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Effect of Partially Defatted Sesame Meal Supplementation on Chemical, Rheological and Sensory Attributes of Bread

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The study was carried out to elucidate the suitability and utilization of sesame meal in the baked products. An increase in protein content due to the addition of partially defatted sesame meal results an increase in farinographic parameters. The mixographic peak height percentages and mixing time of the combined flours decreased significantly by the supplementation. *in vitro* Protein digestibility of breads prepared from composite flours increased gradually as the level of supplementation increased. The sensory score of breads were significantly affected with the difference in levels of supplementation. The partially defatted sesame enhances the chemical components of composite flour.

Keywords: Sesame meal, Composite flour, Farinonograph, Mixograph, Sensory evaluation.

INTRODUCTION

The use of sesame as a useful food is attaining more popularity in the present years. Sesame contains useful nutrients such as protein, soluble and insoluble dietary fiber as well as ω-3 fatty acids. The sesame can be used as a whole or it can be incorporated in different other foods including bakery products. There is a great need of doing some work on the premix flour technology with particular reference to betterment of the wheat flour superiority through fortification with other flours.

The premix flour technique plays significant part in balancing the deficiency of necessary nutrients in wheat [1]. The composite flour technique refers to the procedure of combining wheat flour with other legumes or cereals to take advantage of locally accessible raw materials to prepare superior food products in an inexpensive way [2]. In numerous cases, this involves the incomplete replacement of wheat flour in staple diet with other legumes or cereals as a mean of expanding and improving the local agricultural food products [3].

The addition of sesame in wheat flour at 15 and 20 % levels resulted in decrease of dough stability, lower crust and crumb scores as compared to the control breads prepared form 100 % wheat flour [4]. The effect of sesame on the sensory and chemical composition of bread rolls and cinnamon rolls has also been studied [5].

Keeping in view the medicinal and nutritional benefits of the sesame, this study was carried out to elucidate the effects of partially defatted sesame meal additions in wheat flour on the rheological, physical, chemical and sensory properties of the composite flour and bread.

EXPERIMENTAL

Sample preparation: Commercial wheat flour (white wheat flour) was purchased from local market. Sesame was also purchased from local market and defattening was done by expeller. Samples were prepared as T_0 = control (white wheat flour only), T_1 = 96 % + 4 %, T_2 = 92 % + 8 %, T_3 = 88 % + 12 % and T_4 = 84 % + 16 % as white wheat flour and defatted sesame meal, respectively. For the preparation of pan bread, a straight dough procedure, with 3 h fermentation, 55 min proofing at 30 °C and 25 min baking at 220 °C was used.

Analysis of composite flour

Chemical analysis: The composite flour samples were analyzed for their chemical composition such as moisture, ash, protein content, crude fat and crude fiber contents by the methods [6].

Analysis of physical properties: Dough rheology of composite flour was determined using farinographic and mixographic by following the procedure [6] as follows:

Farinographic studies: This analysis was interpreted for different characteristics such as water absorption, dough stability, dough development time, softening of dough and mixing tolerance index [6].

Mixographic studies: The mixograph equipped with 10 g bowl capacity was used to determine dough development time and peak height percentage. The dough development time from mixograms was observed as the time from the start of the mixogram to the time where the center of the curve attained maximum height while the peak height percentage described as a height of mixogram at optimum development and was recorded as percentage of height [6].

Mineral contents: The mineral contents such as K, Na, Mg, Ca, Cu, Fe, Zn and Mn in composite flours were determined according to AOAC (1990). One gram of sample was digested with 10 mL of nitric acid:perchloric acid (7:3) mixtures at 180-200 °C till transparent content were obtained. The content was diluted to a volume of 100 mL with double distilled water and measured through atomic absorption spectrophotometer (Model 2380, Perkin-Elmer, USA).

Water hydration capacity: Water hydration capacity (water absorption, water uptake, or water holding or binding) was determined [6] and the results were expressed as 1 g of water absorbed per gram of supplemented flour.

Analysis of bread

Colour: The colour of bread was determined according to described method [7] with the help of hand held tristimulus colourimeter. The colourimeter was calibrated by using standards (54 CTn for dark and 151 CTn for light).

Texture analysis: Texture of bread was determined by the method [8] using a texture analyzer (Model, TA-XT2, Stable Microsystems and Surrey, UK) with a 5 kg load cell. The Texture Expert program Version 4 was used for data analysis. Textural determinations were made by using a 75 mm compression platen (P/75) for a compression test. Samples were positioned centrally with the core at right angles to the direction of force, on the bread. Once a trigger force of 100 g achieved, the compression plate proceeds to move down onto the spread and a rapid rise in force was observed. During this stage the sample deformed under the applied force but there was no apparent breakdown of the product. As the compression distance increased, small peaks were seen on the graph profile, each peak indicated a compressive failure of the sample. This stage ended abruptly when the test completed and was indicated by a large decrease in force. The greater the distance, the greater is the ability to withstand compression without sample breakage.

Bread water activity: Water activity was determined by the HygroPalm (HP 21, USA). HygroPalm is a portable humidity temperature indicator, having 9-volt rechargeable batteries. It displays the measurements from the probe connected to the remote unit. The ground sample was filled in the plastic jar and the HygroPalm probe was inserted in it. The up and down keys are used to navigate the function menu, the enter key is press to confirm the settings. The display shows the water activity (0-1), along with temperature (°C) and time (s).

Bread loaf volume: The loaf volume was determined using a rape seed displacement method. Each loaf was put in a container and covered with rapeseeds totally filled the container. Then the loaf was removed and the volume of rapeseed was recorded by the method [6].

***in vitro* Protein digestibility of bread:** *in vitro* Protein digestibility of bread was measured according to method described [9].

***in vitro* Starch digestibility of bread:** *in vitro* Starch digestibility of bread was analyzed by the method [10].

Sensory evaluation of breads: Bread samples were evaluated for their external sensory characters *i.e.* colour of crust, volume, evenness of bake, symmetry of form, character of crust and internal characters such as colour of crumb, taste, aroma and texture by a trained panel of judges using score card described [11].

Statistical analysis: The results obtained were statistically analyzed by completely randomized design using MSTATC software. Means were separated by least significance difference (LSD) at a 5 % level of significance [12].

RESULTS AND DISCUSSION

Properties of composite flour: The chemical composition of composite flours varied significantly because of the supplementation of sesame meal in wheat flour as shown in Table-1. The contents of ash, crude fiber, crude protein and crude fat increased as the level of supplementation of sesame meal were enhanced in the composite flours. The supplementation of sesame in wheat flour significantly improved the

TABLE-1
EFFECT OF SESAME MEAL SUPPLEMENTATION ON PROXIMATE COMPOSITION (%) OF COMPOSITE FLOUR

Treatments	Moisture	Ash	Fat	Protein	Fiber	NFE
T_0	12.09^a	0.90^c	1.83^d	12.43^e	0.30^d	72.4^a
T_1	11.54^a	0.98^{bc}	2.58^c	13.45^d	0.48^c	70.9^a
T_2	11.17^a	1.32^a	4.74^b	14.13^c	0.56^b	68.0^b
T_3	10.80^a	1.39^{ab}	4.81^b	14.90^b	0.61^a	67.5^b
T_4	10.69^a	1.68^a	5.89^a	16.19^a	0.66^a	64.8^c

Means carrying same letters in a column are not significantly different from each other: T_0 = 100 % wheat flour; T_1 = 4 % sesame meal supplemented wheat flour; T_2 = 8 % sesame meal supplemented wheat flour; T_3 = 12 % sesame meal supplemented wheat flour; T_4 = 16 % sesame meal supplemented wheat flour

nutrient profile of the composite flours. The results of the present study are in line with the earlier study conducted [13,14].

Farinographic characteristics: The farinographic results showed that the water absorption ranged from 60.40 to 64.40 % in different composite flours (Table-2). The maximum water absorption (64.40 %) was observed in the 16 % sesame meal supplemented composite flour while the minimum water absorption (60.40 %) was observed in the 100 % wheat flour (control). The values for softening of dough ranged from 40 (BU) to 90 (BU) in different composite flours. The maximum softening of dough was observed in the 16 % sesame meal supplemented flour (90 BU) followed by 12 % sesame meal supplemented flour (80 BU) while the minimum softening of dough was observed in the 100 % wheat flour (control). The values for dough development time ranged from 4.5 to 7.5 min in different composite flours. The highest dough development time was observed in the 16 % sesame meal supplemented flour (7.5 min) while the minimum (4.5 min) was observed in the 100 % wheat flour (control). An overall increasing trend of dough stability was observed with the increase in protein content. The maximum dough stability was observed in the 16 % sesame meal supplemented flour (15 min), while the lowest dough stability (12 min) was observed in the 100 % wheat flour (control). The highest mixing tolerance index was observed in the 16 % sesame meal supplemented flour (30 BU), while the lowest mixing tolerance index (10 BU) was observed in the 100 % wheat flour (control). The increase in protein (gluten) of different composite flours affects the mixing tolerance index of composite flours. The mixing tolerance index in all composite flours decreased with decrease of protein. It is reported that farinographic characteristics increased with the increase in protein content as well as improvement in gluten quality. But other factors like starch damage during milling also affects farinographic characteristics [15]. Kent [16] indicated that flours from stronger wheat had the quality to absorb and retain larger quantities of water as compared to soft wheat flour. The obtain results are in agreement to the results reported by the results [17,18].

Mixographic studies: The highest peak height percentage (58.1 %) was recorded in control. A decreasing trend in peak height percentage was observed with increasing the level of defatted sesame meal. The lowest peak height parentage (38.30 %) was recorded in wheat composite flours supplemented with 16 % sesame meal (Table-2). Mixing time is the time necessary for the curve to arrive at its full development or maximum consistency possessing the highest peak. There is a relationship of high peak height with strong wheat's having long mixing time. The results elucidated that the highest mixing time (4 min) recorded for control treatment which was decreased to 2.7 min. in case of 16 % sesame meal supplemented flour. Butt *et al.* [19] reported that peak height of different wheat varieties ranged from 43 to 65 %. Similar results were found [4,20,21].

Mineral content: The concentration of minerals enhanced significantly due to the supplementation of sesame meal in wheat flour. The highest contents of sodium (10.45 mg/100 g), potassium (355.85 mg/100 g), calcium (91.72 mg/100 g) and magnesium (185.84 mg/100 g) were found in 16 % sesame meal supplemented composite flour (Table-3). The iron and zinc contents improved significantly due to the supplementation of sesame meal in wheat flour. A progressive increase in mineral concentration with the level of sesame meal supplementation was observed. Several workers [1,22-24] found the similar results.

Water hydration capacity: The water hydration capacity differed significantly due to differences in supplementation level of sesame meal in wheat flour. It was observed that the

TABLE-2
EFFECT OF SESAME MEAL SUPPLEMENTATION ON FARINOGRAPHIC AND MIXOGRAPHIC PARAMETERS OF COMPOSITE FLOUR

Treatments	Farinographic parameters					Mixographic parameters	
	WA (%)	SOD (BU)	DDT (min)	Stability (min)	MTI (BU)	Peak height (%)	Mixing time (min)
T_0	64.40^{a}	40.00^{d}	4.50^{d}	12.00^{c}	10.00^{c}	57.26^{a}	4.00^{a}
T_1	63.50^{b}	70.00^{c}	6.00^{c}	12.50^{bc}	10.00^{c}	53.06^{b}	3.70^{ab}
T_2	62.60^{c}	80.00^{b}	6.50^{bc}	12.50^{bc}	20.00^{b}	48.13^{c}	3.36^{bc}
T_3	61.80^{d}	80.00^{b}	7.00^{ab}	13.50^{b}	20.00^{b}	43.56^{d}	3.00^{cd}
T_4	60.40^{e}	90.00^{a}	7.50^{a}	15.00^{a}	30.00^{a}	38.30^{e}	2.70^{d}

Means carrying same letters in a column are not significantly different from each other: T_0 = 100 % wheat flour; T_1 = 4 % sesame meal supplemented wheat flour; T_2 = 8 % sesame meal supplemented wheat flour; T_3 = 12 % sesame meal supplemented wheat flour; T_4 = 16 % sesame meal supplemented wheat flour

TABLE-3
MINERALS CONTENTS (mg/100 g) OF COMPOSITE FLOUR SUPPLEMENTED WITH SESAME MEAL

Treatments	Calcium	Copper	Manganese	Iron	Potassium	Sodium	Magnesium	Zinc
T_0	35.82^{e}	0.27^{e}	1.68^{d}	2.35^{e}	180.72^{e}	3.66^{e}	94.36^{e}	1.70^{e}
T_1	48.84^{d}	0.38^{d}	1.85^{c}	2.62^{d}	218.18^{d}	5.12^{d}	113.92^{d}	1.89^{d}
T_2	63.75^{c}	0.44^{c}	1.89^{c}	2.93^{c}	265.66^{c}	6.67^{c}	134.49^{c}	2.07^{c}
T_3	71.49^{b}	0.57^{b}	2.02^{b}	3.22^{b}	316.72^{b}	8.75^{b}	155.65^{b}	2.34^{b}
T_4	91.72^{a}	0.67^{a}	2.10^{a}	3.57^{a}	355.85^{a}	10.45^{a}	185.84^{a}	2.49^{a}

Means carrying same letters in a column are not significantly different from each other: T_0 = 100 % wheat flour; T_1 = 4 % sesame meal supplemented wheat flour; T_2 = 8 % sesame meal supplemented wheat flour; T_3 = 12 % sesame meal supplemented wheat flour; T_4 = 16 % sesame meal supplemented wheat flour

control treatment has the minimum water hydration capacity (0.93 g/g) and its value increases gradually as the level of sesame meal supplementation increased in wheat flour. The composite flour with 16 % supplementation of sesame meal has the highest water hydration capacity (1.11 g/g) (Fig. 1).

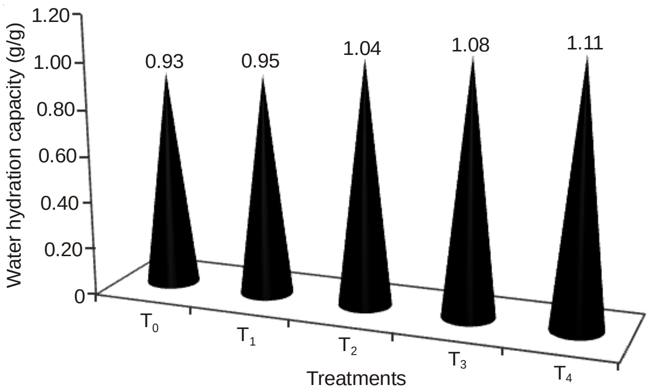

Fig. 1. Effect of sesame meal supplementation on water hydration capacity (g/g)

The water absorption capacity of different cereals ranged from 1.33 to 1.47 g/g. The enhanced water hydration capacity of heat-processed seeds may be due to the denaturation of proteins that facilitates additional binding sites available for water binding, or it may be due to the gelation of carbohydrates and swelling of crude fiber due to heat treatment. WAC is considered a critical function of proteins in viscous foods such as soups, gravies, doughs and baked products. Hence, increased WAC of sesame meals supplemented flour observed in the present study due to some processing treatments can be made use of in these products [25].

Properties of bread

Colour: The mean values of colour of breads prepared from composite flour are presented in Table-4. It indicated that the breads from control (100 % wheat flour) has the minimum colour value that is 166 CTn and its value increased gradually up to 181 CTn as the level of sesame meal supplementation increased up to 16 % in wheat flour. The darker colour is due to sesame meal supplementation. The breads prepared from 16 % supplementation of sesame meal in wheat flour got the maximum colour value (Table-4).

Water activity: The mean values of water activity of bread of different composite flours ranged from 0.74 to 0.78 (Table-4). The maximum water activity was found in the bread produced by 16 % sesame meal supplemented wheat flour while the minimum water activity was found in the bread produced by 100 % wheat flour (control). The increase in protein content affects the water activity of different composite flours. The water activity increases as the percentage of protein content increases. Water activity of bread of all the composite flours showed significant results among each other.

Textural characteristics: Bakery products have a characteristic shape and definite texture that is accepted by the consumers. Any significant deviation from the optimal texture characteristics of the product can be considered as a reduction in the quality. Texture has significant influence on consumer's perception of a good bread quality. The most important attribute of bread include hardness. Hardness is defined as the force required for biting of bread. The mean values showed that bread hardness ranged from 1732.2 to 2811.3 g among the various treatments. The highest bread hardness (2811.3 g) was recorded for the bread prepared from control, while the lowest hardness (1732.2 g) was recorded with the bread produced by 16 % sesame meal supplementation (Table-4). Similar textural and crumb grain profiles have been stated previously by means of sensorial and instrumental studies of bread [26].

Loaf volume: The loaf volume of composite wheat flour bread ranged from 306.67 to 577.33 cm^3. The maximum loaf volume was found by the bread produced by control while the minimum loaf volume was found in the 16 % sesame meal supplemented bread. The increase in protein in different composite flours affects the loaf volume (Table-4).

The reduction in bread volume may be attributed to the reduction in gluten forming proteins and rise in dietary fiber contents supplied by sesame meal, which unconstructively affected the formation of gluten network and depressed the loaf volume due to lack of gas withholding capacities of the composite flour. The sesame meal supplemented to wheat flour acted as dilution factor on gluten content which may cause less volume and also is responsible for reduction in -SH groups. Butt *et al.* [19] found that the genetic factors, damaged starch, α-amylase activity and protein quantity might have significant effect on bread volume and baking quality for different composite flours. The results obtained in the present study are also in line with the study [27], who found a decreasing trend in volume with the level of supplementation of sesame meal.

***in vitro* Protein digestibility:** *in vitro* Protein digestibility differed significantly due to differences in supplementation

TABLE-4
EFFECT OF SESAME MEAL SUPPLEMENTATION ON COLOUR, WATER ACTIVITY, TEXTURAL CHARACTERISTICS AND VOLUME OF COMPOSITE FLOUR BREAD

Treatment	Colour (CTn)	Water activity	Textural characteristics		Bread volume (cm^3)
			Force (g)	Distance (mm)	
T_0	166.00^b	0.74^c	2811.30^a	73.03^c	577.33^a
T_1	171.67^{ab}	0.74^c	2184.80^b	74.16^b	550.33^b
T_2	171.67^{ab}	0.76^b	2090.80^b	74.25^b	525.33^c
T_3	179.67^a	0.77^a	1841.30^b	75.05^{ab}	405.00^d
T_4	181.00^a	0.78^a	1732.20^b	75.55^a	306.67^e

Means carrying same letters in a column are not significantly different from each other: T_0 = 100 % wheat flour; T_1 = 4 % sesame meal supplemented wheat flour; T_2 = 8 % sesame meal supplemented wheat flour; T_3 = 12 % sesame meal supplemented wheat flour; T_4 = 16 % sesame meal supplemented wheat flour

level of sesame meal in wheat flour. The mean values of *in vitro* protein digestibility of breads prepared from composite flours indicated that the breads from control has the minimum value (70.86 %) and increased gradually as the level of sesame meal supplementation increased in wheat flour. The breads prepared from 16 % supplementation of sesame meal in wheat flour got the maximum digestibility value (78.24 %) (Fig. 2). The results obtained correlates with the results [27], who found an increasing trend in protein digestibility with the level of supplementation of sesame meal. In present study, the authors found 71.2 % value with 100 % wheat flour to 78.5 % with 16 % protein level of flour. The increasing trend is due the reason that sesame meal contains up to 50 % of protein that increases the protein content of the composite flour bread that's why the *in vitro* protein digestibility also increases.

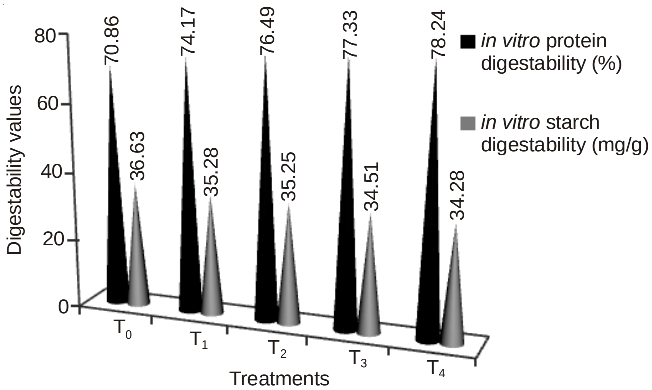

Fig. 2. Effect of sesame meal supplementation on *in vitro* protein and starch digestibility

***in vitro* Starch digestibility:** *in vitro* Starch digestibility differed significantly due to differences in supplementation level of sesame meal in wheat flour. The mean values of *in vitro* starch digestibility of breads prepared from composite flours indicated that the breads from control has the highest value (36.63 mg of maltose per gram of flour) for *in vitro* starch digestibility and its value decreases gradually as the level of sesame meal supplementation increased in wheat flour. The breads prepared from 16 % supplementation of sesame meal in wheat flour got the minimum (32.28 mg of maltose per gram of flour) *in vitro* starch digestibility value. It is also obvious from the results that breads prepared from 4 and 8 % sesame meal supplemented wheat flour possessed non-significant differences among each other. Similarly, breads prepared from 12 and 16 % sesame meal supplemented wheat flour also showed non-significant difference (Fig. 2). The results of the present study are in line with the results [28,29]. They found a decreasing trend with the level of supplementation in wheat flour with non-wheat flours. The decreasing trend may be due to the addition of non-wheat flour, non-starchy flour that results in decrease in *in vitro* starch digestibility.

Sensory evaluation: Different sensory attributes of the bread are presented in Table-5. The volume, colour of the crumb and texture of the bread decreased by the supplementation of the sesame in wheat flour while, the other attributes showed different trends. The decrease in evenness of bake, character of crust, texture and scores of breads prepared from sesame meal supplemented wheat flour beyond 12 % may be attributed towards the coarser grain structure of sesame meal and more fiber contents of sesame meal which resulted in the development of leathery texture and coarser bread grain. The decrease in aroma and taste of breads by the increase in level of sesame meal supplementation might be due to more nutty taste and higher fat contents contributed by higher levels of sesame meal.

Results of the current study are in agreement with the previous work [14], who established that addition of 15 % flaxseed meal in bread negatively affected the crust colour, volume and crumb colour of breads. The sensory scores for texture, appearance and flavour of breads have been stated to be reducing by the integration of non-wheat flours in wheat flours [26]. Filipovic *et al.* [30] also found that addition of fibers (unmodified and modified) demonstrated reduction in scores assigned to crumb quality and volume of bread.

In the current study, task of fewer score by the panelists to the crumb and crust colour of breads may be attributed to the darker colour of sesame meal imparted to resultant breads as the sesame meal (flour) is darker in colour than wheat flours. The darker colour has also been accredited to Maillard reaction between reducing sugars phenolic compounds and proteins during baking process as reported [31].

It is a common choice in Pakistan that consumers like breads with light brown crust and whiter crumb. This factor might have affected the psyche of panelists when rating the breads with higher levels of sesame meal and they assigned lesser scores with respect to their colour.

Conclusions

The research work was carried out to assess the acceptability of sesame meal exploitation in the baked products. The defatted sesame meal was supplemented in to the white wheat flour to get composite flours. The sesame meal supplemented compo-

TABLE-5
EFFECT OF SESAME MEAL SUPPLEMENTATION ON SENSORY CHARACTERS OF COMPOSITE FLOUR BREAD

Treatments	Volume	Colour of crust	Symmetry of form	Evenness of bake	Character of crust	Colour of crumb	Aroma	Taste	Texture
T_0	8.50^{a}	5.70^{c}	4.00^{b}	2.00^{c}	2.90^{a}	8.30^{a}	7.00^{cd}	12.50^{c}	13.20^{a}
T_1	7.90^{b}	5.90^{c}	4.30^{b}	2.00^{c}	2.90^{a}	8.10^{a}	7.40^{bc}	12.90^{bc}	12.30^{ab}
T_2	7.40^{bc}	7.00^{b}	4.30^{b}	2.70^{b}	3.20^{a}	7.80^{ab}	7.90^{b}	14.10^{ab}	12.20^{ab}
T_3	7.00^{cd}	8.00^{a}	4.70^{a}	3.00^{a}	3.30^{a}	7.40^{bc}	8.60^{a}	14.60^{a}	12.00^{b}
T_4	6.80^{d}	5.70^{c}	3.40^{c}	2.00^{c}	2.80^{a}	7.00^{c}	6.80^{d}	12.20^{c}	10.70^{c}

Means carrying same letters in a column are not significantly different from each other: T_0 = 100 % wheat flour; T_1 = 4 % sesame meal supplemented wheat flour; T_2 = 8 % sesame meal supplemented wheat flour; T_3 = 12 % sesame meal supplemented wheat flour; T_4 = 16 % sesame meal supplemented wheat flour

site flours were analyzed for their chemical composition and rheological properties. The breads thus produced were analyzed for other physical and chemical tests such as volume, colour. Texture, water activity and *in vitro* protein and starch digestibility as well as sensory evaluation.

The breads prepared from sesame meal supplemented composite flour indicated a significant reduction in internal and external sensory characteristics by the raising level beyond 12 % supplementation of sesame meal. The scores assigned to aroma and taste of breads prepared from freshly prepared composite significantly higher.

Baking industry should focus on the fortification of bakery products with sesame flour. Sesame meal supplemented breads should be advised for diabetic and heart patients. Sesame should be used in various other products based on dairy and beverages. Active ingredients from sesame should be extracted and used as nutraceuticals in different food products including chapattis and other traditional products.

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