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Developing Cowpea-Based Bread and Evaluating Consumer Acceptance for Home Consumption

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Abstract

This experiment was conducted to characterize the composite flours of Wheat-cowpea and develop flat traditional bread for home consumption. Legumes complement cereals because of their nutritional value especially protein which limited in cereals. Functional properties, nutritional and mineral compositions of the flours were evaluated. Traditional flat bread was developed and evaluated for its sensorial acceptability. Proximate composition was found to be in the range of 7.3-9.8 %, 1.8-3.0 %, 13.7-18.7 %, 1.35-1.45%, 1.35-1.99 %, 64.2-71.4 % and 343.5-361.8 Kcal for moisture, ash, protein, fat, fiber, carbohydrates and energy respectively. The formulation 50%W:50%CP resulted in higher water solubility index and bulk density and 87.5%W:12.5%CP had dispersibility value equivalent to the control sample. The bread prepared from 87.5%W:12.5%CP preferred by panelist in terms of color, aroma, texture and taste as compared to rest of formulations and control, Mineral content of the composites was enhanced by addition of cowpea flour to wheat except calcium. For instance, Zn, Cu, Na and P showed the significant improvement as compared to control. Incorporation of more than 12.5% cowpea in wheat leads to improved protein and total mineral contents of the composites. Additionally, replacing wheat with cowpeas might increase the way that legumes are utilized and strengthen the security of one's diet.

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Composite flour, protein, bread, sensory, nutritional content.

Introduction

Wheat-based bakery products are widely consumed in the world and in Africa in particular. However, only very few Sub-Saharan African countries cultivate can grow wheat due to unfavourable climatic conditions (Tadesse *et al.,* 2018). Among the wheat-based foods, bread is a major food product, which has gained wide acceptance among consumers in the world (Badifu *et al.,* 2005). Supplementation of cereal-based foods with other protein sources such as legumes has gained considerable attentions in the recent time (Olapade and Oluwole, 2013). Complementary to cereals, pulses constitute a significant source of dietary proteins with an excellent essential amino acid profile. They are also rich source of minerals especially magnesium, potassium, zinc, and possibly iron (Boye *et al.,* 2010). Cowpeas *(Vigna unguiculata),* are among legume crops used as dried seeds and forage pods.

They are annual dual-purpose legume that grows in the semi-arid tropics covering Africa, Asia, Central and

South America, being a valuable component of human food and livestock fodder (Singh *et al.,* 2003). Cowpeas are an essential dietary component for humans due to their high protein and carbohydrate amounts, relatively low-fat content, and a complementary amino acid pattern to that of cereal grains.

Recent studies and consumer interest in cowpeas from across the world have increased because of their demonstrated health benefits, which include anti-inflammatory, anti-cancer, anti-hyperlipidemic, anti-diabetic, and anti-hypertensive qualities (Jayathilake *et al.,* 2018). Even though Ethiopia has little experience creating recipes with cowpeas, many different cuisines have previously been created and enjoyed in other African nations. The most often consumed cowpea-based foods have reportedly been identified as Ata (doughnut), Abobo (stew), and Atassi (mixed dish of cowpeas and rice) in Benin (Akissoé *et al.,* 2023).

Several scientific reports have indicated enrichment of wheat flour for baking; including addition of fluted pumpkin flour is important to enhance nutritional values of foods (Giami *et al.,* 2003). Bread making potential of cowpea flour incorporated in soft wheat flour has been investigated (Ahmed & Campbell, 2012; Olapade & Oluwole, 2013). Despite their nutritional and economic importance, cowpeas are underutilized legumes in Ethiopia. In addition, it has been received relatively little attention from a research standpoint. Carbohydrate source foods are staples in the Ethiopia and animal origin proteins are out of reach of many households. Besides, Ethiopian traditional bread and other bakery products are solely prepared from wheat flours. There is a necessity to incorporate nutrient rich legumes in traditional diet to enhance their utilization and improve nutritional quality of foods. Developing nutrient dense, affordable and accessible food products from locally produced ingredients is a viable and sustainable approach diversify diet as well as to address the problem of malnutrition. Thus, this research was conducted to develop cowpea-based traditional bread to diversify diet and alleviate the problem of malnutrition specially protein malnutrition in the country.

Materials and Methods

Ingredient collection and preparation

The grains of bread wheat variety Shorima were collected from Kulumsa Agricultural Research Center. Similarly, cowpea variety Bole was Melkassa Agricultural Research Center. The cowpea seeds were soaked overnight and dried. Both the grains of wheat and cowpea were milled into flour using cyclone sample mill (Model: 3010-019).

Composite flours (wheat and cowpea) formulations

The wheat and cowpea flours were formulated using design expert 14. Table 1 presents actual proportions of the flours. The Cowpea substituted instead of wheat flours and evaluated in comparison with 100% wheat (control).

Nutritional compositions of the composites

The methods developed by Association of Official Analytical Chemists (AOAC, 2010) were used to determine crude protein, crude fat, crude fiber, moisture and ash contents the composites (wheat and cowpea) and bread samples. Total carbohydrate was estimated by difference method.

Mineral content analysis

For mineral content analysis, the samples were prepared using dry ash. Atomic Absorption Spectrophotometer determined minerals including calcium, magnesium, sodium, potassium, iron, zinc, copper and manganese.

Functional properties

Bulk density, Water Absorption Capacity, water solubility index and Dispersibility of the composite flours were determined using standard methods (Abiodun *et al.,* 2014).

Bulk density of the flour

Bulk density was determined based on the methods used by Narasinga (1984). A mass of 50 g of the sample was put in to a 100 ml measuring cylinder. The cylinder was tapped on a laboratory bench continuously until a constant volume was obtained. Then, the volume of sample was recorded. The bulk density was calculated as weight of the ground flour (g) divided by its volume (cm^3).

Water Absorption Capacity (WAC)

WAC was determined with the method reported by Sosulski (1962). 25 ml of distilled water is added to a sample of 3g composite flour (w1) in a weighed centrifuge tube (w2) and stirred six times for 1 min at 10 min intervals. The mixtures were centrifuged at 3000 rpm for 25 min and the clear supernatant was decanted and discarded. Pellets were dried at 50°C for 25 min. The adhering drops of water were removed and then reweighed (w3). The amount of water retained in the sample was recorded as weight gain and was taken as water absorbed. Water absorption capacity was expressed as the weight of water bound by 100 g dried flour.

Dispersibility

Dispersibility was determined by the method of Kulkarni *et al.,* (1991). 10 g of flour sample was weighed into a 100 ml-measuring cylinder. Distilled water was added up to 100 ml volume. The sample was vigorously stirred and allowed to settle for 3 h. The volume of settled particles were recorded and subtracted from 100 to give a difference that was taken as percentage dispersibility. Solubility index was determined by the method of Kusumayani *et al.,* (2015).

Statistical Analysis

All the means of duplicate samples for the proximate composition and sensory properties of the bread were calculated. The data obtained was then subjected to Analysis of variance (ANOVA), where significance difference existed; LSD test was employed in separating the means.

Results and Discussion

Nutritional compositions of composite flours

The nutritional compositions of wheat and cowpea composite flours is presented in Table 2. The result of the study reveals that except for fiber contents, which were not significant; all the formulations were found to be significantly different (P < 0.05). Protein and ash contents of the composites increased with an increasing level of cowpea flour, which might be due to the high protein and mineral contents of legumes in nature. The highest protein and ash contents were recorded for formulations containing 50% cowpea flour. In line with this, Nanyen *et al.,* (2016) have reported protein value of 17.5% in a flour blend of 50% wheat, 20% acha and 30% mung bean. The highest carbohydrate content was recorded in 100% wheat sample that might be due to the starchy nature of cereals in general and that of wheat in particular. The influence of incorporation of cowpea flours on nutritional compositions of the composite flour was observed to be positive. The protein value of the composites increased with an increasing substitution of Wheat flour by cowpea flour. This is could be due to the high protein content of cowpea Moisture content of the composite flours was in the range between 7.3 and 9.8%, indicating longer storage.

Mineral contents of composite flours

Table 3 presents the mineral compositions of wheat and cowpea composite flours. The result showed that all minerals evaluated in this study were significantly different for each proportion ($P< 0.05$) except Calcium. Iron content of the composite was showed that all the treatments had the lower value than control sample 27.773 mg/kg and the treatment$_4$ (87.5W:12.5CP) had the lowest Iron content. While the Zinc content was in range of 21.82 mg/kg-23.85 mg/kg, the control sample treatment3 and 4 had the lowest and highest value respectively. The highest and lowest Cu value of 5.53 mg/kg and .453 mg/kg obtained in 87.5W:12.5CP and 100W flour respectively. Incorporation of cowpea in the traditional flat bread positively affected the level of essential minerals including Fe and Zn. However, the increment of mineral content in most cases was not in the regular order of substitution levels.

The bulk density value of the Wheat-cowpea composite flours was not significantly different (P<0.05) except in 50W:50%CP and 62.5W:37.5%CP. The highest and lowest bulk density value of 0.931% obtained in 50W:50CP flour and the lowest value of 0.794% obtained in 100%W and 87.5W:12.5CP flours. Bulk density value of was found to be high in the sample contained high level of cowpea. According to Okoye (2008), bulk density ranged from 0.94-0.98% was reported for wheat-kidney bean composite flours. This is not in agreement with the current finding which may be attributed to the difference in particle size and density of the flours. Bulk density is vital in determining packaging requirement and material handling. Water absorption capacity of 87.5W:12.5CP and 75W:25CP blends were significantly different among the treatments ($p<0.05$).

Water absorption capacity of the flour was ranged from 117.87 to 145.570%. The WAC value of control sample was found to be lowest as compared to other blends. Cowpea provide more protein than wheat, and the proteins are able to draw in and bind water molecules because of their hydrophilic characteristics.

Table.1 Formulations of the composite flours

Ingredients	Run_1	Run_2	Run_3	Run_4	Run_5	
Wheat (g)	50.00	62.50	100.0	87.50	75.00	
Cowpea (g)	50.00	37.50	0.00	12.50	25.00	

Table.2 Nutritional compositions of wheat-cowpea composite flours

Treatment	moisture	ash	fiber	Protein	fat	carbohydrate	Energy (kcal/g)
1	9.8^{a}	3.0^{a}	4.4^{a}	18.7^{a}	1.45^{a}	64.2^{b}	344.5^{ab}
2	7.6^{b}	2.7^{b}	2.3^{a}	16.1^{c}	1.35^{b}	71.4^{a}	361.8^{a}
3	8.6^{ab}	1.8^{e}	7.0^{a}	13.7^{e}	1.44^{a}	68.9^{a}	343.5^{b}
4	7.3^{b}	2.2^{d}	5.1^{a}	17.9^{b}	1.45^{a}	68.4^{a}	354.4^{ab}
5	7.6^{b}	2.5^{c}	5.8^{a}	15.1^{d}	1.41^{ab}	68.97^{a}	349.1^{ab}
Mean	8.2	2.4	4.9	16.1	1.99	68.40	350.7
CV	10.3	1.7	53.5	1.4	2.7	3.36	2.8
LSD	1.5	0.1	4.8	0.6	0.07	4.16	17.5

***The means with same letters are not significantly different W-wheat CP-Cowpea $Treatment_1$-50%W:50%CP $Treatment_2$-62.5%W:37.5CP, $Treatment_3$-100%W:0%CP, $Treatment_4$-87.5%W:12.5%CP and $Treatment_5$75%W:25%CP*

Table.3 Mineral content of wheat and cowpea composite flour (mg/kg)

Treatment	Fe	Zn	Cu	Ca	Na	P
1	25.6^{ab}	23.0^{d}	4.6^{d}	342.1^{a}	40.2^{d}	3349.5^{d}
2	25.6^{b}	23.3^{c}	4.9^{c}	343.5^{a}	45.8^{c}	3414.8^{c}
3	25.8^{a}	21.8^{e}	3.5^{e}	336.2^{a}	17.7^{e}	3088.1^{e}
4	25.5^{b}	23.9^{a}	5.5^{a}	346.4^{a}	57.1^{a}	3545.2^{a}
5	25.6^{b}	23.6^{b}	5.2^{b}	345.0^{a}	51.4^{b}	3480.2^{b}
Mean	25.6	23.1	4.8	542.6	42.4	3375.6
CV	0.3	0.2	0.4	142.5	0.2	0.3
LSD	0.2	0.1	0.03	1406.9	0.2	15.5

***The means with same letters are not significantly different W-wheat CP-Cowpea, Treatment1-50%W:50%CP Treatment2-62.5%W:37.5CP, Treatment3-100%W:0%CP, Treatment4-87.5%W:12.5%CP and Treatment575%W:25%CP*

Table.4 Functional properties of wheat and cowpea composite flour

Treatments	*Bulk Density*	*WAC*	*WSI*	*Dispersability*
1	0.93^{a}	144.57^{a}	14.90^{a}	72.95^{ab}
2	0.88^{ab}	145.57^{b}	11.26^{b}	60.23^{c}
3	0.79^{b}	117.87^{b}	6.77^{c}	72.30^{b}
4	0.79^{b}	137.43^{ab}	7.75^{c}	73.87^{a}
5	0.82^{b}	139.55^{a}	9.95^{b}	73.87^{a}
Mean	*0.85*	*137.00*	*10.13*	*70.64*
CV	*5.63*	*8.39*	*7.16*	*1.18*
LSD	*0.09*	*20.92*	*1.32*	*1.51*

**The means with same letters are not significantly different W-wheat CP-Cowpea, WSI-Water Solubility Index, WAC- Water Absorption capacity, Treatment1-50%W:50%CP Treatment2-62.5%W:37.5CP, Treatment3-100%W:0%CP, Treatment4-87.5%W:12.5%CP and Treatment575%W:25%CP.*

Table.5 Sensory Evaluation of wheat-cowpea bread

Treatment	Color	Aroma	Texture	Taste	Overall acceptability
1	3.43^{c}	3.71^{a}	3.71^{a}	3.57^{ab}	3.90^{a}
2	4.05^{ab}	3.19^{b}	3.29^{a}	3.05^{b}	3.52^{b}
3	3.95^{abc}	3.76^{a}	3.67^{a}	3.67^{ab}	4.00^{a}
4	4.29^{a}	3.86^{a}	3.67^{a}	4.00^{a}	3.81^{ab}
5	3.71^{bc}	3.57^{ab}	3.52^{a}	3.29^{ab}	3.76^{ab}
Mean	3.89	3.62	3.57	3.51	3.90
CV	7.65	6.53	9.80	11.30	4.55
Lsd	0.54	0.43	0.64	0.72	0.31

***The means with same letters are not significantly different W-wheat CP-Cowpea, Treatment$_1$-50%W:50%CP,Treatment$_2$-62.5%W:37.5CP,Treatment$_3$-100%W:0%CP, Treatment$_4$-87.5%W:12.5%CP and Treatment$_5$75%W:25%CP7*

As a result, bean flours with greater protein contents may be better able to absorb water. The ability of flours to absorb water is indicated by their water absorption capacity (Awuchi *et al.,* 2019). WAC is crucial for baking since it influences the end product's texture, moisture levels, and dough consistency. A flour with a higher water absorption capacity may be able to retain more water, improving hydration and perhaps producing baked items that are softer and moister.

Similar result was reported in previous studies. According to Akubor & Ukwuru (2004), the wheat-cowpea flour (50%:50%) has a water absorption capacity of 86.0%.

The water solubility of the blends was significantly different (p<0.05) except in treatment 3 and 4. The highest and lowest value of WS of 14.903% and 6.765% was obtained in 50W:50CP and 100%W flours respectively. Water solubility value was increased with an increasing level of cowpea in the composites. The water solubility of wheat-legumes-flours can vary depending on the specific type of legume flour added to the mixture.

The addition of legume flours to wheat flour can impact the overall water solubility of the dough mixture. Legume proteins are generally less water-soluble than gluten proteins found in wheat (Arbab *et al.,* 2023).

The dispensability values of the composites were significantly different (p<0.05) except in the case of 87.5W:12.5CP and 75W:25CP flours which were not differed from each other. The despersibility value of the flour was ranged from 60.233% (62.5W:37.5CP flour) to 73.867% (87.5:12.5CP AND 75W:25CP). Control sample had the dispersibility value of 72.300%.

Sensory Evaluation of bread prepared from Wheat and Cowpea composite flours

Sensory evaluation of the bread prepared from Wheat and Cowpea composite flours was presented in Table 3. The bread was evaluated for its color, Aroma, Texture, Taste and Overall acceptability. Color is the most important quality parameter which affects consumer and customer preference to foods. The statistical analysis showed that the bread samples were significantly different (P<0.05) in their color. Bread sample 87.5W:12.5CP ranked first by panelists with 4.2857 and followed by Treatment$_2$ with 4.0477, Treatment3 3.9527, Treatment5 3.7143 and Treatment1 3.4290. The bread samples were not significantly different (P<0.05) in their aroma except 62.5W:37.5CP and 75W:25CP bread samples. Aroma value given by the panelist showed that Treatment$_4$ and Treatment$_2$ had the highest and lowest value 3.8570 and 3.1907 respectively. Even though the bread samples were not significantly differed (P>0.05) in their texture, the highest and lowest textural value of 3.714 and 3.2857 observed in 50W:50CP and 62.5W:37.5CP bread samples respectively. The highest (4.000) and lowest (3.0477) value of taste was obtained in 75W:25CP and 62.5W:37.5CP respectively. The bread samples were significantly differed (P>0.05) in their overall acceptability. The bread sample 100W had the highest overall acceptability score of 4.00 and followed by sample 50W:50CP, 87.5W:12.5CP, 75W:25CP and 62.5W:37.5CP with respective values of 3.9047, 3.8093, 3.7617, and 3.524.

Conclusion

Bread of acceptable quality was prepared from composite flours of Wheat and Cowpea & Wheat and mung beans. The bread prepared from Wheat and mung bean composite flours showed the good sensory acceptance. This study showed well accepted bread was prepared from the formulation of 87.5% Wheat: 12.5% Cowpea and the bread prepared from formulation of 87.5%wheat: 12.5% mung beans as compared to other bread samples. It was found that the incorporation of mung bean flour with wheat flour contributed to the increment in nutritional content of the composites. Therefore, the use of cowpea and mung beans in substitution of wheat can enhance utilization of legumes and in turn alleviate problems of malnutrition by avoiding relying on a single crop.

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