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Development of Wheat-Based Biscuits Incorporated with Common Bean Flour for Improved Nutrition

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Abstract

Most of snack foods are cereal-based and poor sources of protein and have low nutritional values. Supplementation of cereals with legumes is an excellent way for providing proteins, particularly in baked foods including biscuits and cookies. In this experiment, Wheat and Common bean flours were obtained by using Hammer mill machine. The wheat-common bean flours blends were prepared by D-optimal mixture design software in five different blending ratios: T1 (50% wheat: 50% common beans), T2 (62.5 wheat: 37.5 common bean), T3 (75% wheat: 25% common bean), T4 (87.5% wheat: 12.5% common bean and control (wheat 100%). The functional property and proximate composition of the composite flours were analyzed following standard methods. The biscuit was baked at 190°C for 8–10 minutes in oven. The proximate compositions and organoleptic attributes of the biscuits were evaluated using 9-point hedonic scales.

The study revealed that 87.5% wheat and 12.5% common bean and 75% wheat and 25% common bean composite had the highest WAC and OAC respectively. The swelling power of T2 (62.5% wheat and 37.5% common bean) is the highest among other treatments whereas the 87.5 wheat and 12.5% common bean was found to be more soluble than other treatments. The highest ash content was obtained for T4 (87.5% wheat and 12.5% common bean) while the lowest value of ash content was noted for 50% wheat and 50% common bean. The study showed that there are no significant differences in moisture, fat, fiber and protein content among the composite flours. However, sample of 87.5 wheat and 12.5% common bean composite flour had the highest protein content which is 21.55%. The highest overall sensory evaluation of wheat-common bean biscuit was recorded for 50% incorporation of common bean. Based on product evaluation incorporation of common bean in biscuit was found to increase the nutritional value particularly protein, and can ensure food security.

Keywords: Biscuits; Common beans; Organoleptic properties; Proximate compositions; Functional properties

Introduction

Legumes are crucial crops in combating Food insecurity and malnutrition in most developing countries. They are well-known functional foods and their importance as ingredients for food formulations is of great importance in recent times. Several studies have indicated that regular consumption of legumes is connected to physiological and health benefits, such as prevention of cardiovascular disease, obesity, diabetes mellitus and cancer [1]. Legumes play a vital role in human nutrition, particularly in the dietary pattern of low-income countries. Hence, supplementation of cereals with legumes protein is an excellent way of providing proteins, particularly in baked foods including biscuits, cookies, and cakes which are consumed for their good eating quality and long shelf-life [2,3]. Most of snack foods are cereal-based and poor in protein [4].

The snack foods like as doughnuts, pies, cookies among others which are produced from wheat flour have low nutritional values [5]. Biscuit is a crispy cake particularly prepared from wheat based unleavened dough, and considered as the best use of composite flours over bread because it is ready-to-eating, widely consumed, and have long shelf-life, and good eating quality [6]. Choosing healthy snack foods is important at snack time to improve the nutritional quality of cereal proteins by combination with legumes such as pigeon pea, cowpea and soybeans amongst others as protein sources. The incorporation of legumes in the production of bakery products like biscuits have been suggested to enhance nutritional quality [7].

Common bean is among protein-rich legumes and important staple food. It is essential to human diets in many parts of the world. Bean seeds are recognized as good source of energy, carbohydrates (dietary fibers, starch, and oligosaccharides), proteins, minerals and vitamins (iron, zinc, B-vitamins, folate), and antioxidants and polyphenols required for human health [8]. Common beans have the potential to alleviate malnutrition and hunger as they are rich in quality globulin protein (20-28%), energy (32%), fiber (56%) and iron (70 mg/kg) and zinc (33 mg/kg) and vitamin A [9].

Bean seeds are richer in proteins than cereal grains (18-24% *vs.* 8-15%) and the amino acid profile of seed (storage) proteins which are normally rich in sulfur amino acids and poor in lysine, tryptophan and threonine.

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The poor lysine content of cereal flours but rich in the sulphur containing amino acids is improved by the substitution of legume flours. The enrichment of cereal-based diets with oilseeds and legumes has been received considerable attention. This is because oil seed and legumes proteins are rich in lysine, but deficient in sulphur-containing amino acids. The consumption of cereal-based foods like biscuits at affordable cost requires the development of an adequate substitute for wheat. The substitute should be readily available, affordable and able to replace wheat flour in terms of functionality. Flours produced from a combination of cereals, legumes or tubers have a nutritional value superior to a single crop and the advantage of improved overall nutrition.

Now a day, problem of protein energy deficiency is increasing dramatically in infants. As it is already recommended in different researches, the practice of formulating/compositing flours is a critical way of improving protein content of foods. Even though, there is adequate availability of common bean varieties in our country, their utilization as a food ingredient is undermined. National lowland pulse program released different common bean varieties with different quality traits disease resistance, high yield and etc. Since the practice of incorporating common bean in diet through product development and innovation was less considered, there is a need to design project to fill the gap. There is a need to develop food products incorporated with bean among the rural and urban poor to improve the food, nutrition and get health benefits. Therefore, the current study was conducted to develop baked products incorporated with common bean and cowpea flour and evaluate their nutritional and organoleptic qualities as a means of enhancing legumes utilization and combating malnutrition.

Materials and Methods

Study area

The research was carried out at Food Science and Nutrition Laboratory, Melkasa Agricultural Research Center (MARC) in. The experimental laboratory is located at latitude of 8˚24'N, longitude of 39˚21' E and at altitude of 1,550 meters. It is situated at 107 km from Addis Ababa.

Raw materials collection and preparation

Popular wheat (Shorima variety), and Common bean (Roba variety) were collected from Kulumsa (KARC) and Melkessa Agricultural Research Center (MARC). Wheat flour was first Sorted, cleaned, washed and dried on sunlight and finally milled into fine flour by laboratory mill. Common beans were sorted, cleaned, soaked overnight in hot water, dried on sunlight, and milled to fine flour.

Formulations of composite flours

The composite flours of wheat-common beans formulation were done by D-optimal mixture design (design expert), and shown in Table 1.

Run	Wheat	Common bean%
1	50	50
2	62.5	37.5
3	75	25
4	87.5	12.5
5	100	0

Table 1: Formulations of composite flours.

Biscuit preparation procedure

Biscuit was prepared following the procedure described by Mbofung et al. The oil (1 tea cup), salt (0.5 g) and sugar (50 g) were first poured in the blender and blended for 5 min and were dissolved in some volume of water used for each treatment. The flour was then put in mixer and blended. The ingredients were mixed for 5 minutes. The dough was cut into circular shapes with a molding shell after rolled into a continuous sheet (0.5 cm thick). Then, the biscuit was baked at 190°C for 10 minutes. Figure 1 presents the standard biscuits making procedure.

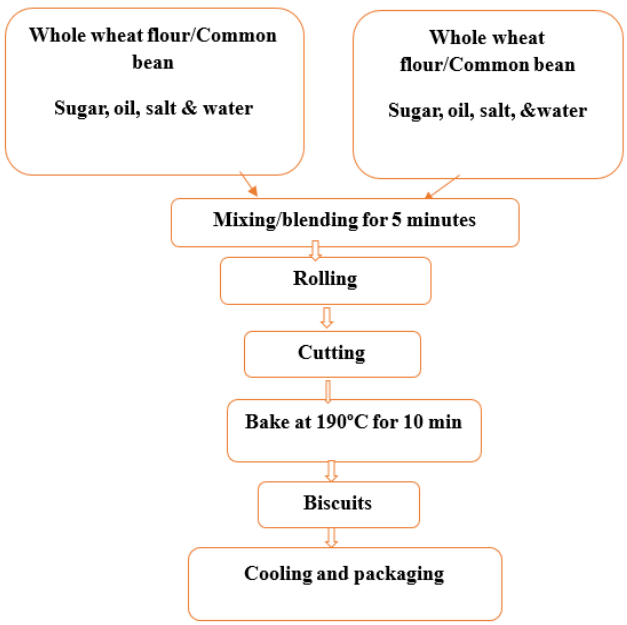

Figure 1: Flow chart of biscuit preparation.

Functional properties of the flours

The water and oil absorption capacities of the flours were determined following the method described by Ekeand Akobundu. Swelling Power (SP) and solubility of the flours were determined according to the method described by Erlingen et al.

Sensory evaluation

A semi-trained a panel of 20 people evaluated 3 each biscuit based on nine 9-point hedonic scale scales: 1-extremely dislike, 2-dislike very much, 3-dislike much, 4-dislike, 5-neither dislike nor like, 6-like, 7-like much, 8-like very much and 9-extremely like method, and organoleptic properties evaluated were the surface color, surface cracking, texture, taste and overall acceptability.

Proximate composition

All the proximate composition including moisture content, ash content, protein content, fat, fiber and total carbohydrates of the composite flours were determined by A.O.A.C method.

Statistical analysis

One-way ANOVA was used for statistical analysis of the data. Generalized Linear Model (GLM) procedure for least square means and Duncan's Multiple Range Test (DMRT) for significant difference between means was used.

Results and Discussion

Functional properties of the flour

Functional properties of (wheat-common bean) composite flours were presented in Table 2. According to the statistical analysis, there is no significant difference among treatments for WAC, OAC, and solubility while in terms of swelling power the means are significantly different. The highest value of swelling power was recorded for composite flour formulated from 87.5% wheat and 12.5% common bean. It was observed that there is an increase in WAC for wheat 62.5% and common bean 37.5% composites as compared to control sample. The previous study showed that the functional properties of millet-common bean composite flours was in the range of 0.725-0.921 g/mg, 117.50-155.10 g/g, 120.36-145.83 g/g, 6.038-14.530% and 65.167-77.33% for bulk density, water absorption capacity, swelling power, water solubility index and dispersibility respectively. This is report is by far different from our current result except in oil absorption capacity which is almost similar. All the functional properties of the flours were improved with the substitution of wheat with common beans. The previous study reported that the swelling power of Jackbean flour was 6.24. This result is higher than the result obtained for the composites flours in the current study.

Treatment	Functional properties			
	Water Absorption Capacity (WAC)	Oil Absorption Capacity (OAC)	Swelling power	Solubility
T1	0.667 ± 0.06^{a}	116.67 ± 30.55^{a}	3.128 ± 0.67^{ab}	8.33 ± 2.93^{a}
T2	0.767 ± 0.29^{a}	123.33 ± 15.28^{a}	3.637 ± 0.79^{a}	9.33 ± 1.94^{a}
T3	0.967 ± 0.26^{a}	143.33 ± 15.28^{a}	2.751 ± 0.05^{ab}	8.100 ± 3.50^{a}
T4	1.000 ± 0.10^{a}	120.00 ± 26.46^{a}	2.420 ± 0.35^{b}	9.83 ± 0.744^{a}
T5	0.800 ± 0.10^{a}	126.67 ± 25.17^{a}	2.854 ± 0.17^{ab}	8.53 ± 1.87^{a}
Grand mean	0.84	126	2.958	8.83
CV	21.95	18.56	16.75	27.12

Note: T1: 100% wheat/control, T2: 87.5% wheat and 12.5% common bean, T3: 62.5% wheat and 37.5% common bean, T4: 50% wheat and 50% common bean and T5: 75% wheat and 25% common bean.

Table 2: Functional property of wheat-common bean composite flour.

Proximate compositions of the composites

The proximate composition of compositions of wheat-common bean composite flours was presented in Table 3. The composite flours are significantly different from each other except control and 87.5% wheat 12.5% common beans composite which are statistically almost the same.

Treatment	Ash	Moisture	Crude protein	Crude fat	Crude fiber	Carbohydrate
T1	1.442 ± 0.06^{c}	7.200 ± 0.38^{a}	11.575 ± 2.02^{a}	1.667 ± 0.03^{a}	1.34 ± 0.79^{a}	78.116 ± 6.36^{a}
T2	1.557 ± 0.06^{c}	7.483 ± 0.28^{a}	18.171 ± 0.58^{a}	1.472 ± 0.03^{a}	2.01 ± 0.27^{a}	71.318 ± 6.364^{c}
T3	2.267 ± 0.28^{b}	7.350 ± 0.09^{a}	16.915 ± 9.03^{a}	1.055 ± 0.54^{a}	1.180 ± 0.01^{a}	72.318 ± 8.49^{b}
T4	3.500 ± 0.20^{a}	7.167 ± 0.41^{a}	21.554 ± 0.48^{a}	1.393 ± 0.17^{a}	2.145 ± 0.32^{a}	66.387 ± 6.36^{e}
T5	2.283 ± 0.20^{b}	7.583 ± 0.06^{a}	19.130 ± 1.12^{a}	1.603 ± 0.08^{a}	2.205 ± 0.403^{a}	69.401 ± 1.27^{d}
Mean	2.21	7.34	17.47	1.44	1.78	71.53
CV	8.19	3.82	23.94	17.64	24.71	0.00

Note: T1: Wheat control 100%, T2: Wheat 87.5% and common bean 12.5%, T3: Wheat 62.5% and common bean 37.5%, T4: Wheat 50% and common bean 50% and T5: Wheat 75% and common bean 25%.

Table 3: Proximate composition (g/100 g) of wheat-common bean flour.

The improved ash content was recorded for 50% wheat-50% common as compared to control sample and other treatments. This shows that the substitution of wheat flour with common bean in different proportions resulted in an increase in ash content because common bean is reach in minerals like calcium, iron and zinc. The ash content indicates the total minerals found in foods. This result shows that there is no significant difference in moisture, fat, fiber and protein content among the composite flours. However, the 75% wheat-25% common bean composite flour had the improved protein content which is 19.130%. The carbohydrate contents were raged from 78.1165% to 66.3875%. It has been reported by Celmeli and Sari that the crude protein of common bean landraces was in the range of 16%-24% which is higher than the current result. The 80% wheat and 20% white beans composite flours was reported to have highest protein content (13.92%). Similar result was reported by Akoja and Coker revealed that the nutritional compositions of Wheat-Defatted Dioclea reflexa Seed flours was in the range of (3.36-4.22%) ash, (2.03-3.84%) fiber, (9.83-13.85%) protein, (3.86-6.72%) fat. The authors also reported that the nutritional compositions increased with an increasing level of *Dioclea reflexa* in the product.

Anti-nutritional contents of the composites

The result of tannin and phytate contents of wheat-common bean composites flour was presented in Figure 2. The tannin and phytate content of the composite flours were not significantly different among the treatments.

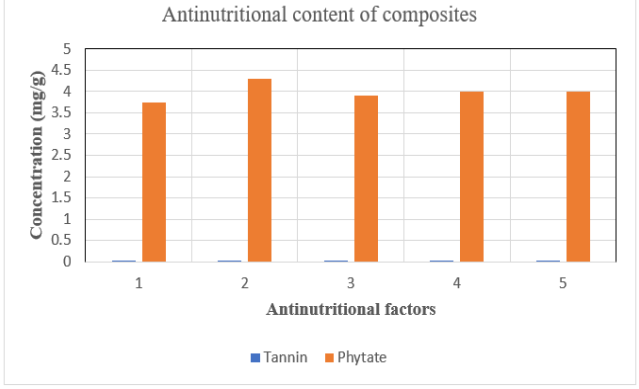

Figure 2: Antinutritional content of the composites.

The amounts of tannin found in wheat-common bean were in the range of 0.0125-0.026 mg/g. However, the highest tannin (0.026 g. 100-1) and phytate (4.297 g.100^{-1}) content was recorded for 87.5% wheat and 12.5% as compared to control and other formulations while lowest value was recorded for T1/control. This shows that common bean incorporation in wheat flour contributed to the increase in anti-nutritional contents of the composite flours because the legumes have more anti-nutritional contents than cereals in nature. The tannin result in this study is lower than previous findings by other authors for cereal-legumes composite flours-based baked foods while the phytate content is higher. According to Moktan and Ojha tannin and phytate content of wheat: 6% germinated horse gram flour bread was 2.06 mg/g and 2.46 mg/g respectively. The previous study conducted by Alamu has been reported that the tannin and phytate content of 50% cassava: 50% cowpea was found to be 0.4 mg/g and 0.3 mg/g respectively. The amount of phytate and tannin in composite flours in this study is low as compared to previous studies because the beans variety used was soaked overnight which could reduce the anti-nutritional contents.

Organoleptic properties of the composites

Organoleptic properties of biscuit made of wheat-common bean composite flours were presented in Table 4. The result illustrated that there the value of color, surface cracking, taste and texture of biscuits are not statistically different except overall acceptability.

Treatments	Organoleptic properties				
	Color	Surface cracking	Taste	Texture	Overall acceptance
T1	6.308 ± 1.89^{a}	6.385 ± 1.85^{a}	7.00 ± 1.58^{a}	7.154 ± 1.57^{a}	6.923 ± 1.32^{a}
T2	6.539 ± 1.27^{a}	5.769 ± 1.24^{a}	6.077 ± 1.50^{a}	6.230 ± 1.54^{a}	6.00 ± 1.22^{b}
T3	6.154 ± 1.41^{a}	6.539 ± 1.20^{a}	6.308 ± 1.32^{a}	6.535 ± 1.33^{a}	6.539 ± 0.88^{ab}
T4	6.077 ± 1.38^{a}	5.923 ± 1.38^{a}	6.308 ± 1.38^{a}	6.308 ± 1.32^{a}	6.385 ± 1.04^{ab}
T5	6.615 ± 1.39^{a}	6.615 ± 0.96^{a}	6.154 ± 1.52^{a}	6.077 ± 1.66^{a}	6.385 ± 1.12^{ab}
Mean	6.339	6.246	6.369	6.462	6.446
CV	23.37	21.74	22.95	23.04	17.49

Note: T1: 50% wheat and 50% common bean, T2: 62.5% wheat and 37.5% common bean, T3: 75% wheat and 25% common bean, T4: 87.5 wheat and 12.5% common bean and 100% wheat

Table 4: Organoleptic properties of wheat-common beans biscuits.

However, control sample had high values in terms of color and surface cracking of biscuit while 50% wheat and 50% common had high values of taste and overall acceptability. This result agrees with the report of François for 70% Wheat+30% OFSP flour biscuits. The previous study reported that biscuits made of Wheat flour (55%)+rice flour (15%)+green gram flour (15%)+potato flour (15%) composite flours was accepted organoleptically accepted in terms of overall acceptability.

Conclusion

This study showed that the functional properties of the formulated flours were increased mainly due to high protein content flour contributes to high ability to absorb water in its matrix due to the polar portions of amino acids component of protein. The proximate composition of the composite flours especially ash and protein were enhanced. The optimum blending ratio which gave the highest possible crude protein content for common bean was 87.5% wheat: 12.5% common bean composite flours. The highest overall acceptability value of biscuits from wheat-common bean composite flour was recorded for the sample of 50% wheat and 50% common bean which could be optimum formulations for the best sensorial acceptance of the products. Chiefly, it was observed that biscuits with acceptable organoleptic attributes with inclusion of common bean in wheat flour had enhanced nutritional value and, help increase utilization of the beans in Ethiopia. Therefore, we recommend providing training to potential producers and consumers to alleviate protein energy malnutrition and ensure food security to help sustainable development of the country.

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