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Evaluation of Physicochemical Properties and Sensory Attributes of Biscuits Produced from Composite Flours of Wheat (Triticum aestivum l.) and Potato (Solanum tuberosum l.)

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Abstract
This research was carried out to evaluate the physicochemical properties and sensory attributes produced from composite flours of wheat and potato as well as to determine the effect of incorporation of potato at different levels for biscuit production. The proximate composition of biscuit produced by substituting potato at different levels with wheat flours were ranged from 4.32 to 5.84% for moisture, 1.5 to 2.55% for ash, 7.02 to 7.36 for fat, 6.56 to 8.10 for protein, 4.44 to 6.80% for fiber and 72.30 to 74.11 for carbohydrate. As the supplementation of potato flour increases, the mineral contents increases, this is due to the supplementation of potato flour which has high mineral contents compared to wheat flour. Even though some significance differences are there the sensory attributes of biscuit produced were in acceptable range. The nutritional quality of the developed biscuits was enhanced due to the addition of potato flour. Therefore, the present results showed that it should be directed towards the utilization of potato flour in food product development particularly biscuit using up to 50% supplementation.
Keywords: Biscuit, physicochemical, sensory attributes, potato and proximate composition

Introduction

Food deficit is increasing day by day. So it is a burning question to meet the food requirement of millions of people living in poverty in the third world. Attempts to resolve the problems of food production have placed great emphasis on increasing the production and productivity of grain crops, but little attention has been given to crops such as potato (Solanum tuberosum L)(Muhammad *et al.,* 2014).

Biscuits are flour confections produced from dough and baked to a very low moisture content within a short period of time to make them flaky and crispy. The consumption of biscuits and other bakery products such as bread and cakes prepared from wheat flour has become very popular in the world, especially, among children (Ayo and Nkama,2003).

Okaka (1997) described the production of biscuits as a mixture of flour and water but may contain fat, sugar and other ingredients mixed together into dough which is rested for a period and then passed between rollers to make a sheet .

Wheat (Triticum aestivum L.) is one of the important grain crops produced worldwide. According to the FAO, 2005 report, about 620 million metric tons of wheat was produced from 217 million hectares in the year 2005/06 with an average yield of 2.85 metric tons per hectare. It is grown on larger area than any other crop and its world trade is greater than for all other crops combined and it is easily stored and transported (Slafer & Satorre, 1999). Wheat is an important source of essential nutrients like carbohydrates, proteins, Vitamins B, iron, calcium, phosphorous, zinc, potassium and magnesium (shewry *et al,* .1999). Wheat is used several ways in food: pasta, noodles, rolls, bread, biscuits, cakes, crackers, cookies, Steamed bread.

Potato (Solanum tuberosum L.) is a nourishing food that has sustained civilizations for centuries in South America and Europe. Potato production has significantly increased in recent years in many countries, particularly Africa where it has become more important as a food and industrial crop. About one half of the world's potato production is being used as human food. Increasing potato production with inadequate, expensive and unevenly distributed refrigerated storage facilities in the country has resulted in frequent gluts in the market causing economic loss to the farmers and wastage of precious foods.

Nutritionally, the crop is considered to be a well-balanced major plant food with a good ratio between protein and calories, and has substantial amounts of vitamins, especially vitamin C, minerals, and trace elements. Due to its correct balance between protein and calories, it is considered a good weaning food (Berga *et al*., 1993). Ethiopia has good climatic and edaphic conditions for higher potato production and productivity (Endale, *et al*., 2008a).

In developing countries like Ethiopia, people are traditionally dependent upon cereals and are generally unaware of the nutritional value of potatoes. Therefore, it is essential that potato consumption is increased to sustain this increase in production and to ensure remunerative prices to the farmers as well. Under the existing circumstances, processing of the bulky perishable potatoes into various processed products is a viable option which can help extend the storage life, solve the storage problem, cater to the consumer preference belonging to

different age groups and social strata and serve as a means to increase the supply in off seasons thus maximizing potato utilization.

Processing of potato into flour is perhaps the most satisfactory method of creating a product that is not only functionally adequate, but also remain for an extended period without spoilage. Different products can be prepared by incorporating potato flour with other flours using different methods of cooking such as baking, roasting, steaming, boiling and deep fat frying.

An approach in the present study will replace the wheat flour in biscuits by potato flour (gluten free flours) in order to increase the fibre and other nutrients. Therefore partial substitution of wheat with potato flour is one of the most cost effective ways of producing biscuits with better nutritional quality and optimizing the daily increasing price of wheat in the world market. This is because of cheap cost of potato and expensive cost of wheat which do not meet the need of our populations. In addition to this, the use of potato flour for different food product development will be an opportunity to enhance the use the underutilized root crops like potato with value addition and minimizing its postharvest loss.

Therefore research toward wheat biscuit product development that comprises potato as component will address the nutrition deficiency challenges and postharvest minimization of potato. It will also contribute in the promotion of potato production, increase farmer's income, create more jobs, reduce dependence and consequently the foreign exchange expended on wheat importation. These would add up to an improvement of food and livelihood security for the vast majority of the citizenry. In view of this, the following objective is proposed to be conducted and addressed by this research.

a. General objective

- The general objective is to evaluate physicochemical properties and sensory attributes of biscuits produced from composite flours of wheat (*Triticum* aestivum l.) and potato (*Solanum tuberosum* L.)

b. Specific Objectives

- To determine the proximate composition and quality parameters of the biscuits
- To identify a suitable formulation of wheat/ potato flour for biscuit making.
- To evaluate consumers acceptance of biscuit made from wheat/ potato flour.

2. MATERIALS AND METHODS

Experimental Materials

Matured roots (20 kg) of potato were randomly collected from Horo Guduru Wollega Zone, Shambu Town, Ethiopia. All the ingredients used for production of biscuits were purchased from Kality food complex share company Addis Abeba. The raw material preparation was conducted in Food Science and Nutrition Laboratory, Wollega University Shambu Campus and Biscuit production were carried out in Quality Control laboratory of Kality Food Complex Share Company, Addis Abeba, Ethiopia.

Sample preparation

The potato tubers were thoroughly sorted to separate damaged samples from the lot. The potato tubers identified to be normal and seem fitting for experimentation were cleaned and washed to remove adhering soil, dirt and extraneous materials. The tubers were peeled and sliced in to chips of 2 – 2.5 cm thickness using Jagson potato slicer (Food slicer, JAG0100089, California) to facilitate fast rate of drying and easy milling operations. The sliced tubers were blanched at 60^{o}C for 5 min in water bath (GLC 400, Grant struments, England) in order to inactivate enzymes that may cause browning reaction. Blanched tuber were then cooled in cold water and drained which was followed by drying at 60^{o}C for 6 hours in an oven (Memmert, 845 Schwabach, West Germany) (Okigbo, 1989 and FAO, 2011). The slices were then milled by Electric Grinder (Nima, Model NM-8300, Japan) and sieved through a 300 µm sieve and packed in an air-tight polythene bag at 4^{o}C until used for different chemical analysis.

2.4. Experimental Plan

Treatment	Potato flour (%)	Wheat flour (%)
T_0	00	100
T1	10	90
T2	20	80
T3	30	70
T4	40	60
T5	50	50

Experimental Design and Statistical Analysis

The experiment was carried out in completely randomized design (CRD) in triplicate using five treatments (T_0 – T_5) of potato as a single factor arrangement. Triplicate data of each nutrient, physical characteristics, minerals and sensory analysis were analyzed using one factor analysis of variance (ANOVA) and data were reported as mean ± standard deviation (SD). Mean comparison were conducted by least significant difference (LSD) test at 0.05 using Statistical Analysis System (SAS version 9.1, SAS Institute, 2008).

Chemical Analyses

The moisture content, crude fat (ether extract) content, crude protein (N×6.25), crude fiber and total ash were determined using AOAC (2000) official methods of 925.09, 4.5.01, 979.09, 962.09 and 923.03 respectively. Total carbohydrate content was calculated by differences as (100-% protein + % fat + % ash + % moisture). All the results were expressed as g/100 g of dry matter of potato flour. The energy value was computed by summing the multiplied values for crude protein, crude fat and carbohydrate (Excluding crude fiber) by their respective Atwater's conversion factors of 4, 9 and 4 kcal/ g respectively.

Dietary minerals analysis

Dietary mineral elements (iron, calcium, zinc in (mg/100g) contents were determined as described in AOAC (2000) by dry-ashing method using atomic absorption spectrophotometer (model 200, and Germany) using air-acetylene as a source of energy for automation. The absorbance for iron, zinc and calcium were measured at 248.3 nm, 213.8 nm and 422.7 nm respectively. The iron, zinc and calcium contents were estimate from a series of 1-5 mg/kg, 0.5-2.5 mg/kg standard calibration curve prepared from analytical grade iron wire, ZnO and CaCO3 respectively.

Physical characteristics of biscuit

Sensory Evaluation of prepared biscuits (Hedonic rating test)

The sensory evaluation of six types of biscuits containing various proportions of potato flour was evaluated for color and appearance, flavor, texture and overall acceptability by a panel of 15 tasters. The panelists were selected form Kality Food Complex Share Company in which most of them was experts of quality analyses. For statistical analysis of sensory data, a 9-point hedonic rating test (Singh 2002) was performed to assess the degree of acceptability of potato flour. The taste panelists were asked to rate the sample on a 9- point hedonic scale for color, flavor, texture and overall acceptability with ratings of: 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely. The results were evaluated by analysis of variance.

Result and Discussion

Physical analysis of composite biscuits

The result of the physical analysis of the biscuit produced from wheat and potato flour blends is shown in Table 1, which shows that the supplementation of various levels of composite flours has a significant effect on weight, diameter and thickness. The highest weight was recorded in control (100% wheat) and the lowest was recorded with the supplementation of 50% potato with values of 8.26 and 7.61g respectively. There were no significance difference between the treatments, but 50% supplementation of potato flours showed significant differences at ($p<0.05$).This is in agreement with the work of Muhammad *et al*., 2014 who reported on their evaluation of quality biscuits prepared from wheat and cassava flour, that is as supplementation of cassava flour increases the weight was decreases.

The highest and lowest volume were recorded in 50% and control (100% wheat) biscuits produced with the value of 14.67 and 13.39 cm3 respectively. All the supplementation level (10 to 50%) showed significant difference ($p<0.05$) with control biscuit. As the supplementation of potato flour increases for biscuit production, the density of the biscuit decrease with the lowest value recorded in 50% substitution of potato flour with value of 0.52 g/cm3.

As the supplementation of potato flour increases from 0 to 50%, the diameter of biscuit produced were decreased with highest and lowest value recorded in 0 and 50% substitution of potato flour with value of 38.39 and 36.29 cm respectively. There were significance differences ($p<0.05$) among the treatments. The thickness of biscuit produced increases as the partial substitution of potato flour increases from 0 to 50% with the highest and lowest were recorded in 50% and 0% supplementation of potato flour with value of 5.09 to 4.30 cm respectively. There were also significant difference ($p<0.05$) between control and potato flour supplementation. This is in line with the work of Agu *et al*., 2007 who reported on quality characteristics of biscuits made from wheat and African breadfruit.

Table 1.Physical characteristics of Biscuit produced from wheat-potato composite flours

Treatment	Weight (g)	Volume (cm3)	Density (g/cm3)	Diameter (cm)	Thickness (cm)	Spread Ratio (W/T)
B0	8.26+0.08^{a}	13.39+0.26^{b}	0.62+0.01^{a}	38.39+0.01^{a}	4.30+0.00^{d}	8.93+0.02^{a}
B1	8.19+0.13^{a}	13.98+0.13^{ab}	0.58+0.02^{ab}	38.31+0.01^{b}	4.56+0.14^{cd}	8.40+0.03^{b}
B2	8.02+0.13^{ab}	14.18+0.07^{a}	0.57+0.10^{b}	37.68+0.02^{c}	4.68+0.12^{bc}	8.05+0.02^{bc}
B3	7.93+0.16^{ab}	14.26+0.11^{a}	0.56+0.01^{b}	37.28+0.02^{d}	4.74+0.06^{bc}	7.86+0.01^{c}
B4	8.09+0.06^{ab}	14.35+0.30^{a}	0.56+0.02^{b}	36.92+0.02^{e}	4.89+0.01^{ab}	7.55+0.02^{c}
B5	7.61+0.28^{b}	14.67+0.24^{a}	0.52+0.01^{c}	36.29+0.01^{f}	5.09+0.01^{a}	7.13+0.05^{d}
CV	2.80	2.05	2.72	0.06	2.36	2.28
LSD	0.55	0.71	0.04	0.06	0.27	0.10

Where; CV=Coefficient of variations, LSD= Least Significance Difference; B1=100% wheat flour; B1= 10% substitution of potato flour; B2 = 20% substitution of potato flour; B3= 30% substitution of potato flour; B4= 40% substitution of potato flour and B5= 50% substitution of potato flour

Proximate composition of biscuit produced

The result of the proximate composition of biscuit produced from wheat and potato flour blends is shown in Table 2. The highest and lowest moisture content of biscuit produced were recorded in 0 and 50% substitution of potato flour with the value of 5.77 and 4.32 g/100g respectively. There were no significance difference between the control and 10% substitution of potato flour. But there were some significance differences ($p<0.05$) among the treatments.

The ash content increases as the supplementation level of potato increases from 0 to 50%. There were significance differences ($p<0.05$) between the control biscuit and the other treatments observed. The highest and lowest ash was recorded in 50% supplementation and control which is 100% wheat with the value of 2.55 and 1.50 g/100g respectively. Similar report was reported by Sneha *et al*., 2012 on quality evaluation of flour and biscuit from sweet potato in which they reported that as the supplementation of sweet potato increases, the ash content was increase in which similar trends happen for this study.

The highest and lowest fat content was recorded in 50 and 0% supplementation of biscuit produced. Significance differences were observed between control and treatments. The protein content of biscuit produced from control (100% wheat flour) was significantly ($p<0.05$) different from the other treatments. The protein decreases as the supplementation level of potato increases from 0 to 50% but, there were no significance differences among the treatments. Similar trend were reported by Muhammad *et al*., 2014 on their report of evaluation of quality of biscuit from wheat and cassava flour in which their report showed that as the supplementation level of cassava flour increases, the protein content decreases in which the same trend happen in this study.

The fiber content of biscuit produced increases as the supplementation level of potato flour increases, showing the highest and lowest in 50 and 0% substitution of potato flour with the value of 6.80 and 4.64 g/100g respectively. The result also showed significance differences ($p<0.05$) among some of the treatments. This work is in line with the work of Sneha *et al*., 2012 in which they report as the supplementation of sweet potato flour increases for production of biscuits, the fiber contents of the final products also increases.

Table 2. Proximate composition of biscuit produced from blends of wheat and potato flours

Treatment	Moisture	Ash	Fat	Protein	Fiber	Carbohydrate	Energy
B0 (0%)	$5.77+0.51^{a}$	$1.50+0.14^{d}$	$7.02+0.02^{c}$	$8.10+0.35^{a}$	$4.64+0.22^{d}$	$72.96+0.26^{cd}$	$387.44+0.28^{a}$
B1 (10%)	$5.84+0.28^{a}$	$1.73+0.11^{cd}$	$7.07+0.06^{bc}$	$6.84+0.41^{b}$	$4.57+0.31^{d}$	$73.96+0.42^{ab}$	$386.78+0.67^{a}$
B2 (20%)	$5.42+0.19^{ab}$	$1.82+0.02^{c}$	$7.13+0.02^{b}$	$6.56+0.03^{b}$	$4.96+0.01^{cd}$	$74.11+0.26^{a}$	$386.85+0.78^{a}$
B3 (30%)	$4.66+0.02^{bc}$	$2.17+0.02^{b}$	$7.30+0.01^{a}$	$6.60+0.02^{b}$	$5.44+0.01^{bc}$	$73.83+0.04^{ab}$	$387.42+0.01^{a}$
B4 (40%)	$4.51+0.01^{c}$	$2.38+0.01^{ab}$	$7.35+0.01^{a}$	$6.63+0.01^{b}$	$5.96+0.07^{b}$	$73.17+0.08^{bc}$	$385.41+0.21^{ab}$
B5 (50%)	$4.32+0.01^{c}$	$2.55+0.01^{a}$	$7.36+0.02^{a}$	$6.66+0.02^{b}$	$6.80+0.02^{a}$	$72.30+0.06^{d}$	$382.12+0.02^{b}$
CV	7.01	5.16	0.58	4.50	4.09	0.45	0.38
LSD	0.87	0.26	0.10	0.76	0.54	0.81	3.55

Where; CV=Coefficient of variations, LSD= Least Significance Difference; B1=100% wheat flour; B1= 10% substitution of potato flour; B2 = 20% substitution of potato flour; B3= 30% substitution of potato flour; B4= 40% substitution of potato flour and B5= 50% substitution of potato flour

The carbohydrate content of the biscuit produced have showed significance differences ($p<0.05$) between the control and all the other treatments. The highest and lowest carbohydrate content was recorded in 20% and 50% supplementation level of potato flour with value of 74.11 and 72.30 g/100g respectively. Similar report were reported by Muhammad *et al*., 2014 in which their carbohydrate content were ranged from 74.18 to 77.00 g/100g for biscuit made from wheat and cassava flour.

Energy content of the biscuit produced didn't show any significance differences ($p<0.05$) between control and all the treatments except the 50% supplementation level of potato flour. The highest and lowest energy were recorded in biscuits supplemented with 0 and 50% with values of 387.44 and 382.12 kcal/100g respectively. The variations of the energy content were because of the variations of fats, proteins and carbohydrates in each treatments.

Sensory mean value of biscuit produced

The sensory mean value of biscuit produced from composite flours of wheat and potato flours is shown in Table 4. Color and appearance of the biscuit produced with supplementation of potato flour didn't show significance ($p<0.05$) between control and 10% supplementation, but there were significance differences between control and all the other treatments and there were no significance differences among the treatments used for biscuit produced.

The flavors of the biscuit produced showed significance differences ($p<0.05$) between the control and all the other treatments, but there were no significance differences among the treatments. All the values obtained in each treatment were in acceptably range though the decrement trends were observed.

The texture of the biscuit produced was in acceptably range, and there were significance differences ($p<0.05$) among some of the treatments. The highest and lowest were recorded in 0 and 50% supplementation

level of potato flour with values of 8.22 and 6.5 respectively in 9-point hedonic scale.

Table 4. Sensory mean value of biscuit produced from composite flours of wheat and potato

Treatment	Color and Appearance	Flavors	Texture	Taste	Overall Acceptability
B0	$8.53+0.29^{a}$	$8.66+0.20^{a}$	$8.22+0.22^{a}$	$8.02+0.23^{ab}$	$8.64+0.14^{a}$
B1	$8.60+0.15^{a}$	$7.88+0.12^{b}$	$7.25+0.25^{abc}$	$8.13+0.12^{a}$	$7.25+0.25^{b}$
B2	$7.25+0.25^{b}$	$7.38+0.38^{bc}$	$7.75+0.25^{ab}$	$7.50+0.50^{abc}$	$7.50+0.5^{b}$
B3	$7.12+0.12^{b}$	$7.12+0.12^{bc}$	$6.87+0.12^{bc}$	$6.88+0.12^{c}$	$6.75+0.25^{b}$
B4	$7.38+0.37^{b}$	$6.75+0.25^{c}$	$6.75+0.25^{bc}$	$6.75+0.25^{c}$	$6.87+0.12^{b}$
B5	$7.00+0.25^{b}$	$6.87+0.12^{c}$	$6.50+0.50^{c}$	$7.12+0.12^{bc}$	$7.25+0.25^{b}$
CV	4.68	4.18	5.67	5.02	5.38
LSD	0.88	0.76	1.00	0.91	0.97

Where; CV=Coefficient of variations, LSD= Least Significance Difference; B1=100% wheat flour; B1= 10% substitution of potato flour; B2 = 20% substitution of potato flour; B3= 30% substitution of potato flour; B4= 40% substitution of potato flour and B5= 50% substitution of potato flour

The taste of the biscuit produced in each supplementation of potato flour was in acceptable range with highest and lowest recorded in 0 and 50% with values of 8.02 and 7.12. There were significance differences ($p<0.05$) among some of the treatments.

The overall acceptability of the biscuit produced from composite flours of wheat and potato showed significance differences between control and the other treatments. But there were no significance differences between each treatment. In general, the produced biscuit was in acceptable range. That is, all the biscuit produced were acceptable. Therefore, it is a promising that partial substitution of potato flour for biscuit production enhances the nutritional values and reduces the cost expended on wheat importations.

Conclusion

It is evident from the study that the biscuit can be made with substitution of potato flour up to 50% without adversely affecting the sensory characteristics of biscuits. The result obtained from this work could be very valuable in decision making for industries, large scale and small scale farmers that want to take the nutritional advantage of potato flour as alternative or supplement to cereal flours. Potato flour could be useful in the manufacture of highly nutritious biscuits.

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