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Physicochemical and Sensory Quality of Biscuits from Composite Flour of Wheat, Moringa and Potato

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Abstract

Biscuit is an important staple food in many developing countries and it is commonly prepared from wheat flour alone. However, a biscuit which is made only from wheat may not give a nutritionally balanced diet. Therefore, the aim of this research is to investigate the possibilities of improving the physical properties and sensory qualities of the biscuit with partial substitution of wheat by moringa and potato flour.The wheat flour (WF) was substituted by moringa flour (MF) and potato flour PFat levels of 0%, 5%, 10%, 15%, and 20%. Nine treatment combinations were generated by Minitab software version 16 mixture designs from the blend of wheat, moringa and potato flour. Moisture contents, ash and physical property (thickness, diameter, and spread ratio) and sensory quality of the biscuit were evaluated using standard procedure. Data were analyzed using Minitab software. The result showed that moisture and ash contents of the biscuit varied from 1.5% to 9% and, 1.7% to 2.9% respectively. Physical properties of the biscuits; diameter, thickness and spread ratio varied from 55.2mm to 58.25mm, 10.2mm to 10.55mm, and 5.3 to 5.7 respectively. The sensory preference of the biscuit varies from 2. 4 to 4.2 in 5 hedonic scale evaluation. Increase in the levels of moringa and potato flour in the blend resulted in increased ash content, flavor, taste, overall acceptability, thickness and spread ratio of the biscuit. However, increasing the proportion of moringa flour in the blend decreases color and texture of the biscuit. The finding revealed that the inclusion of potato and moringa flour improved physicochemical and sensory properties of the biscuit. Generally blending at optimum ratio;68.06%wheat flour,16.94% moringa and15% potato flour can be used to produce biscuit with improved nutritional and sensory qualities. Further investigation is required to determine mineral and proximate compositions which are not addressed in this study.

Keywords: Moringa Leaf Flour; Potato Flour; Composite Flours; Biscuits; Physicochemical and Organoleptic Quality

Introduction

The consumption of cereal snack foods such as biscuits (also known as cookies), wafers and short bread has become very popular especially among children. Biscuits possess several attractive features including wider consumption base, relatively long shelf life and good eating quality [1]. Biscuit and biscuit-like products have been made and eaten by man for many hundreds if not thousands of years and their good eaten quality makes them attractive for protein fortification and nutritional improvements, particularly in children feeding programmes, for the elderly and low income groups [1]. The quality of biscuits is influenced by several factors like quality and level of ingredients used, and processing conditions such as mixing, resting and molding of the dough, and baking and cooling of the biscuits. Several ingredients are used in biscuit formulation which includes wheat flour, sugar, vegetable fat, milk powder, salt, leavening agents, flavors, and preservatives [2]. Among the ingredients, the quality of flour, sugar and fat greatly influence the quality of biscuits.

At present, wheat is produced solely under rained conditions [3]. Wheat is probably the most common cereal available all over the world and is in even higher demand in recent years due to its abundant health benefits. Wheat flour is the main ingredient for biscuit production, though imported; it is a carbohydrate based food raw material and also lack some nutrients. In many countries, biscuits are prepared with fortified or composite flour to increase their nutritive value [4].

The potato is a root vegetable native to the Americas, a starchy tuber of the plant Solanumtuberosum, and the plant itself is a perennial in the nightshade family, Solanaceae. Egata [5] described that among Africa countries, Ethiopia has the most potential of potato production because of high land comprises 70% of the country and home to higher percent of the production. Today roots and tubers are the third largest carbohydrate food source in the world with potatoes representing nearly half of all roots crop consumed [6]. Potato tubers are excellent food source for providing energy from carbohydrate, but are also rich in vitamins and minerals and present high quality protein [7]. Potato contributes key nutrients to diet including vitamin C, Potassium, dietary fiber [8]. Potatoes also contain dietary antioxidants, which may play a part in preventing diseases related to ageing, and dietary fibre, which benefits health [9].

Moringa, often referred to as the "miracle tree", leaves are good sources of protein, vitamins and minerals, but poor in carbohydrates and fat, and can be used as a complementary food security crop in different developing countries, including Ethiopia [10-12]. The Nutrition content moringa plants plays an essential function in medicinal, nutritional, and therapeutic properties [13]. In Ethiopia Moringastenopetala is widely cultivated in different zones of the country and is found in more the in Oromia and SNNP [9]. Moringais an important food commodity which has had enormous attention as the nature tropics. The leaves of Moringaare rich in minerals like calcium, potassium, zinc, magnesium, iron and copper [14]. Vitamins like beta-carotene of vitamin A, vitamin B such as folic acid, pyridoxine and nicotinic acid, vitamin C, D and E also present in Moringa [15]. Moringa helps in controlling different health complications such as diabetes, anemia and high blood pressure. An extract from the Moringa leaf has been shown to be effective in lowering blood sugar levels within 3 hours ingestion, though less effectively than the standard hypoglycemic drug it could be regarded as a more natural alternative [16]. Moringa leaves contain isothiocyanates that attenuate in vivo inflammation [17]. Due to antioxidant properties the regular intake of Moringa leaves through diet can protect normal as well as diabetic patients against oxidative damage [18]. Moringa leaf powder in nutrition biscuits; cookies make more comprehensive nutrition than ordinary biscuits, balance. Therefore, the aim of this finding is to obtain improved quality of biscuit from composite flour of moringa leaf powder and potato flour to enrich and restore the nutrients lost from wheat during processing into flour.

Materials and Methods

Raw Materials and Its Preparation

Raw Materials and its Source: The raw materials (wheat flour, potato, and salt, sugar, baking powder and shortening) were purchased from Jimma local market. Based on skin color and size, potato variety which is commonly preferred by the society was purchased and used for the experiment. Moringa leaf was purchased from Jimma town and processed into flour as indicated in Figure 1.

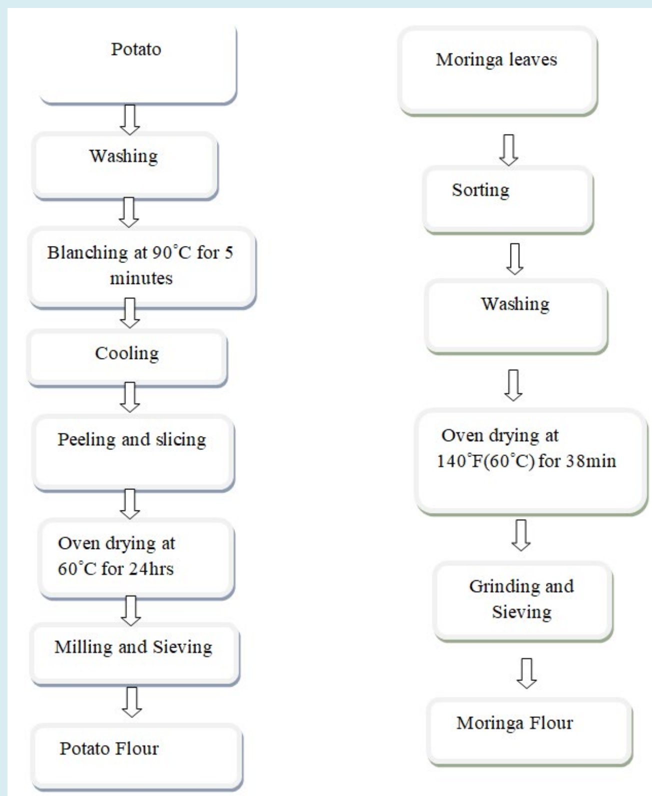

Figure 1: Process of moringa and potato flour preparation. Source: [19,20]

Preparation of Potato Flour: Uniform sized potatoes having no signs of infection was soaked in water to remove any adhering soil, dirt and dust. The potatoes peeled and sliced. Then also it was blanched at 90oc for 5 minutes. The blanched potatoes cooled and dried by oven at 600C for 24 hours. After complete drying, the flour was milled and allowed passing through sieve to obtain fine flour [19].

Preparation of Moringa Flour: The leaflet was stripped, washed thoroughly, spread in well on tray and dry in the oven at 1400F (600C) for 38minThe dried leaves was grounded and sieved using kitchen sieve to get moringa leaf flour [20]. The flour was packed and sealed in polyethylene bags. The below flow diagrams display the procedures of potato and moringa flour preparation.

Experimental Design and Formulation of Composite Flour

The formulation of composite flour was done by considering some important facts about the characteristics of biscuits and based on previous studies. The major components of biscuits were soft wheat flour, since flours that produce biscuits with larger spread and softer texture are favored and many studies shows that incorporation of non-gluten flour to wheat flour will affect important quality indices of biscuits such as sensory qualities and textural properties [21]. Therefore, in this study wheat was considered as a major ingredient and the lower limit was taken as 60% in the composite flour formulation and the rest 40 % was used for manipulation of the composite flour based on previous studies.

The lower and upper limits for each component in composite flour are indicated in Table 1 here under. Using the upper and lower value indicated in Table 1, a total of nine run was generated using Minitab software which uses mixture design. The experimental run generated are indicated in Table 2 and. blending of wheat flour, moringa flour and potato flour was according to the proportion indicated in the table. After making blending based on the run the flours were packed polyethylene bags and stored at room temperature until use for the biscuits production.

Components in composite flours	lower value	upper value
WF %	60	100
PF %	0	20
MF %	0	20

Table 1: Percentage composition of composite flour.
PF =Potato flour, WF=Wheat flour, MF =Moringa flour.

StdOrder	Run order	Pt Type	Blocks	Wheat	Potato	Moringa
3	1	1	1	80	0	20
4	2	1	1	80	20	0
5	3	0	1	80	10	10
9	4	-1	1	80	15	5
1	5	1	1	60	20	20
6	6	-1	1	70	15	15
8	7	-1	1	80	5	15
7	8	-1	1	90	5	5
2	9	1	1	100	0	0

Table 2: Experimental run generated by mixture design using Minitab software.

Process of Biscuit Manufacturing

The composite flour was mixed with the other ingredients such as sugar, shortening, baking powder and salt, and then slowly mixed with the addition of water to prepare dough. The weight of Composite flour (100 g), sugar (20g), oil (20ml), salt (1g), baking powder (2g) and water (75ml) will be mixed manually in bowl to prepare each nine biscuits [4]. The dough was prepared by manual kneading of all the dry and liquid ingredients to attain uniformity with desirable visco-elastic characteristics. When dough was ready for baking, it was kept for 2hr as it is and then sheeted by rolling balls of dough on wooden platform. These sheets was cut by hand and arranged on oil coated tray and kept for baking.

Baking was carried out at 160oC for 25-30min in oven [22]. Finally, it was taken from the oven and cooled to minimize the raised heat during baking, and then the product was packed in the polypropylene packaging material (Figure 2).

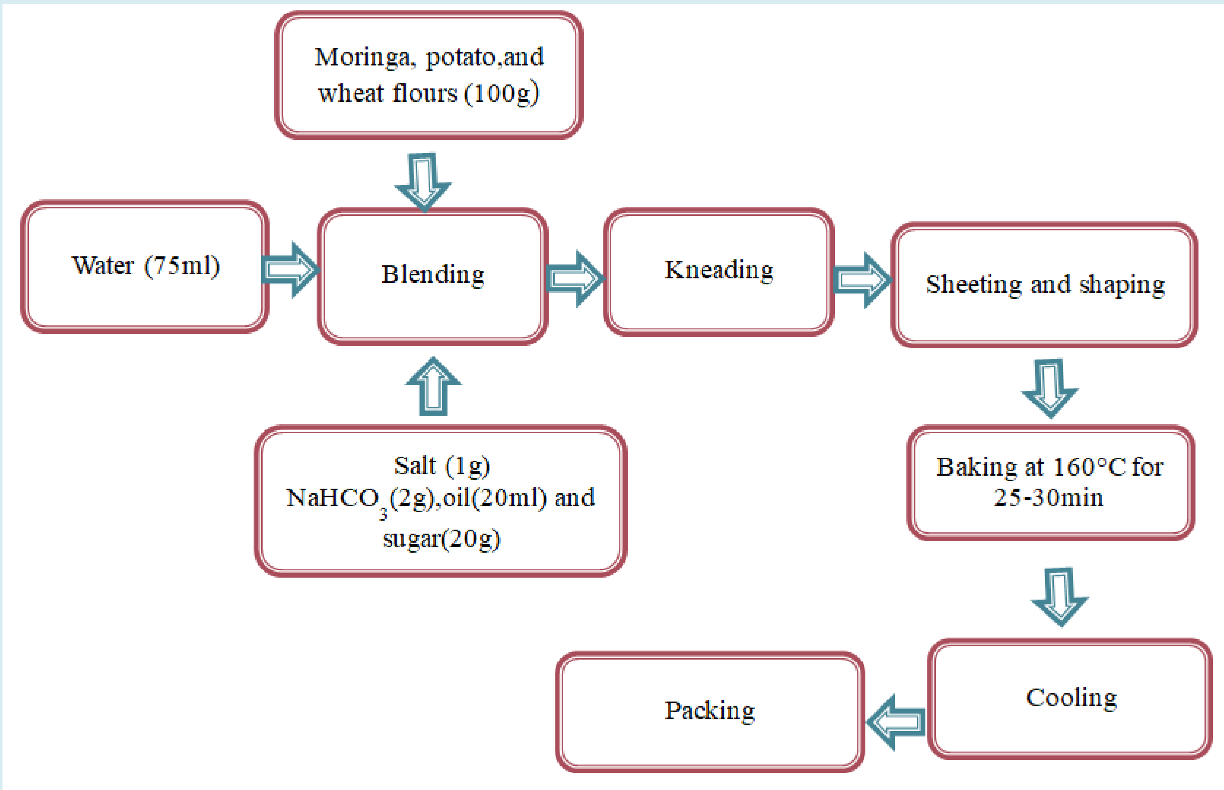

Figure 2: Process flow diagrams of Biscuit Production in the laboratory room.
Source: [22]

Data Collected

Physical properties, proximate and sensory data were collected. Some of the property of biscuits samples was determined according to the below methods.

Physical Properties of Biscuits

Diameter: To determine the diameter (D), nine biscuits were measured by digital Vernier caliper. The diameter of the each of nine biscuits was measured in mm by using a ruler. The biscuit was rotated at an angle of 90o for duplicate reading. It was repeated once more and average diameter was taken in mm (millimeter).

Thickness: The thickness of biscuits was measured in millimeters with the help of digital Vernier caliper. This process was repeated twice to get an average value and results was taken in millimeter (mm) [23].

Spread Factor: Spread ratio or diameter is used to determine the quality of flour used in preparing biscuits and the ability of the biscuit to rise [24]. The higher the spread ratio of biscuit the more desirable it is Chauhan A, et al. [25]. Spread factor (SF) was determined from the diameter and thickness, with the following formula.

$$SF = D/T$$

Where T and Dare thickness and diameter of the sample respectively

Proximate Composition

Moisture Determination: The moisture content was determined by hot air oven method as described by AOAC [26]. An empty Petri dish was weighed dried first in oven for 15 minutes and 2g of the samples were transferred into the Petri dish. The Petri dish was taken into the hot air oven and dried for 6 hours at 100°C. The Petri dishes were cooled in the desiccators and their weights were taken. The loss in weight was taken as moisture content and expressed as

$$(\%)\ \text{Moisture content} = (IW-FW)/IW \times 100$$

Where, IW =Initial weight of sample before moisture is

vaporized
FW=Final weight of the sample after its moisture is vaporized

Ash Determination: Ash content was determined using the method of AOAC [26]. Since ash content is the minerals content of the food matrix or component which has low in volatility, so that it will not be vaporized at 550°C.About 5 g of each sample was weighed into crucibles. Then the sample was placed in a muffle furnace at 550°C for overnight. After that the sample was taken and kept in desiccators to avoid reabsorption of moisture and weighed to obtain ash content.

$$Ash\ (\%) = (M3 - M1)/(M2 - M1) \times 100$$

Where;
M3= Weight of ash + crucible
M2=Weight of crucible + sample and
M1=Weight of crucible

Sensory Properties of Biscuits: Sensory Properties of biscuits samples were evaluated by selecting, 30 untrained panelists students from Jimma University, department of Post-harvest management. The biscuits were served in random order identified by codes. This analysis was conducted in food science and post-harvest technology laboratory. Before participating on panels Panelists were advised to avoid strong odorous materials, such as soaps, lotions and perfumes and also to avoid eating, drinking or smoking at least for 30 minutes. Consumers were asked to fill questionnaire prepared for the evaluation of sensory attributes of the biscuits samples like, crispness, appearance, color, flavor, taste, and overall acceptability using, five hedonic scale Like very much = 5, like moderately = 4, neither like nor dislike = 3, dislike moderately = 2, dislike very much = 1 [27].

Data Analysis

The experiment was analyzed by Mixture Design and modeled using statistical software packages (Minitab version 16) to generate second degree polynomial. The significant terms in the models was identified by analysis of variance (ANOVA) for each response and accepted at 0.05 level of probability. To visualize the combined effects of two of the factors on the response, surface/contour plots was generated by keeping the third factor at the center. Numerical optimization of mixture ratio, within the experimental range of conditions, was carried out with the objective of finding optimum levels of mixing ratio that would give optimum levels of physicochemical and sensory property of biscuit.

Result and Discussion

Moisture and Ash Contents of the Biscuit

The moisture and ash contents of the biscuits prepared from different mixtures of composite flour are presented in Table 4. Analysis of variance (ANOVA) for the p-value of moisture and ash contents of the biscuit was summarized in Table 3.

Sources	M.C	Ash
Linear	0.646	0.161
Quadratic	0.75	0.787
M*P	0.878	0.525
M*W	0.623	0.631

Table 3: Analysis of variance (ANOVA) for the p-value of moisture and ash contents of the Biscuit.
M= Moringa, P= Potato, W= Wheat

The values of moisture and ash contents of the biscuit prepared from the blend of wheat, potato and moringa flour were indicated in the Table 4. The minimum and maximum value of moisture and ash content varies 1.5% to 9% and, 1.7% to 2.9% respectively.

Run order	Moringa	Potato	Wheat	Moisture Content %	Ash Content %
1	20	20	60	7.5	2.9
2	0	0	100	7	1.7
3	5	15	80	8.5	2.39
4	10	10	80	4.5	2.3
5	5	5	90	4	1.9
6	0	20	80	1.5	2.26
7	15	15	70	6	2.2
8	15	5	80	3.5	2.36
9	20	0	80	9	2.37

Table 4: Measured values for moisture and ash contents of biscuits.

Moisture Content Analysis

The moisture content of the biscuits flour varied between 1.5% and 9% indicated in table 4.the moisture contents of the biscuit showed no significance difference at the interaction of the component and model. However, the moisture content of the biscuit increased with the increment moringa flour in the blend. This might be due to moringa flour has high water holding capacity. Similar result has been reported, moringa flour has the highest ability to hold water [28]. In contrast to this finding has been reported that as the proportion of potato four increases the moisture content of biscuit is also increased [29]. The variation in moisture content of the biscuit might be duet to difference preparation procedure, variety of ingredient used and geographical difference of the ingredients.

Ash Content Analysis

Ash content was not significantly affected by interaction of blending ratio of the composite flour. Ash content is an estimate of the total mineral content in a given quantity of food substance [30]. In this research it was found in the range of 1.7% - 2.9% in the biscuits. The lowest value corresponded to the sample containing (0%, 0% and 100%) moringa, potato and wheat respectively. Maximum was recorded from the biscuits which was made 20% MF, 20%PF, and 60% WF. The Figure 3 indicated increasing the proportion of moringa flour in the blend increased the ash contents of the biscuit. The ash content of biscuits was not show a significance (p>0.05), but there was a change in ash content from proportion of wheat, moringa and potato in the blends (Table 4). The differences were observed because the ash content of the blends increased steadily with increasing content of moringa and potato flour. This might be because of high mineral contents of moringa and potato. The differences were observed because the ash content of the blends increased steadily with increasing content of moringa and potato flour. The result of current finding is in line with the researcher who stated that of the high content of ash in leaves of moringa increase the ash content of product [14].

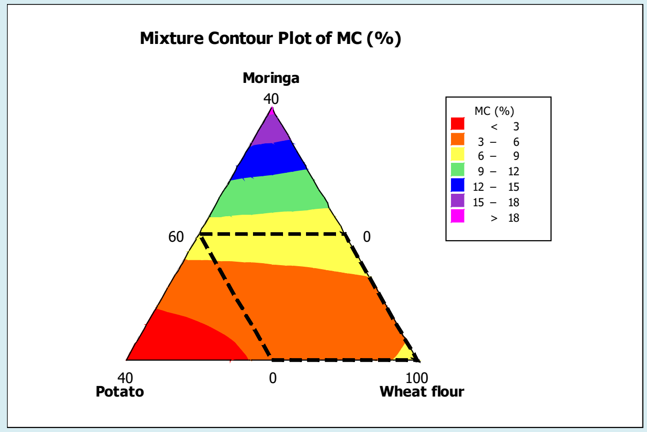

Figure 3: Contour plot of % ash content of biscuit prepared from wheat, potato and moringa flour.
MC% = Moisture Content

Physical Properties of Biscuit

The values of physical properties (thickness, diameter and spread ration) of the biscuit prepared from wheat potato and moringa flour were indicated in Table 5. There were no significant (p > .05) differences in the thickness, diameter, and spread ratio of the biscuit samples (Table 6). The thickness of the biscuits increased as the inclusion of MF and WF increased in the biscuit formulation.

Components			physical analysis		
M	P	W	Thickness(Mm)	Diameter(Mm)	Spread Ratio
20	20	60	10.36	55.5	5.35
0	0	100	10.2	58.25	5.7
5	15	80	10.45	56.7	5.4
10	10	80	10.5	56	5.3
5	5	90	10.45	57	5.45
0	0	80	10.36	55.6	5.37
15	15	70	10.36	55.25	5.33
15	15	80	10.36	58.2	5.67
20	0	80	10.55	55.65	5.17

Table 5: Measured values for physical properties of biscuits.
Where M=Moringa, P=potato and W=Wheat

Sources	thickness	diameter	spread ratio
Linear	0.388	0.243	0.277
Quadratic	0.213	0.651	0.491
M *P	0.964	0.463	0.675
M*W	0.319	0.694	0.828

Table 6: Analysis of variance (ANOVA) for the p-value of physical properties of Biscuit.
Where; M=Moringa, P=potato and W=Wheat

Thickness: The thickness was significantly affected by increasing the level of incorporation of moringa flour. The thickness of the control was 10.2 mm lowest among samples, while the highest thickness was 10.55 mm which was observed in biscuits made from 20%, 0% and 80% of moringa, potato and wheat flour respectively. Singh [31] also reported similar observations when wheat flour was substituted with 20 - 80% potato flour (Figure 4).

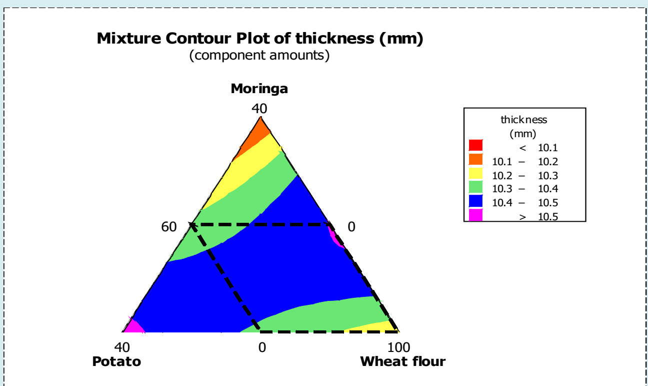

Figure 4: Effects of formulation on thickness of biscuits indicated by contour graph.

Diameter: Before baking biscuits had equal diameter but after baking their diameter varied from 55.25-58.25 mm with no significance difference. However, when average values are compared, bigger diameter (58.25 mm) was measured for biscuit baked from 100%WFand smaller one (55.25 mm) from baked biscuits from 15% PF, 15%MF and 70%WF (Table 5). Increasing the proportion of moringa and potato flour in the blend decreased the diameter of the biscuit and increasing the proportion of wheat flour in the blend increased diameter of the biscuit as indicated in Figure 5. This is due to the availability of gluten which has a great role in increment of the volume of biscuit. Similarly, Srivastava, et al. [32] reported that increase in level of potato flour resulted in linear decrease of thickness and diameter of biscuit.

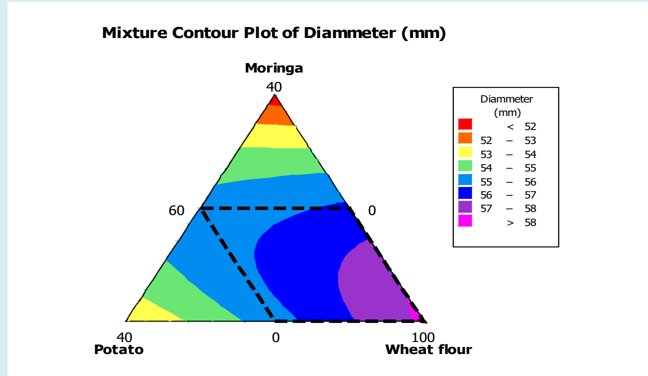

Figure 5: Effects of formulation on diameter of biscuits indicated by contour graph.

Spread Ratio: The spread ratio of biscuits was varied from 5.3 (from flour of 10%MF, 10%PF, and 80%WF) to 5.7 (from 0%MF, 0%PF, and 100%WF). Spread ratio is used to determine the quality of flour used in preparing biscuits and the ability of the biscuit to rise [24]. The higher the spread ratio of biscuit the more desirable it is [25]. High spread ratio was obtained from the biscuit prepared from the control flour containing 0% MF, 0%PF, and 100% W. Results show that the spread ratio of the composite biscuits displayed decreasing trend along with the increasing potato and moringa (Figure 6). The finding is in line with Mc Watters reported a decrease in spread ratio of cookies when wheat flour was supplemented with non-wheat flours. He opined that use of composite flour increases dough viscosity and forms aggregates by competing with limited free water available in cookie dough. However, this finding is contradicted with the finding of Singh, et al. [31] who reported that the spread ratio of cookies increased as non-wheat protein content increased. The variation might be due to preparation or processing condition of composite flour and the ingredients used.

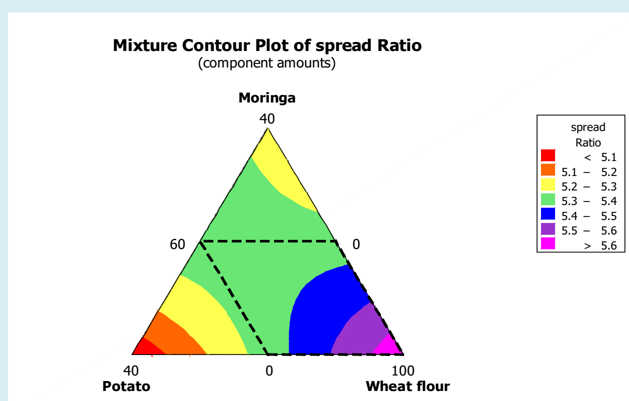

Figure 6: Effects of formulation on spread ratio of biscuits indicated by contour graph.

Sensory Evaluation

Sensory qualities are the main criteria that makes the product to be liked or disliked [33]. The mean values of the results of evaluation by panelist were analyzed statistically to assess the significant difference among the nine biscuits that were produced from the blends of wheat, moringa and potato flour. The mean score for sensory evaluation of the biscuits were indicated in Table 7.

Components			Sensory Evaluation				
Moringa	Potato	Wheat	Color	Flavor	Taste	Texture	O A
20	20	60	2.6	4	4	2.6	4.2
0	0	100	3.2	2	3	3.2	2.6
5	15	80	2.4	2.8	3	2.4	3.6
10	10	80	3.4	3.2	3.2	3.4	3.2
5	5	90	3.6	3.2	3.5	3.6	2.8
0	20	80	3.2	3	3.2	3.2	3.5
15	15	70	2.8	3.2	3.6	2.8	3
15	5	80	3.4	2.8	2.8	3.4	2.8
20	0	80	3.2	3.4	3.4	3.2	3.6

Table 7: Measured values of sensory quality parameters.
OA= overall acceptance; values indicating that 5- like very much, 4- like, 3- Neither like nor dislike, 2- dislike and 1- dislike very much

Sensory evaluation of the biscuit showed no significance difference (p>0.05) in linear and quadratic model as well as the interaction between the component (moringa with potato and moringa with wheat) on all of the sensory attributes of biscuits (Table 8). However, the biscuit which is composed from 20%MF, 20%PF, and 60%WF was obtained the greatest value in taste, flavor, and overall acceptability according to the preference of panelists.

Sources	Color	Flavor	Taste	Texture	OA
Linear	0.158	0.446	0.804	0.757	0.143
Quadratic	0.662	0.962	0.542	0.823	0.373
M*P	0.548	0.822	0.95	0.951	0.19
M*W	0.843	0.898	0.543	0.724	0.211

OA = Overall Acceptability.

Table 8: Analysis of variance (ANOVA) for the p-values of sensory properties of the Biscuit.

Color is a strong indicator of the acceptability of a product because a small improvement in color rating can result in a big difference in the acceptability of the product. The color and texture of biscuits made from 5%MF, 5%PF and 90%WF was preferred by panelists than the other sensory quality of the biscuits. The decreased sensory attributes of biscuit samples with increasing moringa leaves powder may be due to the color and odor of the dried green leaves.

The deep green color of moringa leaves (due to the chlorophyll pigment) has persisted during drying, milling of the leaves and later manifested in the biscuit after cooking. Similar responses were also reported on moringa-supplemented fortified products [34-39].

Except for texture and appearance, the sensory attributes of the biscuits increased with increasing the amount of moringa flour and potato in the blend. The research indicated that the inclusion of composite flour in the proportion of 60 % wheat, 20%PF and 20%MF could still give acceptable biscuits in taste, flavor, and overall acceptability. The sensory attributes such as texture, appearance, odor, taste and overall acceptance were illustrated by contour graph and response surface (Figure 7).

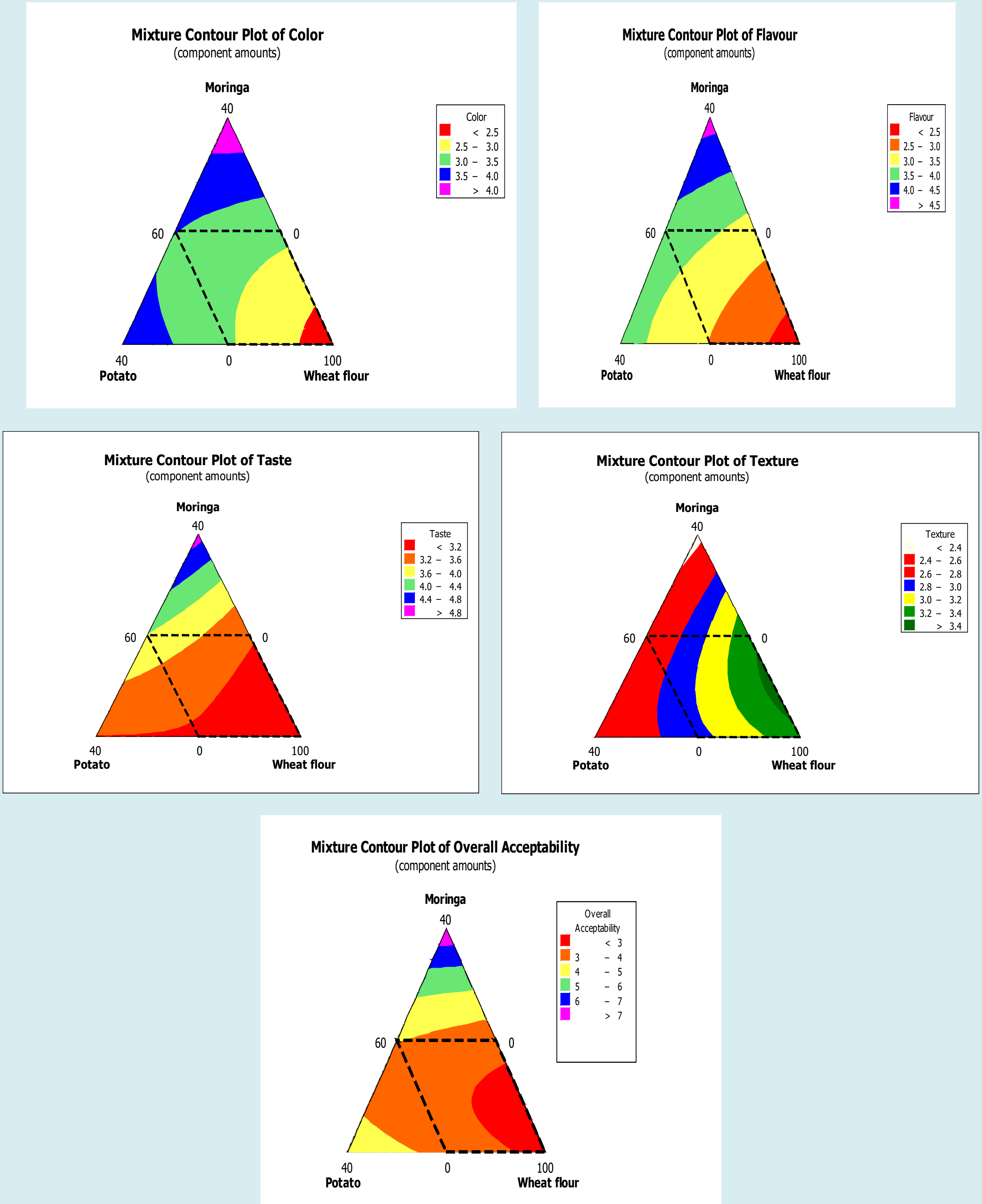

Figure 7: Effects of formulation on sensory attributes of biscuits indicated by contour graph.

Optimization of Blending Ratio Moringa, Potato and Wheat Flours

Overlaid plot of all response variables were generated by mixture design using Minitab software. The result showed that the optimum amount of moringa, potato, and wheat flour should be 16.9%, 15%and 68.06%respectively, at this optimum blending ratio of the three flours optimum values for physicochemical and sensory parameters were obtained from the experiment. Therefore, mixing wheat, potato and moringa flour at this optimized blending ratio will be the best to get optimized nutritionally and organoleptically acceptable biscuit (Table 9).

Flours amounts %			Optimum values for each parameters										
M	P	W	Mc%	Ash%	T(mm)	D(mm)	SR	col	flav	tast	Text	OA	Desirability (%)
16.94	15	68.06	6.46	2.56	10.4	55.8	5.35	3.3	3.54	3.6	2.84	3.58	57

Where Mc= Moisture Content, T =Thickness, D = Diameter, SR = Spread Ratio, Col= Color, Flav= Flavor, Tast=Taste, Text= Texture, OA= Overall Acceptability.

Table 9: Numerical optimization of the blending ratio of moringa,potato and wheat flour.

Conclusion

Biscuits possess several attractive features including wider consumption base, relatively long shelf life and good eating quality. However, preparing biscuits from wheat alone is not recommendable as it lacks important nutrients, vitamins and minerals. Substituting Moringa leaf powder and potato powder with wheat can improve the mineral and vitamin content of biscuits.

The result of this study indicated that, substituted wheat flour at the level of 40% with moringa and potato provides biscuit with improved physical properties and organoleptic acceptable to the consumer. Moreover, the study was conducted with the broad intention of increasing the consumption of moringa in the society by including it in the already established existing product i.e. biscuits with improved mineral content to minimize the problem of malnutrition in our country. Generally, it's advisable to blend 16.94%MF 15% PF and 68.06%WF to obtain biscuits with desirable physicochemical and organoleptically acceptable by consumers. Consumption of these alternative food ingredients in a form of biscuit can suppress nutrient deficiencies and can play a significant role in developing countries as a viable long-term food-based strategy to control nutrient deficiencies. Further investigation is required to determine mineral and proximate compositions which are not addressed in this study

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