45% and from 22.86 to 25.41%, respectively, as the amount of LSF in the wheat flour-based biscuit formulations was increased from 5 (BL_0) to 20% (BL_{20}). Also, the cellulose content increased from 2.95 (BL_0) to 3.84% (BL_{20}). By contrast, the carbohydrate content of biscuits decreased from 71.41 (BL_5) to 67.66% (BL_{20}). Furthermore, the EV of biscuits increased substantially from 461.15 (BL_0) to 541.49 kcal/100 g (BL_{20}).

Table 2: Biochemical composition of biscuits*

	BL_0	**BL_5**	**BL_{10}**	**BL_{15}**	**BL_{20}**
g/100 g dry sample biscuit					
Moisture	$5.13^a\pm0.02$	$5.16^a\pm0.06$	$5.94^b\pm0.04$	$6.49^c\pm0.02$	$7.17^e\pm0.03$
Crude protein	$6.88^a\pm0.16$	$7.35^{ab}\pm0.14$	$7.78^b\pm0.16$	$8.80^c\pm0.64$	$11.45^d\pm0.40$
Crude lipid	$22.86^a\pm0.92$	$22.87^a\pm0.15$	$22.89^a\pm0.19$	$24.69^b\pm1.09$	$25.41^c\pm0.66$
Total carbohydrate	$69.76^a\pm0.00$	$71.41^b\pm0.00$	$70.70^c\pm0.00$	$68.27^d\pm0.00$	$67.66^d\pm0.00$
Ash	$0.75^c\pm0.02$	$0.56^b\pm0.06$	$0.53^b\pm0.01$	$0.53^b\pm0.02$	$0.41^a\pm0.01$
Cellulose	$2.95^a\pm0.01$	$2.16^b\pm0.03$	$3.57^c\pm0.03$	$3.67^d\pm0.04$	$3.84^e\pm0.02$
EV (k**cal/100 g)**	$461.2^a\pm0.0$	$520.9^b\pm0.0$	$519.9^b\pm0.0$	$530.6^c\pm0.0$	$541.5^d\pm0.0$

**Data are expressed as means ± standard deviations (n= 3). The values in the same line with different superscript letters are significantly different at P < 0.05 using the Duncan's test.*
EV: energy value

Chemical features of biscuits

The chemical characteristics of LSF-incorporated wheat flour-based biscuits are presented in Table 3. It could be seen that the pH of biscuits increased significantly (P <0.05) from 5.24 to 6.01 as the proportion of LSF in formulations was increased from 5 (BL_0) to 20% (BL_{20}). By contrast, the titratable acidity decreased from 3.33 to 2.33 meq/100 g as the as the proportion of LSF was increased from 5 (BL_0) to 20% (BL_{20}).

Table 3. Titratable acidity and pH of the LSF-incorporated wheat-based biscuits*

	BL_0	**BL_5**	**BL_{10}**	**BL_{15}**	**BL_{20}**
pH	$5.24^a\pm0.00$	$5.62^b\pm0.00$	$5,69^b\pm0.00$	$5,87^c\pm0.00$	$6.01^d\pm0.00$
Acidity (meq/100 g)	$3.33^c\pm0.01$	$3.00^b\pm0.00$	$3.00^b\pm0.02$	$2.33^a\pm0.02$	$2.33^a\pm0.03$

**Data are expressed as means ± standard deviations (n= 3). The values in the same line with different superscript letters are significantly different at P < 0.05 using the Duncan's test.*

Physical characteristics of biscuits

The physical characteristics of biscuits are shown in Table 4. The diameter of biscuits increased significantly from 41.27 to 45 mm with increasing proportion of LSF from 5 (BL_0)

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to 20% (BL_{20}) in formulations. In contrast, the proportion of LSF in formulations had no effect on the thickness of biscuits (*P* >0.05). The ratio of the diameter to thickness (D/E) increased from 4.91 to 5.63 with increasing LSF in formulations from 5 (BL_0) to 20% (BL_{20}). The weight also increased significantly (*P <0.05*) with the proportion of LSF incorporated into the wheat flour-based biscuits, whereas the volume remained unaffected.

Table 4: Physical characteristics of biscuits

	BL_0	BL_5	BL_{10}	BL_{15}	BL_{20}
Diameter **(mm)**	$41.27^a \pm 0.25$	$44.30^{bc} \pm 0.10$	$44.47^c \pm 0.47$	$43.23^b \pm 1.23$	$45.00^c \pm 0.10$
Thickness **(mm)**	$8.40^b \pm 0.10$	$7.90^a \pm 0.10$	$7.87^a \pm 0.12$	$8.00^a \pm 0.10$	$8.00^a \pm 0.10$
Ratio **(D / E)**	$4.91^a \pm 0.09$	$5.61^{bc} \pm 0.06$	$5.65^c \pm 0.12$	$5.40^b \pm 0.22$	$5.63^{bc} \pm 0.08$
Weight **(g)**	$7.35^a \pm 0.03$	$8.41^b \pm 0.02$	$8.90^c \pm 0.02$	$10.07^d \pm 0.12$	$10.10^d \pm 0.01$
Volume **(mm^3)**	$3582.1^a \pm 7.8$	$3876.0^a \pm 66.5$	$3859.6^a \pm 66.2$	$3807.7^a \pm 75.8$	$3956.3^a \pm 78.3$

**Data are expressed as means ± standard deviations (n= 3). The values in the same line with different superscript letters are significantly different at P < 0.05 using the Duncan's test.*

Organoleptic characteristics of biscuits

The organoleptic characteristics of biscuits are presented in Table 5. All the panelists showed higher visual attraction for LSF-incorporated wheat flour-based biscuits. The results revealed no significant difference between LSF-incorporated biscuits (BL_5, BL_{10}, BL_{15} and BL_{20}) and control sample (BL_0) with respect to color. The color appreciation of the panelists ranked at the level 7 ("very good") on the 8-point hedonic scale. The texture of biscuits was slightly improved with increasing incorporation of LSF up to 10% (BL_{10}) after which further increase in the proportion of LSF seemed to negatively affect it. The texture appreciation of the panelists ranked between level 7 (very good) and 6 (moderately good). By contrast, the taste of biscuits was improved with incorporation of no less than 10% of LSF and the panelists appreciation ranked between level 8 (very, very good) and 7 (very good). Incorporation of LSF did not improve aroma, but over 10% of LSF, aroma was likely to be negatively affected. The appreciation of panelists for aroma ranged between level 8 (very, very good) and 6 (moderately good). The overall acceptability increased significantly (*P <0.05*) above 10% incorporation of LSF.

Table 4. Sensory properties of biscuits*

	BL_0	BL_5	BL_{10}	BL_{15}	BL_{20}
Color	$7.10^a \pm 0.26$	$7.10^a \pm 0.17$	$7.15^a \pm 0.15$	$7.00^a \pm 0.10$	$7.00^a \pm 0.10$
Texture	$6.40^b \pm 0.10$	$6.50^b \pm 0.00$	$7.37^c \pm 0.21$	$5.93^a \pm 0.40$	$5.97^a \pm 0.15$
Taste	$7.50^a \pm 0.10$	$7.50^a \pm 0.10$	$7.63^a \pm 0.15$	$7.70^b \pm 0.10$	$7.67^b \pm 0.00$
Aroma	$6.40^b \pm 0.12$	$6.77^b \pm 0.06$	$6.73^b \pm 0.21$	$6.37^a \pm 0.15$	$6.30^a \pm 0.10$
Acceptability	$6.40^a \pm 0.20$	$6.50^a \pm 0.11$	$7.30^b \pm 0.10$	$7.35^b \pm 0.10$	$7.30^b \pm 0.10$

**Data are expressed as means ± standard deviations (n= 3). The values in the same line with different superscript letters are significantly different at P < 0.05 using the Duncan's test.*

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DISCUSSION

In this study, wheat flour-based biscuits, supplemented with LSF, were prepared. These cookies were intended for the reduction of protein-energy deficiencies among young children in developing countries. Therefore, the biochemical composition of biscuits was of primary interest. The results obtained showed that partial replacement, at a rate of 5–20%, of wheat flour with LSF had a significant influence on the biochemical composition of biscuits.

The biochemical characteristics, notably the protein, lipid, and cellulose contents of biscuits increased significantly, compared with the 100% wheat flour-based biscuit (sample control). Indeed, the protein content increased with increasing proportion of LSF and its content in the formulation BL_{20} satisfied the standard criteria as recommended by international health and/or food organizations such as WHO. The improvement of the protein content of LSF-incorporated wheat flour-based biscuit is similar to that reported elsewhere for loaves obtained by replacing progressively and up to the rate of 20 % of wheat flour by that of *Citrullus lanatus* [1]. The improvement in the amounts of these macronutrients could be explained by their high concentrations in LSF. The lipid content of LSF-incorporated wheat flour-based biscuit is considerably higher than that reported for *Citrullus lanatus* flour-fortified loaves [1]. This could be explained by the rather high fat content of LSF.

On the other hand, the carbohydrate content of cookies decreased significantly with increase of LSF in formulations, in consistent with previous work [10]. The moisture content increased with increasing proportion of LSF and may be due to its high protein concentration, which also favored the water retention capacity of dough [11]. Thus, the fortification, to different rates of wheat flour with LSF, resulted in positive variation in the biochemical composition of the biscuits prepared.

The physical characteristics of the biscuits changed as a function of the rate of replacement of LSF. The diameter increased, while the thickness decreased with increasing rate of LSF, in agreement with previous reports [12]. The ratio of diameter to thickness (D/E), also known as the coefficient of development, increased with increasing rate of LSF. This ratio is the most important parameter for evaluating the quality characteristics of biscuits [13] and those biscuits with higher values of coefficient of development are usually considered to be of the best quality [14]. The weight of biscuits increased following incorporation of LSF into formulations. This could be explained by hydrophilic character of the proteins of LSF, which causes over-hydration of proteins of the mixture of wheat flour and LSF.

As regards the sensory characteristics, the color of biscuits was glazed-brown and was not influenced by the presence of LSF. This color is believed to result from the reaction of protein amino acids with reducing sugars to form Maillard products, which explains why biscuits are generally dark-brown with increase rate of proteins [15]. However, color is a very important criterion for judging of baked cookies [16] and the light glazed-brown ones are by far preferred. The aroma of biscuits was not affected by the rate of incorporation of LSF into formulations. All the biscuits had a rough texture to the touch. The conditions of cooking, the status of biochemical components such as fiber and the amount of water absorbed during the kneading of dough are known to contribute to the texture of the final product [17]. The taste

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is the main factor that determines the overall acceptability of a manufactured product, which has the highest impact on the evaluation of its marketability [18]. The level of overall acceptability of cookies was found to be > 6 on an 8-point hedonic scale. Thus, incorporation of LSF improved significantly the taste of biscuits and might be due to the lentil own taste which improves with cooking. All the biscuits had good appearance and showed good overall acceptability up to 20% LSF replacer.

CONCLUSIONS

The fight against infant protein malnutrition requires the improvement of the nutritional quality of this "fragile" group of people. With the aim of improving the nutritional quality of food for children, wheat-based biscuits, fortified with protein-rich lentil seed flour, at different rates, were prepared for children over six months. The results of this study revealed that incorporation of lentil seed flour significantly improved the nutritional values, sensory (color and taste) and physical properties of biscuits. Thus, the protein content and energy value of cookies were increased to reach acceptable values as internationally recommended. The sensory analysis enabled us to show that incorporation of lentil seed flour, up to a rate of 20%, may be accepted by the targeted people. The physical characteristics of the biscuits prepared were in the range of the qualities needed. With partial replacement of wheat flour with lentil seed flour, organoleptic properties of the cookies were generally conserved, while the protein concentration and energy value were considerably increased. In the light of the results obtained, LSF-incorporated wheat flour-based cookies and especially the formulation BL_{20}, fulfilled the quality characteristics required for utilization as food supplements for young children.

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