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Functional, physical and sensory properties of cookies prepared from okara, red teff and wheat flours

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ABSTRACT

The present study was carried out to determine the effect of different proportions of red teff, wheat and okara on the physical, functional and sensory properties. The experiment was conducted in a D-optimal mixture design using Design Expert® and generated 16 runs with different proportions of three flours. The minimum and maximum values of red teff, wheat and okara were considered as 40-50%, 20-40% and 10-20% respectively. The functional, physical and sensory properties were determined for all the cookies as well as for the control sample (100% wheat) according to the standard methods. Statistically significant ($p \leq 0.05$) difference in bulk density was observed between red teff with okara. The water absorption capacity showed a highly significant difference ($p \leq 0.01$) in red teff with okara interaction. The highest hardness value (71 N) was recorded for cookies prepared from 40%, 10%, 50% of red teff, wheat and okara flour blends respectively, whereas the lowest value (23 N) was recorded for the control. The spread ratio of the cookies varied between 1.652 and 2.067. Okara concentrations affected the aroma and taste due to the beany flavour. The overall acceptability of cookies prepared from red teff, wheat and okara showed no significant difference ($p \leq 0.05$) in both linear and quadratic models and overall acceptability of the cookies from 100% wheat and blends was almost the same. In conclusion, the functional and physical properties of the cookies that are prepared with the different concentrations of okara, and teff blended cookies correspond to the levels shown by the control samples. In sensory analysis, overall acceptability of the cookies prepared with okara was similar to the control (only wheat). So, okara can be successfully used in the preparation of cookies.

Introduction

Snack food consumption has been increased due to urbanization and change of lifestyle (Pratima and Yadave, 2000). Cookies are baked food products with lower water activity compared to biscuits (Okaka, 2009). They are very popular among all age groups, especially in children; cookies are consumed broadly all over the world because of their reasonable price, convenience, nutritive values and extended shelf stability (Akubor, 2003; Hooda and Jood, 2005). The expected global market for cookies in 2016 was $1,825.00 billion US dollars (Euro monitor, 2012). Cookies have a significant role in baking industry due to the variety in taste, texture and aroma. Cookies are normally small in size, containing flat surface, sweet or low sweet food, usually prepared from wheat flour, milk powder, eggs, sugar, salt, butter or cooking oil or shortenings and water (Manley, 1998).

Some minor ingredients like sodium bicarbonate, ammonium bicarbonate and emulsifiers are optionally used in cookies preparation to improve the functional and sensory properties. Refined wheat flour is a principle ingredient in cookies because it is rich in gluten, as well as in starch, low dietary fibre and minerals. The resultant cookies from refined

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wheat flour are characterized as inferior in proteins, fat and mineral contents (Kent, 1994). To improve cookies nutritive value and make them suitable for different special requirements of people, there is a clear need for replacing refined wheat flour with other flours which contain superior nutritional characteristics (Hugo et al., 2000; Hasmadi et al., 2014).

Nowadays extensive studies on the preparation of cookies by fortification with some natively available and superior nutritional value flours, for instance, whey protein, wheat germ, mushroom, cassava, and water chestnut flours have been conducted (Okafor et al., 2002; Arshad et al., 2007; Aziah, et al., 2012; Bala et al., 2015; Wani et al., 2015). Okara is the white coloured solid residue generated as a byproduct in huge quantities from the soy beverage production and its related (tofu) industries (Smith et al., 1978; Travaglini et al., 1980). Dried okara contains 10% fat, 24% protein, 52.3% dietary fibre, 4% ash and considerable amounts of vitamins (Van Der Riet, 1989).

Bowles and Demiate (2006) reported that okara contains slightly higher amount of amino acids than soy milk, okara holds around 33% of isoflavonoids from soy bean. Okara is extensively used as a food ingredient in Japanese soups, salads and vegetable dishes and it is often said that it resembles coconut in its texture and form (Soy20/20, 2017). Okara contains high quality protein and researchers suggested it as a good, low cost source of nutrients for human beings. This high quality protein is accountable for binding of water and fat, emulsification and foaming properties, which affects the properties of the determined food.

Teff (*Eragrostis tef*) is an ancient tropical cereal, which belongs to family of *Poaceae*. Ethiopian highlands are famous for their diversity, and it is believed that teff has been domesticated there (Ketema 1997; Demissie 2001). Teff is a staple crop in Ethiopia and is used to make *injera*, an Ethiopian traditional fermented pancake (staple food), and different traditional beverages. In rest of the African countries, it is considered as minor crop, and is classified on the basis of the seed colour as white, red/brown and mixed for the marketing purposes (Tefera et al., 1995). Among all types of teff, red/ brown teff has been reported to contain superior quality of nutrients. Internationally, the demand of teff is rising because of its attractive nutritional profile (good source of Fe, Ca and Zn) and gluten-free nature (Bultosa and Taylor 2004). The demand for gluten-free foods is rising as more people are diagnosed with celiac disease and other types of gluten sensitivities (Dekking et al., 2005; Hopman et al., 2008). Recently, cookies are prepared with composite flours, not only to improve the nutritional quality, but also the desired physical and functional properties of the end product.

The composition of flours in the preparation of cookies is directly affecting the different physical and functional characteristics apart from the nutritional properties. It is an inexpensive process to use cereals or any other grains or pulses as a replacement for wheat. The nutritional content of cookies can also be enhanced to a great extent, which cannot be provided by the white flour (Chavan and Kadam, 1993; Arshad et al., 2007). As consumers become more focused on their health, demand for functional foods has increased. Therefore, cookies prepared with fortified flours containing a significant amount of non-traditional sources (mixing with composite flours) and having acceptable sensory, functional, physical properties are desirable.

The texture of the food is related to its physical properties which depend on its chemical composition. Texture is one of the prime sensory and physical attributes for the acceptance of cookies, determining their quality (Gaines et al., 1992). Cookies contain a slightly compacted granular structure and air is trapped in those granules without the uniform distribution. Changes in the composition of the ingredients and processes cause variations in the texture (Zoulias et al., 2002). Functional properties are very important for the acceptability of the bakery products. The ingredients, individually, can have more than one function in a product (Cauvin and Young, 2006). The main objective of the present research is to evaluate the effect of different concentrations of wheat, teff and dried okara flours on the selected physical, functional and sensory properties of the cookies.

Materials and methods

Sample collection

Soybean (Avgat) was obtained from Jimma Agricultural Research Center, Ethiopia and Red teff (H-0199) and Wheat (Digalu) were obtained from Holeta Agricultural Research Center, Ethiopia. The other ingredients required for the preparation of cookies, like eggs, were collected from College Poultry farm (College of Agriculture and Veterinary Medicine, Jimma, Ethiopia), while milk powder, baking powder, table salt, sugar and shortening were obtained from the local market (*markato*). The experiment was conducted in laboratories of Post-Harvest Management department, College of Agriculture and Veterinary Medicine, Jimma University, Jimma, Ethiopia.

Sample preparation

Collected red teff and wheat were carefully manually cleaned to remove contaminants and immature grains. The cleaned grains were ground into flour in an attrition mill and sieved through a 0.5 mm sieve and packed in airtight polyethylene plastic bags for further research (AACC, 2000). The left over residue (okara) of a specified variety of the soy milk processing was collected from my co-researcher (who used Avgat soybean variety). The collected okara was dried in a hot air oven at 60 ^{o}C temperatures for 24 hrs. The dried samples were ground into flour using an attrition mill and passed through 0.5 mm sieve and packed in polyethylene plastic bags for further research (Wickramarathna and Arampath, 2003).

Experimental design

A 16-run constrained D-optimal mixture experiment was generated using design Expert® (Version 8.0, Stat-Ease) software. The range of flours used to prepare cookies was 20-40% red teff, 10-20% wheat and 40-50% okara and one sample was considered as control with 100% wheat flour, the total runs in present experiment were 17. The range of flours used in the preparation of cookies in this study was based on both preliminary studies and available literature (Chen et al., 2003; Chinma and Gernah, 2007; Aziah et al., 2012; Coleman et al., 2013; Nwanekezi, 2013; Hrušková and Švec, 2015).

Cookies preparation

Total of 17 cookies samples was prepared from the composite flour with a minor modification according to the method reported by Aziah et al. (2012). For 1000 g composite flour, whole egg (60 g), powdered milk (20 g), baking powder (0.1 g), salt (1 g), sugar (200 g) and 250 ml of deionized water were mixed in a bowl by a dough mixer (Hamilton Beach 63325, India) until a stiff paste was obtained and kept aside. In other mixer, creaming of shortening (60 g) was done until foaming occurred. The previous blend was added to the creamy mass of shortening and mixed for 10 min at medium speed in a laboratory dough mixer (Hamilton Beach 63325, India). The dough was allowed to rest for 30 minutes at room temperature and rolled to thickness of 0.3 cm on a floured board using a rolling pin. The rolled dough was cut by pre-moulded cookies shape, arranged on a grease tray and baked at 120 ^{o}C for 15 min in a convection oven (Kookmate, India) (temperature and time were determined in preliminary work). Following the baking, cookies were cooled to ambient temperature, packed in polyethylene plastic bags and kept in airtight plastic containers for the subsequent laboratory analyses.

Functional and physical properties

Bulk density

Bulk density was determined by the method of Adeleke and Odedeji (2010). 50 g of cookies sample was put into a 100 ml measuring cylinder. The cylinder was tapped several times on a laboratory bench to a constant volume. The volume of sample was recorded and bulk density was calculated using the following equation 1.

$$\text{Bulk density (g/cm}^3) = \frac{\text{weight of the sample}}{\text{Volume of the sample after tapping}}$$

Water absorption capacity (WAC)

The WAC was determined using the method developed by Beuchat (1977). One gram of sample was mixed with 10 mL of distilled water for 30 seconds at high agitations (set on fast speed). The samples were allowed to stand at room temperature for 30 min, centrifuged at 2000 rpm (Centrifuge model 800-1) for 30 min and the volume of the supernatant was measured by a 10 mL graduated cylinder. The percentage WAC was calculated as:

$$\text{Water absorption capacity} = \frac{\text{Weight of water bound}}{\text{Weight of sample (dry base)}} \text{ x } 100$$

Physical properties

Texture determination

Texture Profile Analysis (TPA) of cookies samples was performed in triplicate using a Texture Analyzer (TA.XT PLUS, Canners Machinery Ltd. Simcoe, Ontario, Canada). Hardness was determined by compression with 50 kg of load. The probe (30 mm^2), Ottawa cell with a solid base plate was used (Instron Corporation, Canton, Massachusetts 02021, USA). Pre-test speed of 1.00 mm/s, Test speed of 5 mm/s, Post-test speed of 10 mm/s, Distance of 30 mm, Data acquisition rate of 400 points per second and Trigger force of 0.3 Newton were the parameters used to determine the texture of the cookies. Major peaks were obtained in the product during compression. The first peak of the force-distance plot of the texture analyzer was interpreted as hardness of the product, expressed in Newton (N) (Chakraborty et al., 2009).

Determination of thickness

Thickness was determined using a calibrated ruler as described by Ayo et al. (2007) and using a digital Venier caliper (Fowler, US). The measurement was repeated thrice to get an average value and results were reported in mm (AACC, 2000).

Diameter

Diameter was measured by two ways: a digital Vernier caliper (Fowler, US) and a calibrated ruler as described by Ayo et al. (2007).

Spread ratio

Spread ratio was calculated as diameter (length) to thickness ratio (Shrestha and Noomhorm, 2002) by using the following equation:

$$\text{Spread ratio}=\frac{\text{Diameter}}{\text{Thickness}}$$

Sensory evaluation

Prepared cookies were coded with three digits randomly and were allowed for the sensory evaluation. The sensory attributes that were measured were colour, aroma, taste, crispness and overall acceptability using a five point hedonic scale, where 1= dislike extremely, 2= dislike moderately, 3= neither like nor dislike, 4= like moderately and 5= like extremely (Muhimbula et al., 2011). A total of 50 untrained consumer panelists participated in this study. The panelists were instructed to palate cleaning with water after tasting each coded sample and before moving to the next. The scores of all judges for each sample were then summed up and divided by the number of panellists to find the mean value.

Statistical analysis

The data collected from the laboratory experiment was analyzed by using Minitab ver. 16 software package. The statistical significance of the terms in the regression equations was examined by the analysis of variance (ANOVA) for each response and the significance test level was set at 5% ($p \leq 0.05$). The normal distribution of all data was checked. The fitted models for all the parameters were generated in two-dimensional contour plots. Finally, graphical optimization was carried out to determine the optimum formula of okara based cookies by substituting some level of red teff and wheat in terms of functional, physical and sensory attributes (Montgomery, 2013).

Results and discussion

The Analysis of variance p-value of functional, physical and sensory properties of cookies prepared from blends of wheat, okara and red teff flours are presented in Table 1.

Functional properties

Models for functional properties indicated that the lack-of-fit were significantly different at 5% probability level (Table 1). Diagnostic tools like normal distribution plot of residuals indicated that the residuals of all the response variables were normally distributed. The mean values of functional properties for cookies such as water absorption capacity and bulk density are summarised in Table 2.
The bulk density of cookies prepared from the blended/composite flours varied between 0.62-0.75 g/cm^3. The highest value was identified in the cookies prepared with 35% red teff, 15% of wheat and 50% of okara, whereas the lowest result was obtained from 40% red teff, 17% of wheat and 43% of okara (Table 2). This might be due to the higher particle size of okara and red teff than that of wheat. There was statistically significant difference ($p \leq 0.05$) between red teff with okara (Table 1). The models for Bulk Density R^2 values showed that the models were satisfactory to experimental results in both linear and quadratic models (Table 1). Masood and Rizwana, (2010) reported that the bulk density increased in the composite flour as the soybean concentration increased. The increase in bulk density is desirable; it offers greater packaging advantage as greater quantity may be packed within constant volume (Molina et al., 1983). The bulk density of a food material is important in relation to its packaging (Bello and Okezie, 1982). A good quality food should have appropriate nutrient density and bulk density (WHO, 2003).
The water absorption capacity (WAC) is the ability of a product to associate with water under limiting conditions (Singh, 2001). The WAC showed increasing trend with the level of okara and red teff flour increase. According to Kaur and Sing (2005), flours with high WAC have more hydrophilic constituents, such as polysaccharides. Therefore, the higher WAC of teff and okara flour than the other ingredient flours could be attributed to the presence of greater amounts of hydrophilic constituents, whereas Dewey (2001) stated that carbohydrate content decreased the WAC of most food systems. The WAC of the cookies varied between 123-140% (Table 2) and the WAC showed a significant difference ($p \leq 0.01$) in red teff with okara interaction (Table 1).

Table 1. Analysis of variance p-value of functional, physical and sensory properties of the cookies prepared from blends of wheat, okara and red teff flours

Regression Model	Functional Properties		Physical Properties				Sensory Properties				
	B.D (g/cm^3)	WAC (%)	Hardness (N)	Diameter (mm)	Thickness (mm)	S.R	Colour	Aroma	Taste	Crispness	O.A
Linear	0.426	0.105	0.888	0.229	0.003	0.049	0.592	0.014	0.141	0.473	0.643
Quadratic	0.055	0.082	0.113	0.016	0.016	0.003	0.789	0.409	0.024	0.143	0.816
Teff*wheat	0.863	0.915	0.392	0.027	0.005	0.004	0.854	0.257	0.801	0.993	0.707
Teff*okara	0.013	0.014	0.040	0.017	0.155	0.011	0.497	0.734	0.005	0.039	0.635
Wheat *okara	0.243	0.694	0.200	0.114	0.287	0.043	0.494	0.247	0.241	0.306	0.485
Lack of fit	0.408	0.131	0.161	0.423	0.916	0.335	0.657	0.622	0.104	0.069	0.269

B.D=Bulk Density; WAC=Water Absorption Capacity; S.R= Spread Ration; O.A= Overall Acceptability

Physical properties of cookies

The results of various physical properties of cookies prepared from red teff, wheat and okara blends as well as 100%wheat flour cookies are shown in Table 2.

Hardness of the cookies prepared from different concentrations of composite flour is depicted in Table 2. Hardness differs significantly ($p \leq 0.05$) among the linear model interaction of red teff with okara samples (Table 1). The highest hardness value (71 N) was recorded for cookies prepared from 40% teff, 10% wheat and 50% of okara, whereas the lowest value (23N) was recorded for the control. This might be the result of the incorporation of protein rich flour (okara) which requires more water. The cookies prepared from high water absorbed dough tend to be extremely hard (Hoojjat and Zabik, 1984). Similar finding that more strength was needed to break cookies incorporated with legumes flour was reported by Lee and Beuchat (1991). In conclusion, increase in hardness and adhesiveness may be due to adding red teff and okara powder because of their high WAC.

The diameters of cookies in the present study ranged from 6 to 7.4 mm (Table 2). The highest diameter was found from the blending ratio of 35% red teff, 18% wheat and 47% okara, while the lowest result was obtained in cookies from 40%, red teff 10% wheat and 50% okara blended flour. This might be due to the spreading ability of fat and gluten contents of composite flour (Adeyeye, 2016). There was significant ($p \leq 0.05$) difference in quadratic model in diameter of the interaction between teff with wheat and teff with okara composite flour cookies and 100% wheat flour cookies, but no significant difference in the linear model (Table 1). These results were in agreement with the results reported by Ogunjobi and Ogunwolu (2010) on the diameter of biscuits made from cassava and soy flour.

The thickness of cookies was significantly different ($p \leq 0.05$) in both linear and quadratic model, whereas highly significant different ($p \leq 0.01$) was noticed between both red teff and okara (Table 1). The thickness of blended and control cookies was 3.3 - 3.7mm, and it increased after baking when compared to that before baking. The lowest thickness of cookies was reported from the composition of teff 35%, wheat flour 15%, okara of 50%; highest was determined in cookies from teff 30%, wheat flour 20%, okara of 40% (Table 2). However, the cookies prepared from blended flours were thicker than the control cookies (100% wheat). This might be due to the protein content of okara which increases the dough thickness during baking. Similar results were observed by Ryan and Brewer (2006). They reported that soy flour-added cookies were thicker compared to wheat cookies due to the extreme water absorptive properties of soy flour.

The spread ratio is an indicator of the cookies quality. The spread ratio of the mixed flours of cookies varied between 1.652 and 2.067. The highest results were reported in the cookies prepared from 35% red teff, 18 wheat, and 47% okara flour, while the lowest was in that of 40% red teff, 20% wheat, and 40% okara flour (Table 2). There was statistically significant difference ($p \leq 0.05$) in both linear and quadratic model. The spread ratio of cookies exhibited highly significant difference ($p \leq 0.01$) with the red teff, wheat and also significant difference between ($p \leq 0.05$) red teff with okara and wheat with okara (Table 1). The cookies from wheat had the lowest spread ratio and this indicates that the starches in wheat were highly hydrophilic in nature (Laura et al., 2013). Cookies having higher spread ratios are considered the most desirable (Kirssel and Prentice, 1979). In the present study, higher spread ratios were recorded for cookies from all blended flours relative to the control sample. Chinma and Gernah (2007) observed a similar trend in cookies produced from cassava/soybean/mango composite flours. The spread ratio is increased by the increase in protein (Singh and Mohamed, 2007). The increased spread ratio observed in okara flour substituted cookies may be due to the difference in the particle sizes and the characteristics of the constituent flours of soya, wheat and teff (Agu et al., 2007).

Table 2. Functional, physical, sensory properties of the cookies prepared from different ratios of teff, wheat and okara flours

Ratios of different flours			**Functional Properties**		**Physical Properties**				**Sensory Properties**				
Teff	**Wheat**	**Okara**	**Bulk density (g/cm^3)**	**WAC (%)**	**Hardness (N)**	**Diameter (mm)**	**Thickness (mm)**	**S Ratio**	**Colour**	**Aroma**	**Crispness**	**Taste**	**Overall acceptability**
35	15	50	0.75	135	67.88	6.4	3.32	1.92	3.46	1.67	4.80	2.65	4.00
40	20	40	0.68	133	68.00	6.2	3.68	1.68	3.00	3.89	3.25	4.00	2.68
30	20	50	0.74	132	67.00	6.3	3.70	1.70	4.06	2.00	4.35	2.50	3.68
30	20	50	0.72	130	67.50	6.7	3.60	1.86	2.40	2.40	4.45	2.70	4.55
37	16	47	0.68	134	66.60	7.0	3.45	2.02	4.00	2.42	3.60	3.53	4.35
40	10	50	0.73	140	70.00	6.0	3.30	1.81	2.06	2.70	4.60	2.78	3.50
34	20	46	0.65	129	65.00	6.6	3.70	1.78	2.32	3.10	3.50	3.60	4.00
35	18	47	0.66	127	67.50	7.4	3.58	2.06	4.00	3.40	4.00	3.45	3.50
40	17	43	0.62	136	67.00	6.5	3.50	1.85	3.7	3.76	3.20	3.78	4.50
38	18	44	0.63	126	67.25	6.8	3.56	1.91	2.00	3.20	3.00	3.86	3.32
40	15	45	0.69	137	66.70	6.2	3.40	1.82	3.90	3.28	4.30	3.50	2.50
40	10	50	0.7	138	71.00	6.1	3.20	1.90	4.50	1.53	4.50	2.63	3.73
34	20	46	0.64	124	64.00	6.9	3.67	1.88	3.03	2.50	3.40	3.55	2.50
35	15	50	0.70	134	68.00	7.0	3.35	2.08	3.20	1.65	4.40	2.72	3.55
40	20	40	0.64	131	66.00	6.0	3.63	1.65	3.60	3.69	2.80	4.20	3.00
33	18	49	0.67	136	65.00	6.7	3.48	1.92	2.50	2.30	4.20	2.54	4.25
0	100	0	0.47	110	23.00	6.5	3.21	0.54	4.50	5.00	5.00	5.00	4.50

WAC= Water Absorption Capacity; S. Ratio= Spread ratio

Sensory analysis

The results of sensory evaluations are presented in Table 2. Cookies made with wheat had the highest ratings for all the sensory parameters tested. With the exception of overall acceptability in sensory analysis, all other parameters of cookies made from red teff, okara and wheat flour blends were not significantly different ($p \le 0.05$) from the control (Table 1).
The colour of the product plays a major role in sensory analysis. The mean value of the present study ranged from 2 to 4.5. Among the entire mean values of colour, the highest colour value was recorded for the cookies made from 40% red teff, 10% wheat and 50% okara; the lowest result was recorded for cookies prepared from 38% red teff, 18% wheat and 44% okara blend. The colour showed no significant differences in both quadratic and linear models, and also all possible interactions of the mixed samples. The colour of the cookies gets darker; it might be due to the high level of red teff present in the product as red teff is having red colour. The mean range of 1.65 to 3.89 aroma values was reported to the cookies prepared from different blends of flours. Among the entire mean values of aroma, the highest acceptability of aroma was recorded for cookies prepared from 40% red teff, 20% wheat and 40 % okara, whereas the lowest results were recorded for cookies prepared from 40% red teff, 10% wheat and 50% okara. This might be due to the beany flavour of okara. Similarly, Mc Watters, (1978) indicated that the beany flavour in legumes flour could reduce the acceptability of the baked product. The aroma of the cookies showed non-significant difference ($p \le 0.05$) in both quadratic and linear model and in the interaction of all possible sample mixtures. As reported by Muhimbula et al., (2011), aroma is an integral part of taste and general acceptance of the food before it is put in the mouth.
The mean values of taste for cookies from different blends were found in the range of 2.5 to 4.2. There was a significant difference ($p \le 0.05$) between the interactions of red teff with okara. Significant difference was also obtained from quadratic models, while non-significant difference was observed for linear and other interactions. The highest mean score of taste was obtained for cookies from 40% red teff, 20% wheat, 40% okara, in contrast; the lowest value was obtained for cookies from 30% red teff, 20% wheat and 50% okara blended. The acceptability of the taste was decreased with the level of okara proportion, because okara has beany flavour and taste. The significant decrease in taste value may be attributed to the soy composition; the soy beany flavor will dominate when used in high amounts (Husain, 1993).
The results of the present study revealed that significant difference ($p \le 0.05$) was observed in red teff with okara, while non-significant difference was observed for other interactions.

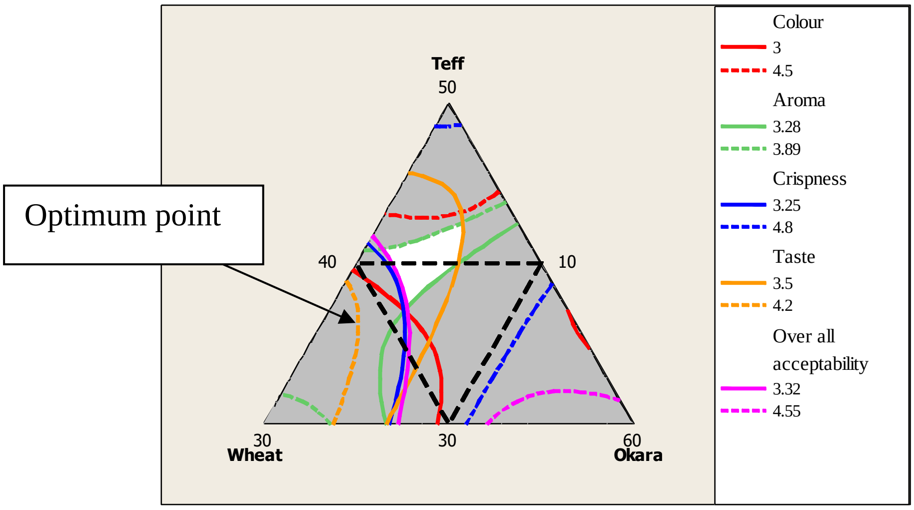

Fig. 1. Contour plots for the optimum concentration of wheat, red teff and okara for best sensory quality of cookies

Both of the quadratic and linear models that were observed showed non-significant difference as judged by consumer panelist among all tested samples in terms of crispness. The results of cookies crispness in the present study varied from 2.8 to 4.8. The highest value was obtained from 35% red teff, 15% wheat and 50% okara blend, while the lowest result was obtained from 40% of red teff, 20% of wheat and 40% of okara.

The overall acceptability of cookies showed no significant difference ($p \leq 0.05$) in the blended flour of red teff, wheat and okara in both of linear and quadratic models. All the results imply that the evaluated sensory properties of the made cookies are not much different from the 100% wheat (control) cookies. All the cookies made from both the 100% wheat and the mixed flours were generally well accepted. The highest overall acceptability of cookies (4.55) was shown from the samples made with 30% red teff, 20% wheat and 50% okara, whereas lowest was from 40% red teff, 20% wheat and 20% okara.

Optimization based on the sensory evaluation

The optimum formulation should maximize consumers' acceptance. However, it is impossible to develop a product with all five sensory qualities that would satisfy consumers in most applications (Moskowitz, 1994). Acceptability of a product by consumers is an essential parameter, especially for a new product business. To obtain the optimum region, the ingredient formulation should obtain optimum colour, aroma, taste, crispness and overall acceptability for cookies. The optimum point for all sensory attributes was graphically presented. The white region of Fig. 1 shows the optimum sensory acceptability of the formulation. The point prediction shows that 37-40% red teff, 16-20% wheat and 47-50 % okara would give optimal point for colour, aroma, taste, crispness and overall acceptability in range of 3-4.5; 3.28-3.89; 3.25-4.8; 3.5-4.2 and 3.32-4.55, respectively.

Conclusions

The minimum and maximum range of the values for the bulk density, water absorption capacity, texture, diameter, thickness and spread ratio are 0.63-0.75 g/cm^3, 124-140%, 64-71 N, 6.0-7 (mm), 3.2-3.68 (mm), 1.65-2.08, respectively. In case of sensory properties, colour, aroma, crispiness and taste scored the minimum and maximum values as 2.0-4.06, 1.53-3.69, 2.8-4.45, 2.5-4.2. In case of overall acceptability, the acceptability of the cookies was similar to the control, the cookies from teff 30%, wheat 20%, okara 50% showed over acceptability value of 4.55 and the control sample (100% wheat flour) 4.5. The physical and functional properties of the cookies with the composite flour are similar to those of the control samples. In case of sensory analysis, the overall acceptability scores of the cookies from flour blends and control was similar, but individual sensory properties like aroma and taste has not showed good sensory acceptability as the okara flour increased. This may be because of beany flavour of okara and panels less appreciated colour values of the cookies as red teff concentration increased. The optimization prediction of sensory parameters determined that 37-40% red teff, 16-20% wheat and 47-50% okara provide optimal point for colour, aroma, taste, crispness and overall acceptability in range of 3-4.5; 3.28-3.89; 3.25-4.8; 3.5-4.2 and 3.32-4.55 respectively. Finally, further research has to be made to enhance the sensory acceptability of the okara based cookies.

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