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Substitution of Sweet Potato (Ipomoea Batatas) and Soybean (Glycine Max.) Flour with Durum Wheat (Triticum Durum) Flour Effect on Physicochemical and Sensory Characteristics of Cookies

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Abstract
Cookie production is currently limited to wheat and few cereal grains in many countries. This study was initiated with the objectives of investigating the possibility of producing cookies from blends of durum wheat, sweet potato and fermented soybean flours at the ratio of 100:0:0, 75:25:0, 75:0:25, 75:22.5:2.5, 75:2.5:22.5, 75:20:5, 75:5:20, 75:17.5:7.5, 75:7.5:17.5, respectively. The cookies were evaluated for physical properties such as diameter, thickness, and spread ratio; proximate compositions (moisture content, total ash, crude fat and crude protein); and sensory attributes like color, taste, crispness, texture, appearance and overall acceptability. Physical characteristics; the ratio of sweet potato and soybean flour increased in cookies preparation with wheat flour increased the diameter, thickness and spreading factor of cookies to some extent. There were valuable effect on proximate composition of the product (sweet potato and soybean ratio increase in cookies formulation made irregular increase and decrease, respectively in the product moisture content. The fat content of cookies was decreased and irregularly increased with increased ratio of both sweet potato and soybean, respectively. Both sweet potato and soybean ratio increment in the product, resulted in the irregular increase of total ash. Protein content of cookies was decreased for the increased ratio of sweet potato and increased for the increased ration of soybean. Sensory acceptability evaluation of the product based on color, taste, crispness, texture, appearance and overall acceptability was preferred by the panelists without any difference.
Keywords: Cookies, physical properties, proximate composition, sensory characteristics.

1. Introduction

1.1 Background an justification

Wheat (*Triticum aestivum* L.) is a major staple crop to billions of people around the world and is used in a wide variety of food products such as bread, breakfast cereal, flatbreads, tortillas, cookies, pie crusts, soup thickeners, noodles and gravies (Lev-Yadun *et al*., 2000). Wheat meal used for human consumption provides 20% of all the energy consumed by the human population. In addition to being a fundamental source of calories and nutrients, wheat is an economically important crop around the world.

Sweet potato (*Ipomoea batatas* L.) is one of locally available food crops used to consume in many parts of the world in East Africa. It is most versatile for snack food, but it is used as staple food or as a substitute in many countries for different types of foods (Zuraida, 2003). It is a low input crop, wide production geography, adaptability to marginal condition, short production cycle, high nutritional value and sensory versatility in terms of flesh colors, taste and texture. It ranks the seventh most important food crop in the world and fourth in tropical countries (FAO, 2008). Sweet potatoes comprise β-carotene, anthocyanins, total phenolics, dietary fiber, ascorbic acid, folic acid and minerals (Chassy *et al*., 2008).

Soybean *(Glycine max.)* is rich in dietary proteins and low-cost sources nutrients for a large part of the world's population (Egounlety and Aworh, 2003). These grain legumes contribute significantly towards protein (about 35-40%), mineral and B-complex vitamin needs of people in developing countries (Dhingra and Jood, 2002), and play an important role in the traditional diets of many regions throughout the world. It is a very rich source of vegetable protein for all including growing children (Dandago and I.G.W.E., 2006); and it has been identified as a suitable protein rich crop that could improve the nutritional and economic status of the general population in developing countries (Babajide *et al*., 2003). The reasonable price and steady supply are also favorable factors in soybeans emerging as an important source of protein in nutrition. Soybean production in Ethiopia is very crucial to overcome malnutrition and it is cheap substitute for expensive animal protein.

Cookies are flat, dry which is produced from a mixture of flour and water which may contain fat, sugar and other ingredients mixed together into dough. Research into the use of tropical crops has shown that biscuits and other pastries such as meat-pie, cookies, cake, etc. could be made from flours of locally available crops such as sweet potato, cassava, rice, millet, sorghum, etc. It represents the largest category of snack item among baked

food products throughout the world (Pratima and Yadave, 2000). It provides an excellent means of improving the nutritional quantity of foods through incorporation of less expensive high quality protein, minerals, vitamins and has been employed in food product enrichment. Cookies hold an important position in snack foods due to variety in taste, crispiness and digestibility. Most of bakery products are used as a means for incorporating different nutritionally rich ingredients for their diversification (Sudha *et al*., 2007); such enrichment may be attained through the incorporation of protein rich non-wheat flours (Sharma and Chauhan, 2002). Protein-energy malnutrition, in children associated with poor nutritional knowledge resulting in early weaning, delayed introduction of complimentary foods, low protein diet and sever or frequent infection (Ramakrishna ad Jhanesi, 2006). Sub-Saharan African bears the brunt of protein-energy malnutrition in the world (Muller and Krawinkel, 2011). In Ethiopia the most important nutritional problem in foods consumed by the children in many parts are protein-energy malnutrition, micronutrient and macronutrients deficiency (Bukusuba *et al*., 2010).

The increasing phenomenon of urbanization, coupled with the growing number of working mothers, have contributed greatly to the popularity and increased consumption of snack foods such as cookies and biscuits. However, wheat flour, which is the flour of choice for producing cookies and other baked food products, is either unavailable or uneconomical in many regions of the world. Therefore, to produce baked goods, regions with limited supplies of wheat flour must rely on imports or exclude wheat products from the diet. The production of cereal-based baked products like cookies at an affordable cost therefore requires the development of an adequate substitute for wheat. The substitute should be one that is readily available, cheap and able to replace wheat flour in terms of functionality. Flours produced from only either cereals, legumes or tubers were have a nutritional value inferior to those produced from a combination of cereals, legumes or tubers. For instance, composite flours produced from cereals and legumes have the advantage of improving the overall nutrition while composite flours produced from legumes and tubers was have high protein content and high calorific value. In selecting the components to be used in composite flour blends, the materials should preferably be readily available, culturally acceptable and provide increased nutritional potentials.

Therefore, the purpose of this study was to investigate the product of sweet potato, fermented soy bean and durum wheat flour cookies nutritional status, physicochemical properties and organoleptic acceptability which benefits in combating protein nutrient deficiency.

1.2 Objectives

1.2.1 General objective

To evaluate the effects of blending ratio of sweet potato and soybean flour on physicochemical and sensory characteristics of cookies produced from durum wheat flour.

1.2.2 Specific objectives

1. To prepare cookies from sweet potato, soybean and durum wheat flour.
2. To analyze proximate composition of cookies produced from durum wheat, sweet potato and soybean composite flours.
3. To examine the physical properties of cookies produced from durum wheat, sweet potato and soybean composite flours.
4. To evaluate sensory quality of cookies made from blending of durum wheat, sweet potato and soybean composite flours.

2. Materials and Methods

2.1 Raw material collection

Three kinds of raw materials, *i.e*., wheat, soybean, and sweet potato were obtained from Hawassa Agricultural Research Center (HARC), Ethiopia, while ingredients such as milk, sugar, egg, oil, salt, water, and baking powder were obtained from Hawassa local market.

2.2 Experimental design

The experiment was done by two way analysis of variance (ANOVA) (factorial), complete randomized design (CRD) was used to evaluate physicochemical properties, and complete randomized block design (CRBD) was applied for sensory evaluation. Data was collected in replicate and the average was taken for data analysis.

Table 1. Percentage of different treatment used to prepare cookies.

Treatment	Durum wheat flour (%)	Sweet potato flour (%)	Soybean flour (%)
Control	100	0	0
T1	75	25	0
T2	75	0	25
T3	75	22.5	2.5
T4	75	2.5	22.5
T5	75	20	5
T6	75	5	20
T7	75	17.5	7.5
T8	75	7.5	17.5

Source: Sukhcharn *et al*. (2008)

2.3 Composite flour formation

Durum wheat, sweet potato and soybean flour were mixed at ratio of 100:0:0, 75:25:0, 75:0:25, 75:20:5, 75:5:20, 75:15:10, 75:10:15, 75:17.5:7.5, 75:7.5:17.5, respectively as of Sukhcharn *et al*. (2008), in a Kenwood blender. The blends were kept in airtight containers at room temperature for cookies preparation.

2.4 Cookies preparation procedures

Cookies were prepared according to the method of AACC (2000) with some modification in the recipe. Flour (100 g) from each sample of different flour blend, corn starch 10g, sugar 7.5g, baking powder 12 g, four egg (120 g), oil 0.5ml, salt 1 g and the 75ml of water were added. The dry ingredients (composite flour, sugar, salt and baking powder) were mixed until uniform mixtures of the ingredients obtained. Egg was then added and the mixtures were needed.

The butter was rolled and cut with cookie cutter (knife in this case). The cookies were placed in baking trays, leaving 25 mm space in between and baked at 180℃ for 10 minutes in the baking oven. Following baking, the cookies were cooled on a wire racks at 27℃ for 30 minutes and packed in polyethylene bags and stored in cool and dry area. The ingredient used was shown in Table 6. The dry ingredients were weighed using an analytical balance and thoroughly mixed.

2.5 Physicochemical properties

2.5.1 Physical Property determination

The cookies were selected randomly for physical properties (diameter, thickness, and spread ratio) evaluation and examined according to Zoulias *et al*. (2000). The weight, height and diameter of the baked cookies were determined by weighing on a weighing balance (Mettler PE160 Balance, Switzerland) and measuring with a calibrated ruler, respectively on duplicate samples of cookies.

2.5.2 Chemical composition determination

The moisture content, crude fat, crude protein and total ash were determined according to the AOAC (2005) methods on duplicate samples of the cookies.

2.6 Sensory evaluation

Sensory characteristics (such as color, taste, crispness, texture, appearance and overall acceptability) of cookies sample were evaluated in duplicate by 20 trained panelist using 7 point hedonic (Moreira, 2008).

2.7 Data analysis

The data obtained was subjected to analysis of variance (ANOVA), followed by the General Linear Model of the Statistical Analysis System (SAS for windows; SAS 9. 1 software version, Institute, Inc. Cary, NC, USA) and mean comparisons were made by Duncan's Multiple Range Test at significance level of $p \leq 5\%$.

3. Results and Discussions

3.1 Physical properties

3.1.1 Diameter

The diameter of cookies is presented in Table 2. There was a significant ($p<0.05$) difference on the diameter of cookies developed by the blends of durum wheat, sweet potato and soybean. The increase in sweet potato flour ratio made the increase in the diameter of cookies. This might be due to high protein, specifically gluten protein content in wheat brought the elasticity.

Table 2. Physical property evaluation of cookies.

Blends	Diameter(cm)	Thickness(cm)	Spread ratio
C (100W:0soy:0sp)	4.04± 0.01^{d}	0.86± 0.03^{a}	0.19± 0.01^{a}
T1 (75W:25soy:0sp)	4.01± 0.01^{de}	0.79± 0.02^{b}	0.17± 0.01^{b}
T2 (75W:0soy:25sp)	4.19± 0.02^{a}	0.47± 0.04^{f}	0.11± 0.01^{e}
T3 (75W:2.5soy:22.5sp)	4.10± 0.01^{c}	0.54± 0.01^{e}	0.13± 0.00^{d}
T4 (75W:22.5soy:2.5sp)	4.12± 0.01^{bc}	0.61± 0.01^{d}	0.14± 0.00^{cd}
T5 (75W:5soy:20sp)	4.02± 0.01^{de}	0.56± 0.02^{de}	0.14± 0.01^{cd}
T6 (75W:20soy:5sp)	4.14± 0.01^{b}	0.72± 0.01^{c}	0.15± 0.00^{c}
T7 (75W:17.5soy:7.5sp)	4.02± 0.04^{de}	0.60± 0.10^{d}	0.12± 0.02^{de}
T8 (75W:7.5soy:17.5sp)	3.10± 0.02^{e}	0.60± 0.02^{d}	0.14± 0.01^{cd}
LSD	0.0416	0.064	0.0173

Mean ± Standard deviation values within columns bearing with the same superscripts are not significantly different at $p < 0.05$.

This is supported by the finding of Pareyt and Delcour (2008) and Shazia *et al*. (2012), reported that the diameter of cookies developed from wheat and OFSP blend flour was increased. So that the diameter was reduced due to the lower elasticity nature in sweet potato flour. When the proportion of soya bean increased in the blended cookies, the diameter of cookies' was increased irregularly, this could be due to the lower elasticity nature of the soya bean protein (Pragya *et al*., 2016 and Abayomi *et al*., 2013).

3.1.2 Thickness

As shown on Table 2, there was a significant difference on the thickness of C, T1, T2, T3, T5, and T6 cookies developed by the blends of durum wheat, sweet potato and soybean at ($p<0.05$). The thickness of cookies decreased when more sweet potato flour was added to wheat during the cookies development. This is agreed with the finding of Shazia *et al*. (2012) and Sukhcharn *et al.* (2008) were reported that thickness of cookies developed from sweet potato supplemented with wheat flour was reduced with addition of more sweet potato flour. This might be due to the heat applied and water holding capacity of potato flour (Pragya *et al*., 2016). The ratio of soybean increased regularly but the thickness of cookies was increased irregularly. This might be due to the lower elasticity nature of the soya bean protein (Pragya *et al*., 2016 and Abayomi *et al*., 2013).

3.1.3 Spread Ratio

The spread ratio of cookies presented in Table 2 indicated that the increase in sweet potato flour supplementation made the decrease in spread ratio of cookies. The present study finding was similar to the findings of Sharif *et al.* (2009), who reported that spread factor of sweet potato flour supplemented wheat cookies decreased with the increasing of sweet potato flour. This might be due to water absorption capacity difference of sweet potato and wheat flour. Sukhcharn *et al.* (2008) reported that spread factor of cookies developed from wheat was higher than sweet potato blends. The spread factor was greater for cookies made from wheat flour and decreased significantly with increasing of sweet potato proportion (Jemziyal and Mahendran, 2017). The finding was in line with the present study due to decreasing of spread factor by addition of more sweet potatoes in wheat during cookies development. When the proportion of soya bean increased in the blended cookies, the spread ratio of cookies' were irregularly increased, this might due to the fact that the lower elasticity nature of the soya bean protein (Pragya *et al*., 2016).

3.2 Proximate *analysis*

3.2.1 Moisture content

As shown on Table 3, there was a significant ($p<0.05$)difference in the moisture content of T2, T3, and T4 of the developed cookies, while there was no difference on C and T6, T1 and T7, and T5 and T8. With an increase in the sweet potato flour in the cookies, there was an irregular increase in the moisture content. This could be probably due to high water binding capacity of the starch in the sweet potato flour, which is in line with the finding of (Njintang *et al*., 2007). Moreover, the study reported by Gebremedhin *et al.* (2013), and Omer *et al.* (2014) on sweet potato and wheat blended bread, and on sorghum and sweet potato blended flat-bread, respectively were indicated that the increase in substitution level of sweet potato were associated with increased level of moisture content. Increased proportion of soybean resulted in irregular decrease of moisture content of cookies, this was agreed with the finding of Tharise *et al*. (2014), composite flour from cassava, rice, potato, soybean and xanthan gum the increment in soybean showed irregularity in moisture content.

3.2.2 Ash content

The blending proportion of soybean and sweet potato were found to have significant ($p<0.05$) effect on the ash

content of the cookies (Table 3). It was observed that the proportion of sweet potato flour and soybean flour increase in the blend, resulted in irregular increase in the ash content of the product. This result is in agreement with the result reported by Vasantharuba *et al*. (2012) about sweet potato and wheat blended bread, and also incorporation of sweet potato flour and soybean flour in making cookies enhanced the mineral content, as ash is an indicative of the amount of minerals content in any food sample (Laoye *et al*., 2007).

Table 3. Proximate composition of cookies

Blends	MC	Ash	Fat	protein
C (100W:0soy:0sp)	7.69± 0.55^{f}	2.25± 0.00^{d}	15.25± 0.35^{c}	13.25± 0.35^{e}
T1 (75W:25soy:0sp)	6.64± 0.51^{e}	2.95± 0.35^{bc}	17.75± 0.35^{a}	21.75± 0.35^{a}
T2 (75W:0soy:25sp)	12.95± 0.13^{a}	3.75± 0.35^{bc}	12.75± 0.35^{e}	12.75± 0.35^{g}
T3 (75W:2.5soy:22.5sp)	11.82± 0.54^{b}	3.45± 0.00^{b}	12.75± 0.35^{e}	16.75± 0.35^{f}
T4 (75W:22.5soy:2.5sp)	10.82± 0.34^{c}	3.00±0.35^{c}	17.25± 0.35^{a}	20.25± 0.35^{b}
T5 (75W:5soy:20sp)	9.24± 0.17^{d}	3.55± 0.35^{cd}	13.25± 0.35^{e}	17.25± 0.35^{e}
T6 (75W:20soy:5sp)	7.03± 0.69^{f}	3.95± 0.35^{a}	16.25± 0.35^{b}	19.25± 0.35^{c}
T7 (75W:17.5soy:7.5sp)	8.24± 0.17^{e}	2.75± 0.35^{bc}	14.25± 0.35^{d}	18.25± 0.35^{d}
T8 (75W:7.5soy:17.5sp)	10.39± 0.81^{d}	2.75± 0.35^{bc}	15.75± 0.35^{bc}	18.75± 0.35^{d}
LSD	1.1045	0.4554	0.7998	1.1045

Mean ± Standard deviation values within columns bearing with the same superscripts are not significantly different at $p < 0.05$.

3.2.3 Fat

The fat content of cookies was significantly affected at ($p<0.05$) by blend proportions of wheat, sweet potato and soybean (Table 3). As the amounts of sweet potato flour in the formulation increased, the amount of fat in the cookies decreased. This might be due to the presence of high fat in wheat than in sweet potato flour as the finding reported by Ifie (2011), who found the same trend on madiga (local bread in Nigeria) produced from composite flour of sweet potato and wheat blend. However, the decrease in the fat contents of the composite cookies observed in this study could be due to the heat imposed, duration of heating and the pH that leads to the destruction of nutrients Sharif *et al*. (2009). There was an irregular increase in fat content due to the increase in soybean flour proportion. This indicates that supplementing sweet potato flour with soybean flour could be greatly improved the `protein quality of cookies (Pragya *et al*., 2016). This could be due to the significant quantity of protein in the soy bean flour.

3.2.4 Protein

As Table 3 presented, there was a significant ($p<0.05$) difference in the protein content of the developed cookies. With an increased amount of soybean in the cookies, there was an increase in the protein content in soybean incorporated cookies. This indicates that supplementing wheat and soy bean flour would greatly improve the protein nutritional quality of cookies produced Pragya *et al*. (2016). On the other hand, as the amounts of sweet potato flour in the formulation increased, resulted in decreased amount of protein in the cookies, which is inversely proportional. This could be due to low protein content of sweet potato. Similar report was made by Okorie and Onyeneke (2012), for cookies from sweet potato and wheat.

3.3 Sensory evaluation

The sensory evaluation of the cookies revealed that there were no differences (Table 4) among the entire samples; this implies that control sample and treated samples were equally preferred by the panelists. This was similar to the finding reported in West Kenya on OFSP and sweet potato incorporated food product (Rono *et al*., 2006), which was accepted in producers and consumers side. Vasantharuba *et al*. (2012) also reported that a substitution of 30% of wheat flour by sweet potato flour was feasible and acceptable for baked products. Consumer tests in a market in Mozambique showed a strong preference for golden bread made with boiled and mashed sweet potato 38% of weight of wheat flour (Graham *et al*., 2009). This result was also in agreement with Sukhcharn *et al*. (2008); this states that the substitution level of sweet potato flour for cookies up to 40% was acceptable. Greene *et al*. (2004) reported that sweet potato flour can be used as substitute of wheat flour in amount of 25-50%, specifically in baked products without the change in the acceptability on the sensory attributes (Vasantharuba *et al*., 2012).

Table 4. Sensory evaluation of cookies

Blends	Color	Taste	Crispness	Texture	Appearance	Over all acceptability
C (100W:0soy:0sp)	6.20±1.42 *a*	6.20±1.40 *a*	6.47±1.50 *a*	6.63±1.61 *a*	6.23±1.41 *a*	6.83±1.42 *a*
T1 (75W:25soy:0sp)	6.88±1.38 *a*	6.66±1.31 *a*	6.93±1.62 *a*	6.47±1.25 *a*	6.77±1.55 *a*	6.70±1.21 *a*
T2 (75W:0soy:25sp)	6.03±1.62 *a*	6.76±1.33 *a*	6.94±1.16 *a*	6.30±1.53 *a*	6.23±1.54 *a*	6.70±1.49 *a*
T3 (75W:2.5soy:22.5sp)	6.87±1.35 *a*	6.97±1.50 *a*	6.77±1.77 *a*	6.80±1.75 *a*	6.50±1.48 *a*	6.93±1.60 *a*
T4 (75W:22.5soy:2.5sp)	6.13±1.25 *a*	6.93±0.97 *a*	6.47±1.26 *a*	6.93±1.17 *a*	6.17±1.29 *a*	6.33±1.10 *a*
T5 (75W:5soy:20sp)	6.67±1.12 *a*	6.97±1.25 *a*	6.80±1.45 *a*	6.67±1.21 *a*	6.83±1.64 *a*	6.10±1.77 *a*
T6 (75W:20soy:5sp)	6.64±0.84 *a*	6.37±0.93 *a*	6.71±1.07 *a*	6.54±0.98 *a*	6.47±1.01 *a*	6.87±0.90 *a*
T7 (75W:17.5soy:7.5sp)	6.70±1.18 *a*	6.90±1.24 *a*	6.80±1.13 *a*	6.87±1.22 *a*	6.70±1.37 *a*	6.13±1.38 *a*
T8 (75W:7.5soy:17.5sp)	6.30±1.62 *a*	6.03±1.45 *a*	6.90±1.58 *a*	6.850±1.36 *a*	6.87±1.85 *a*	6.13±1.72 *a*
LSD	0.2265	0.2488	0.2177	0.293	0.2482	0.222

Mean ± Standard deviation values within columns bearing with the same superscripts are not significantly different at $p < 0.05$.

4. Conclusion and Recommendation

4.1 Conclusion

Blends of sweet potato and soybean flour with wheat flour have significant effect on the physical properties of the cookies. Cookies from wheat, soybean and sweet potato flour blends had improved proximate composition compared to cookies from wheat to some extent. This study has shown that cookies containing 20%, 5%, 7.5% and 5% soybean flour and 5%, 20%, 17.5% and 20% sweet potato flour have great potentials and compare favorably with 100% wheat in moisture, ash, fat and protein content. Thus their use would go a long way in reducing dependency on importing wheat for wheat flour preparations. Sweet potato and soybean flour mixed with wheat flour cookies have equally accepted in physical and organoleptic characteristics as compared to 100% wheat flour cookies.

4.2 Recommendations

The outcome of the present research can be used as valuable information source for the development of high fiber low gluten sweet crunchy cookies. The results obtained could be very valuable in decision making for industries that want to take nutritional advantage of sweet potato flour as alternative or supplement to cereal flours. However, more research is recommended:

- as if the shelf life of the cookies is determined to evaluate the keeping quality of the product.
- as if the functional quality of the composite flour is determined.

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