Impact of Lentil Fortification on Physical, Chemical and Instrumental Properties of Dough and its Influence on overall Quality of Cookies

Seema Ashraf[1], Syed Muhammad Ghufran Saeed[1], Syed Asad Sayeed[1], Habiba Kanwar[2]
Mubarak Ahmed[3] and Rashida Ali[4,]

[1]Department of Food Science and Technology, [2,4]International Center for Chemical and Biological Sciences, HEJ Research Institute of Chemistry, University of Karachi, Karachi, 75270, Pakistan.
[3]Grain Quality Testing Laboratory, Pakistan Agricultural Research Council

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Corresponding Author
Syed Muhammad Ghufran Saeed
Email: smghufransaeed@yahoo.com

ABSTRACT

Current study is based on the fortification of lentil in dough as a substitute of fat in soft dough cookies. Fat replacement in "Low Calorie Foods" is major challenge for food processors. The chemical composition of lentil-wheat composite flour was analyzed with NIR. The composite flour of lentil was used in accordance with the quantity of fat used in cookies' formulation i.e. 10, 20, 30, 35, 40, 45 and 50%. The changes in rheological behavior of the dough, due to elevated level of lentil, were studied by the Farinograph and Alveograph. Present studies significantly correlate with the overall quality score with Alveograph characteristics (P, L and W). Cookies made with composite flour were acceptable upto 50% and were showing an appealing sensory score, without any significant adverse effect on taste, aroma or the texture. Functional properties of composite flour, such as foaming capacity, foaming stability and swelling power suggest the use of lentil as a fat substitute may be beneficial.

KEYWORDS

Lentil flour, Low caloric cookies, Fat replacer, Functional properties, Sensory quality.

Introduction

Public health organizations recommend cutting off 30% or more of the fat consumption from total consumption per day. However, replacement of fat is not an easy task for food processors because fat is an important ingredient of food products. Fat not only contributes to soft texture, appealing mouth feel and attractive appearance but also has a positive impact on flavor/aroma (Zoulias, *et al.* 2002). Low fat products are considered to be ones which contain 3g less fat per serving or 25% reduced fat than their normal counter parts (Chronakis, 1997).

Lentil (*Lens culinaris*) is one of the important legume commonly consumed world wide and particularly in the developing countries. Lentil contains about 25 g proteins, 56 g carbohydrates, 1.0 g fats, 2.6 g ash and 31 g fibers per 100 g of the seed. Legume proteins are considered to be one of the best and the cheapest source of vegetable proteins, such as the essential amino acid lysine (Adsule, *et al.* 1989), while wheat flour proteins are deficient in some of the essentials amino acids; lowering the quality and nutritional properties of foods and their products (Dhingra and Jood, 2001). The combination of cereal and legume proteins provides a balance of essential amino acids (Eggum and Beame, 1983). Legume starches are suitable for incorporation in bakery products as they contribute to high thermal stability (Chung, *et al.* 2008; Hoover and Sosulski, 1991). Lentil is known for its low glycemic response due to the presence of β-glucan which induces short term satiety and may help in body weight maintenance (Kim, *et al.* 2006). The soluble and insoluble dietary fibers of legumes exhibit many health benefits such as lowering cholesterol, LDL, blood pressure and sugar level, while the control of gastric emptying property gradually eliminates constipation and other intestinal disorders promoting laxation (Tosh and Yada, 2010).

The physicochemical properties of lentils such as bulk density, hydration capacity, water absorption and swelling index have supported its function as a fat replacer (Jood and Sharma, 1998; Lazou and Krokida, 2010).

Currently, wheat flours are being used in combination with other flours in manufacturing extruded snacks and bakery products. Recently

Alu'datt and coworkers (2012) investigated the effect of supplementation of barley flour and barley protein isolates on the chemical and functional properties of pita bread. In past three decades many studies have been conducted to analyze the effect of lentil on physical, chemical, instrumental and sensorial properties of dough and bakery products. They include cakes and breads made with lentil flour (Hera *et al,* 2012; Hettiaratchi *et al*, 2009; Dalgetty and Baik, 2006; Lorimer *et al,* 1991).

In the present study lentil flour has been used as a fat replacer. It has been observed to be an innovative formulation replacing 50% fat by using an equivalent amount of lentil flour. Replacement of fat with lentil seems to be a good idea to produce low calorie foods without affecting the rheological behavior of dough and overall quality of the soft dough cookies.

Material and Methods

(A) Materials

Lentil flour (LF) was milled by the laboratory-grinding mill (Perten 3100, Presten, Springfield, IL); installed with a 0.8 mm sieve to deliver flour of 80 mesh size and the refined wheat flour was supplied by Madina Flour Mills, Karachi. The baking ingredients were purchased from the Karachi University's grocery store. An Inframatic 9200 NIR (Near Infrared Reflectance) analyzer (Perten, Springfield, IL) was used for the compositional analysis. All other chemicals and solvents were of analytical grade. The Brabender Farinograph E (CW Brabender Duisbery, NJ, USA) and Alveograph NG consistograph (Chopin 50-54 France) were used for the study of the rheological characteristics of the flour.

(B) Methods:

1. Chemical Analysis

The ICC/AACC method (2005) were used to determine the moisture (44-45A), total protein (39-11), hardness score (39-70A), fibers (32-05) and ash (08-01) by Inframatic 9200 NIR (near infrared reflectance) analyzer (Perten, Springfield, IL) for the analysis.

2. Foaming Capacity and Foaming Stability

FC and FS were determined in triplicates using the methods described by Makri and coworker (2005). Concentrations of 1% lentil flour were prepared in de-ionized water and pH 7.4 was adjusted with 0.1N NaOH and 0.1N HCl. A volume of 100 ml (V_i) as the lentil suspension was blended for 3 min using a high speed blender poured into a 250 ml graduated cylinder and the volume of foam (V_f) was immediately recorded. FC was calculated using the following equation, $FC=V_f-V_i$ while foaming stability was a measurement of time of maximum stability, as shown in table 2, (see, table 2).

3. Swelling Power

Swelling power and the solubility index of the lentil flour (LF) were determined in triplicates according to the procedure of Tsai and coworker (1997). 0.5 gm of LF was suspended in 30 ml of deionized water and heated at 85°C for 30 min. The suspension was then centrifuged at 3000 g for 15 min, the supernatant decanted and the swollen granules were weighed. Only the remaining material that adhered to the wall of centrifuge tube was considered as the sediment and weighed (W_s). 10 ml of the cloudy supernatant was taken in a dried pre weighed china dish and dried overnight in an air oven at 100°C. The supernatant was dried to constant weight (W_1) in an air oven at 100°C. Results are given in table 2, (see, table 2).

The water soluble index (WSI) and SP were calculated by the following equations:

$SP=W_s/[0.1(100\%-WSI)]$(g/g).

$WSI=[W_1/0.1]\times100\%$,

4. Rheological Properties

4.1. Farinograph Parameter

Effect of the addition of lentil flour (LF), as a fat substitute, on the mixing properties of the wheat dough was evaluated by Farinograph using a 50 gm bowl (14% moisture basis) is employed.; following the AACC method, 54-21 (1). . Briefly describing, known amount of refined wheat flour, on the bases of moisture in flour was taken in the bowl with or without the known amount of LF according to the formulation given in preparation of cookies. The water was added from the burette during mixing to give a dough consistency of 500 Brabender Units (BU).The mixing was continued for 20 minutes and the following parameters were derived from the resulting Farinogram, water absorption (WA), dough development time (DDT), dough stability (DS),Farinograph quality number (FQN) and the degree of softening.

4.2. Alveograph Properties

Effect of the addition of LF on extensibility and elasticity of the dough was determined using Chopin Alveograph equipped with hydrostatically controlled air flow unit; following the method of Approved methods, (American Association of Cereal Chemists AACC, 54-30A). The dough (250 g) with known amount of LF according to formulation in prepration of cookies was mixed in the mixer with 2 % salt solution, sheeted and five patties of 4.5 cm diameter were cut and rested for 20 min approximately. It was then subjected to Alveograph where air blows into a dough patty and then a bubble expands till it breaks. The maximum length of bubble (L) and maximum power to blow bubble (P) swelling index (G) and baking power (W) are represented as the mean of five measured values.

5. Preparation of Cookies

The cookies were prepared using wheat and substituted flour (46 g), salt 0.21 g, icing sugar 18 g, lecithin 0.14 g, eggs 5 g, condensed milk flavor 0.03 g and distilled water 6 ml. The control contained 23 g of shortening (Kisan Ghee). In the standards the amount of fat was replaced with 10%, 20%, 30%, 35%, 40%, 45% and 50% Lentil Flour (LF), and an additional 3% water on the basis of Lentil Flour was added. The dough was prepared by first mixing the shortening and sugar in a Hobart N-50 mixer at a low speed for 2 min, the flour was added and the mixing was continued for further 3 min at slow speed followed by the addition of other ingredients. The dough was further mixed for 2 min at low speed. The cookie dough was made into sheets of thickness 0.5 cm and cut using a circular die of 6.5 cm diameter. The cookies were baked in a preheated oven at 205^{o}C for 8 minutes, cooled to room temperature (24^{o}C) for 20 minutes, sealed in polypropylene pouches separately and stored at 15^{o}C.

6. Physical Properties of Cookies

6.1. Spread Ratio

The end qualities of the cookies were evaluated by measuring their thickness, diameter and spread ratio according to the AACC Approved Method 10-50D.

6.2. Sensory Qualities of Cookies

The cookies were analyzed by twenty trained panelists who measured sensory attributes such as the surface-color, appearance, texture, taste and mouth feel. Each attribute was examined using a 10 point Hedonic scale, representing number 1 as the most unacceptable while 10 indicated highly acceptable. The attributes, texture and taste, were evaluated twice and the score was taken as the sum of the two numbers i.e. 20.

7. Statistical Analysis

All the tests were conducted in duplicates and were analyzed by one-way analysis of variance (ANOVA). The data was analyzed using the Minitab software of window's version. The linear correlation coefficients between the matching parameters of the samples were calculated, using formula $r=\sigma xy/\sigma x\sigma y$ where r is represented as correlation coefficient, σxy represents standard deviation or covariance of two data sets, σx shows standard deviation of the x value and the σy stands for standard deviation of y value. (See table 6).

Results and Discussion

1. Chemical Characteristics

Overall chemical composition of wheat-lentil composite flour was not much affected. The amount of lentil flour (LF) substitution, as shown in table 1, was based on the replacement of fat from the recipe of the cookie.

The moisture content of the composite flour was constantly reduced by increasing the LF in recipe. Wheat flour contained 13.4% moisture while 50% LF replacement reduced the moisture to 12.1%. The overall change in the moisture was minimal. The initial or the inherent moisture present in the flour had more influence on the cookie surface than the added water in the dough (Manohar and Rao, 1999). However total water content was responsible for the viscosity of the dough. The hardness score of the composite flour increased from 44.1 to 47.1 by increasing LF which reflected the extent of protein-starch interactions that influenced the gluten network (Carver, 2006). The results show that both the hardness score and protein content of the flour mixture increased by increasing the LF. Lentil contains 26% proteins in its composition but when it was combined with wheat flour the overall content of the protein in the composite flour increased. It was observed that the protein content increased from 9.8 to 10.8% in the final 50% composite flour. The grain hardness was linked to milling quality assessment and the strongest relations were observed with ash, semolina particle size and protein content (Hruskova and Svec, 2009). Lentil contains a high quantity of dietary fibers (26%) and ash (2.7%). In composite flour both dietary fiber and ash content increased from 3.2% to 8.7% and 1.3% to 1.7% respectively, in a constant manner upto 50% of composite flour. The ash content of the substituted dough was correlated with the rheological behavior. It made the dough denser which was responsible for the hard texture of the cookies. Moreover the hard texture of the dough and that of the cookies is expected to be due to the absence of fat.

Table 1: Effect of lentil on chemical composition of substituted wheat flour (Lentil Substitute of Fat).

Substitution	Moisture,%	HS	Protein,%	Fiber, %	Ash, %
Lentil	10.5±0.38 [a]	NA	26.0 ±1.2 [k]	30.5±1.7 [o]	2.7±0.20 [v]
Control	13.4±0.35 [b]	44.1±0.8 [g]	9.8±0.00 [l]	3.2±0.20 [p]	1.3±0.20 [w]
10%	13.2±0.21 [bc]	45.2±0.7 [h]	9.9±0.04 [l]	4.1±0.35 [q]	1.4±0.13 [wx]
20%	13.1±0.10 [c]	45.5±0.5 [h]	10.1±0.05 [lm]	5.4±0.41 [r]	1.5±0.25 [xy]
30%	12.9±0.14 [c]	45.1±0.3 [h]	10.3±0.06 [m]	6.2±0.32 [s]	1.6±0.01 [y]
35%	12.8±0.17 [d]	45.5±0.4 [h]	10.4±0.07 [m]	6.8±0.23 [t]	1.6±0.12 [yz]
40%	12.5±0.16 [e]	46.2±0.2 [i]	10.5±0.07 [mn]	7.2±0.45 [tu]	1.7±0.26 [z]
45%	12.3±0.24 [ef]	46.2±0.2 [i]	10.7±0.07 [n]	8.0±0.45 [u]	1.7±0.14 [z]
50%	12.1±0.28 [f]	47.1±0.2 [j]	10.8±0.07 [n]	8.7±0.45 [u]	1.7±0.09 [z]

HS= Hardness Score, each value is expressed as mean± S.D. (n=3)
Mean with different letters in superscript within a column are significantly different from each other. They are calculated by LSD method (P<0.05).

2. Foaming Capacity and Foaming Stability of LF

The foaming capacity of LF as 16.0 mL is considerably higher than the foaming capacity of wheat flour, 11.0 mL (shown in table 2) which increased constantly until 50% replacement of fat by LF, the final value was 17 ml.

The higher foaming capacity with LF may be attributed to several components, especially the proteins/peptides and to a lesser extent to starches etc. Foaming capacity plays a determining role in giving a soft texture to the final product. Foaming stability is an important characteristic of proteins which keeps the dough soft during processing. Foaming stability, as shown in table 2, is 25 for LF while it is 5 for the wheat flour. It increased constantly until it reached 35 on 50% fat replacement by LF. Results indicate that there may be some interaction between small peptides from LF and wheat flour to generate new peptides/protein which have higher foaming stability. The saturated triacylglycerides in fat are responsible for entrapping small air bubbles during mixing and retaining them during baking to make the texture soft. It seems that LF protein components play the same role as that of incorporation of air and can easily replace the fat. The gluten network and extent of starch gelatinization in the absence of fat produce hard textured end-products whereas fat play the role of softening the dough which is only partially fulfilled by the LF.

3. Swelling Power

The swelling power (SP) is a measure of water absorption which according to the Farinograph values was not highly affected by the addition of LF. The swelling power increased dramatically and constantly from 80 to 300 on gradual addition of LF from 10% to 50%, as shown in table 2. One of the reasons of this marked increase in swelling power is perhaps because of heating at 80ºC for 30 min in order to determine the swelling power, while Farinograph readings were recorded at 30ºC. Heating at 80ºC is probably responsible for gelatinization of starch that holds large amounts of water and promotes molecular interactions. However, increase in swelling power with increase in LF still needs further explanation, perhaps lentil proteins and starch form a gel which has more water holding capacity than wheat flour components.

4. Rheological Behavior of Dough

4.1. Farinograph Characteristics

The Farinograph parameters measured are given in table 3, and each significantly illustrates the dough behavior. Water absorption (WA) increased slightly on addition of LF. In wheat flour water absorption was 61.1% but on addition of 10% LF, the WA value decreased to 58.6%. On increasing the level of LF upto 50% an increase in WA value upto 61.9% was observed. The WA is expected to rise because addition of LF increases the amount of proteins, starch and fibers; these components compete for absorption of water during dough formulation. The dough stability (ST) is time in minutes, when the curve remains on or above the 500 BU line and is measured by the difference in time when top of the curve intercepts and leaves the 500 BU line. ST of wheat flour was 1.5 min. Initially ST decreased by addition of 10% LF (0.95 min) but then it increased and finally reached 1.48 min at 50% composite flour. Results indicate that gluten network is least disturbed and dough strength finally achieves the value close to the control.

Table 3: Rheological properties of dough with partial substitution of fat with lentil.

	Farinograph					Alveograph			
Subs	WA (%)	ST (Min)	DDT (Min)	DS (BU)	FQN	P (mm)	L (mm)	G (mm)	W (10^4 J)
Control	61.1±0.1[a]	1.5±0.2[c]	1.60±0.3*	109.1±4.2[e]	28.1±0.7[l]	79.3±1.2[a]	38.2±0.5[f]	19.4±0.5[j]	96.2±1.1[m]
10%	58.6±0.2[b]	0.95±0.1[d]	1.50±0.2*	116.2±3.1[f]	26.3±0.9[m]	70.5±1.7[b]	29.1±0.3[g]	18.7±0.1[k]	90.1±1.5[n]
20%	60.5±0.4[a]	1.2±0.3[cd]	1.54±0.1*	118.5±2.7[fg]	29.1±1.5[n]	72.2±1.1[c]	31.5±0.8[g]	18.4±0.4[k]	93.5±1.8[o]
30%	59.1±0.1[b]	1.34±0.2[c]	1.80±0.1*	120.4±3.6[gh]	26.4±1.2[m]	74.5±0.9[d]	32.6±0.4[g]	18.4±0.3[kl]	94.2±0.9[o]
35%	59.1±0.1[b]	1.3±0.2[c]	1.53±0.2*	123.7±4.2[h]	26.9±0.8[mn]	75.3±1.4[d]	33.7±1.1[gh]	18.2±0.4[l]	92.7±1.6[no]
40%	61.1±0.2[a]	1.38±0.1[c]	1.58±0.1*	126.2±2.4[i]	27.2±0.6[n]	77.6±1.2[e]	35.2±0.6[h]	18.3±0.5[kl]	95.3±0.7[n]
45%	61.2±0.1[a]	1.4±0.3[c]	1.65±0.4*	130.5±1.2[j]	27.3±1.7[n]	78.2±1.7[ea]	37.6±0.7[hi]	18.1±0.2[l]	95.6±1.9[n]
50%	61.9±0.3[a]	1.48±0.1[c]	1.69±0.3*	145.4±5.5[k]	29.2±0.6[o]	80.1±1.5[a]	40.3±0.4[i]	20.1±0.5[l]	97.4±1.7[n]

Subs= Substitute, WA=Water absorption, ST= Stability, DDT=Dough development time, DS= Degree of softening FQN=Farinograph quality number, P(mm)=Force required to blow bubble, L(mm)=Elongation of bubble, G= Index swelling ,W=Deformation energy of dough.(n=3)

Mean with different letters in superscript within a column are significantly different from each other. They are calculated by LSD method (P<0.05).

**Mean is not significantly different (P>0.05)*

The DDT represents the time required by the dough to reach maximum consistency after the first addition of water. It indicates the minimum mixing time for dough formation. Inclusion of LF showed insignificant effect between 1.5 to 1.8 minute, but the overall DDT slightly raised by the increase of LF that is in accordance to Fu L, Sun C, and Li C (2008). The degree of softening (DS) is represented by the difference between the center of the curve obtained at 12 min to the end of the peak and is reported to the nearest 5 BU. The LF increased the DS from 109 to 145 BU because gluten content lowered and the protein network became weaker and softer. However, the texture of the cookies got slightly harder than the control because of the increase in fiber and ash, but the overall sensory characters remained comparable to the control recipe. Farinograph Quality Number (FQN) is a measure of dough strength and represents the distance in mm from the time when water is added or factually mixing starts, upto the middle of the curve crossing the lower line. The dough breakdown time BDT (time from the start to the decrease of 30 BU from maximum torque value) and FQN are closely associated and indicate the collective values of DDT, DS and ST. Farinograph characteristics show that LF may be used up to 45%; excess will make both the dough and the end product harder and unacceptable.

4.2. Alveograph Properties

Alveographic parameters demonstrate the dough rheology and predict the quality of the final baked products. The parameters include work (W) [104 J] of the dough or the deformation energy showing the baking strength, G (mm) the swelling index is a measure of square root of volume of air needed to inflate the bubble till it ruptures, P (mm) is the maximum pressure for tenacity or pressure required to below the dough bubble, which is taken as resistance to extension, that is a measure of the resistance to deformation, L represents extensibility in mm, P/L is the curve configuration ratio showing stability which is an index of gluten performance or dough behavior in mixing and baking. The elasticity of the dough is directly related to protein/gluten network and is more closely related to glutenin macro polymers (GMP) which, since weak, decreases elastic property. A lower configuration ratio, P/L, represents extensible and low strength dough that has greater extensibility or lower P/L to produce large diameter of the cookies (Agyare, et al. 2005). The alveographic results shows that W-value slightly increases from 90 to 95 upto 45% addition of LF which is expected since the protein contents are increased from 9.8 to 10.7%. Both the increase in protein contents and the related increase in the W-value are found to be related to the width (diameter) of the cookies which was found to have increased from 7.52 to 7.90 upto 45% addition of LF, as shown in table 3. However earlier studies of Bartolcce and Launay (2000) have reported that biscuit length decreases with increase in W-value. Alveographic values have shown soft behavior of the flour after LF addition which is well expected. Pressure to blow the bubble (P), extensibility (L) and swelling index decrease rapidly by the addition of Lentil flour upto 10 % but the constant increase of Lentil flour upto 50% affects these parameters and approximately achieves the same pressure (80 mm), extensibility (40 mm) and swelling index (40 mm), as found in the control recipe.

5. Effect of Fat Replacement by Lentil Flour on Size of the Cookies

The effect of lentil substitution on the cookies's width (diameter), thickness and the spread ratio is mentioned in table 4. It illustrates that decrease in the amount of fat causes an increase in diameter, puffiness (thickness) was not adversely affected and the effect on the size of the cookies was insignificant. The LF substitution from 10% to 50% increased the width (diameter) from 7.52 cm to 8.1 cm and the thickness from 1.08 to 1.11cm. The spread ratio slightly decreased from 6.96 to 6.75, an insignificant difference which is due to a smaller difference in width then in thickness. The net result is not significantly visible.

6. Sensory Qualities of Composite Flour Cookies

The sensory quality parameters such as the color, appearance, texture, taste and mouthfeel evaluated are given in table 5. It is clear that although there are not much significant differences in the sensory factors, however the combined effect is not very encouraging as the over all quality score decreased to 57.4 for 35% of composite flour while it increased to 61 and 64.2 on 40% and 45% substitution of LF. All the parameters showed deterioration on 50% LF substitution.

Table 4: Spread ratio of cookie by replacement with lentil in different percentages.

Lentil Substitution	Width(W) (cm)	Thickness (T) (cm)	Spread ratio (W/T)
Control	7.52±0.5	1.08±0.1	6.96
10%	7.61±0.3	1.10±0.6	6.92
20%	7.72±0.1	1.16±0.3	6.66
30%	7.81±0.4	1.19±0.3	6.56
35%	7.85±0.5	1.19±0.2	6.60
40%	7.89±0.1	1.15±0.4	6.86
45%	7.90±0.2	1.11±0.6	7.12
50%	8.10±0.5	1.11±0.2	6.75

Each value expressed as mean± S.D. (n=3)
Mean within a column is not significantly different (P>0.05)

Table 5: Sensory qualities of cookies determined by hedonic scale

LS	Color (10)	Appearance (10)	Texture (20)	Taste (20)	MF (10)	OQS (70)
Control	$9.5±0.67^{a}$	$8.9±0.68^{f}$	$19.5±0.52^{j}$	$18.7±1.05^{r}$	$8.9±0.78^{x}$	65.5
10%	$5.2±1.03^{b}$	$5.4±1.01^{g}$	$11.5±1.57^{k}$	$14.5±1.12^{s}$	$5.0±0.84^{y}$	40.9
20%	$7.1±1.14^{c}$	$5.8±0.95^{g}$	$14.5±0.97^{l}$	$15.0±0.91^{st}$	$7.2±1.08^{z}$	48.8
30%	$7.3±1.11^{c}$	$6.0±1.11^{g}$	$16.0±1.34^{m}$	$15.6±1.16^{t}$	$7.5±0.92^{z}$	52.4
35%	$8.2±1.12^{d}$	$7.0±1.30^{h}$	$17.1±0.82^{n}$	$17.5±1.12^{u}$	$7.8±1.12^{za}$	57.4
40%	$9.1±0.80^{e}$	$8.0±0.95^{i}$	$18.0±0.71^{o}$	$18.0±0.77^{uv}$	$8.1±0.89^{za}$	61
45%	$9.4±0.49^{e}$	$8.6±1.03^{i}$	$19.1±1.09^{p}$	$18.5±0.92^{v}$	$8.7±0.84^{a}$	64.2
50%	$6.4±1.07^{e}$	$6.0±1.17^{g}$	$15.2±0.93^{q}$	$15.8±0.98^{w}$	$5.2±0.87^{b}$	46.8

LS= Lentil Substitute, MF= Mouth Feel, OQS= Overall Quality Score.
Each value expressed as mean± S.D. (n= 20 panelists)
Mean with different letters in superscript within a column are significantly different from each other. They are calculated by LSD method (P<0.05).

Table 6: Correlation coefficients between rheological characteristics of the blended dough and sensory characteristics of cookies.

	Color	Appearance	Texture	Taste	Mouth feel
WA (%)	0.47	0.52	0.54	0.48	0.26
DS(Min)	0.69	0.64	0.64	0.69	0.53
DDT(Min)	0.10	0.01	0.26	0.03	0.10
Softness	-0.14	-0.14	0.00	-0.03	-0.36
FQN	0.04	-0.02	0.10	-0.03	-0.06
P	0.60	0.66	0.75	0.70	0.37
L	0.49	0.57	0.65	0.60	0.26
G	0.01	0.16	0.20	0.17	-0.21
W	0.50	0.51	0.64	0.50	0.32

* *For abbreviations see caption of Table 3 and 5*

7. Correlation of Rheological Characteristics with Sensory Attributes

Many research workers have correlated the farinograph and alveograph parameters of flour with cookie sensorial properties (Saeed, *et al.* 2009), bread making properties (Addo, *et al.* 1990), bread and cookie baking (Bettge, *et al.* 1989) and Parrotta making properties (Indrani, *et al.* 2007). A significant correlation was observed in dough softening and all sensory attributes of the cookie. Maximum power to blow bubble (P) also correlated well with all the sensory properties except mouth feel. Taste and texture had significant correlation with deformation of energy of dough (W).

Significant correlation was also seen to have been established between OQS(overall quality score) and P, L & W values from alveograph, represented in figures 1, 2 and 3 respectively. Correlation was most significant in case of P & L while moderate correlation was seen with W. These rheological correlations with OQS were highly applicable up to 45% of lentil flour substitution in cookies. The regression equations used to calculate OQS are as follows: OQS = 2.707P - 147.3, r = 0.99; OQS= 2.699L - 35.10, r = 0.97 and OQS=3.742w - 294.4, r=0.87, showing the possibility of the application of these values in processing.

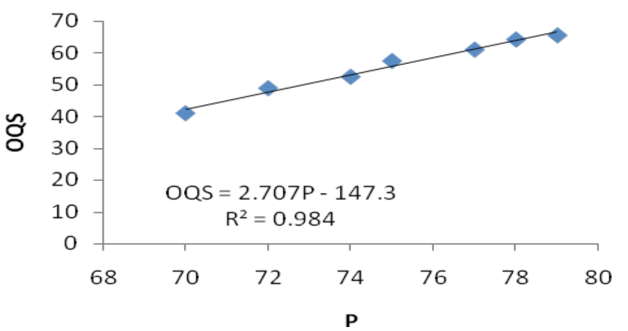

Figure 1. Relationship between alveograph maximum power to blow bubble of dough (P) and overall quality score (OQS) of Cookies

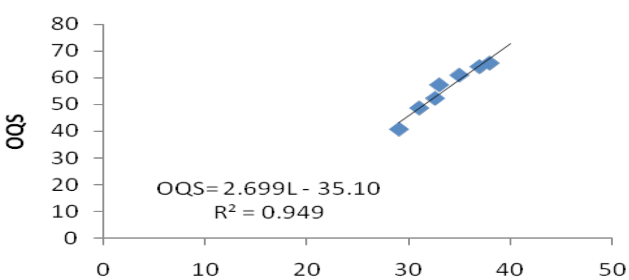

Figure 2. Relationship between alveograph maximum length of bubble (L) and overall quality score (OQS) of cookies

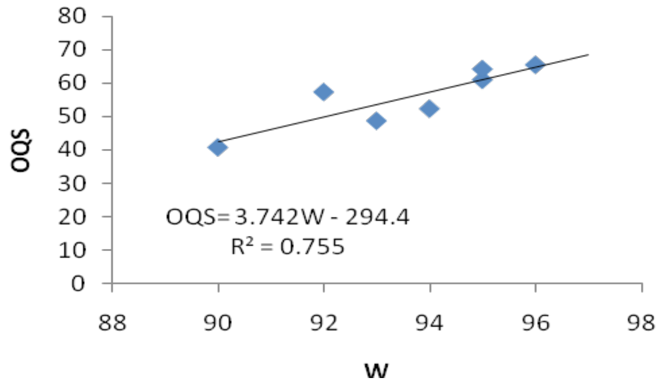

Figure 3. Relationship between alveograph baking power (W) and overall quality score (OQS) of cookies

Conclusion

Lentil is a cheap source explored to blend with wheat flours to replace equivalent amount of fat which produced significant effects on functional behavior of dough. Present study showed that low calorie soft dough cookies prepared by 45% wheat-lentil composite flour had good sensory attributes. The end quality of cookies was close to their fat containing counter parts. It has elaborated the ability of fine lentil flour as a replacement of fat up to a certain extent by adjusting WA and other components in baked products. Moreover the lentil substituted cookies have superior nutritional status having high protein content, minerals, fibers and phytochemicals, while comprising of low calories, GI and saturated fats.

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