EFFECT OF ADDITION OF SESAME FLOUR TO WHEAT FLOUR ON BREAD QUALITY

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September 2006
To my parents

To my husband

To my brothers and sisters

With ever lasting love and respect

I dedicate this work
ACKNOWLEDGMENTS

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The effects of addition of white or red sesame flour at different replacement levels (5, 10 and 15%) to wheat flour, on bread making quality were investigated.

Wheat flour was obtained directly from Sayga Flour Mills, while the white and red sesame seeds were purchased from the local market.

The sesame seeds were dehulled, defatted and then milled into flour. Bread was prepared by the straight dough method.

Chemical analysis were carried out for the wheat flour and also for the sesame seeds and then the sesame seeds flour.

The proximate chemical analysis of the sesame flours, both white and red, showed fluctuation when compared to ranges reported in the literature. For the white sesame, the moisture, ash, fat and carbohydrates contents were lower than that recorded by previous investigators, while the protein content was within the range and for the red sesame flour, moisture, ash, carbohydrates and protein content were also lower than that reported by previous workers. This could be attributed to the genetic and environmental factors which are known to affect the physical and chemical composition of the crops.

Farinograph results of bread dough indicated that the addition of white or red sesame flour at different replacement levels (5, 10 and 15%), increased the water absorption and degree of weakening, but decreased the dough stability and dough development time.

The bread made from wheat and sesame flours, showed significant decrease (P ≤ 0.05) in specific loaf volume. With increasing levels of
replacement there were significant increase (P≤ 0.05) in protein content and *in vitro* protein digestibility.

Nevertheless the bread prepared with wheat flour and 15% replacement level with white sesame or red sesame flours were superior in protein content and *in vitro* protein digestibility, but organoleptically unacceptable.

Bread made from wheat flour and 5% white sesame flour showed higher specific loaf volume compared to bread with the same replacement level with red sesame flour. This could be attributed to high enzymatic activity of the white sesame flour as confirmed with the results of the falling number.

Sensory evaluation indicated that the quality of the bread was significantly affected by the incorporation of sesame flours, nevertheless bread with 5% white sesame flour was not much different from the control.
ملخص الطرحة

نُتِبِّعَتْ العِسَائِرُ الأحمرُ أّو الأبيضُ بَينَما الإضافةُ للسَّمَسَّرِ مَعْنَىُهُ مَنْ عَلِى **القَمحّ النَّقِي**.

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١. أعطوا الأحمر أو الأبيض السميسم الدقيق من اللمجز ووالخبز ١٥٪. 

٢. إذا كان الحس في تقييم الناحية، والكائن السروي والبروتين السروي ناحية من الناحية، فأعلى قبول.

٣. إضافة ٥% لقمة القمح إلى الأبيض السميسم الدقيق مما يزيد في زيادة إلى الأحمر السميسم الدقيق نسبة بنفس مقارنة للخبز السقطي رقم نتائج مع توافقة والكائن الأبيض السميسم للدقيق.

٤. معنى تثرب الخبز جودة كبان الحس في تقييم نتائج أظهرت، وأليس السميسم الدقيق بأضافة إختلاط في ذلك إضافة بين ف ٥% القياسية للعبة بجانب القمح الدقيق الأبيض السميسم الدقيق من الناحية.
CHAPTER ONE
INTRODUCTION

Bread making is an ancient art which has originated in Egypt about 3500 BC. (Joswellman, 2003). Bread making is closely identified with the development of man and his civilization. It was changed from the simple unleavened product made in early civilization to the light airy ones we enjoy today. The improvement in bread making technology such as milling, baking and related operations was slow. With the evolution in food science and technology, it was possible to control these different bread-making operations.

The leavened bread from wheat flour has numerous advantages over other staple foods. Nutritionally, bread is high in complex carbohydrate which gives the body sustained energy (Bennion, 1967) it is superior, particularly in protein and vitamin content, compared to other staple foods such as rice, potatoes, … etc. As with other staple foods bread is rarely eaten alone, it acts as a vehicle for protein and vitamin–rich materials such as meat and cheese. In addition to that, the solid state of bread facilitates its transportation, it is extremely convenient in that it requires no further preparation once purchased. Lately the changes in human food habits through which the increased
consumption of bread is derived -in part- from the convenience and wholesomeness of bread and as a result of the improvements in the transport infrastructure as well (Dendy, 1992). Consequently, in most developing countries many flour mills are built to process wheat and thus sustaining the bread eating habit. Also, the migration phenomena from country side inward to the urban centers has imposed the spread out of this habit.

Composite flour may be considered a combination of wheat and non wheat flours for the production of leavened breads, other baked products and pastas, or wholly non wheat flour prepared from mixture of flours from cereals, root tubers, legumes raw materials to be used for traditional products.

Composite flour is important from an economical point of view whereby through this technique wheat imports are reduced.

The basic criteria for composite flour include firstly, wheat flour of reasonable strength preferably over 13% protein; secondly, clean fine flour from the non- wheat flour compatible in colour with wheat flour (Dendy, 1992).

Supplementation of cereal with high protein legumes is one of the best solutions presented to antagonize the protein deficiencies in the world. Soya bean is a good source of protein flour to be used in
baked products, peanuts are a good source of protein if the problem of aflatoxin can be avoided. Glandless cotton seed flour can be used as a protein supplement for bakery products if the problem of discoloration and acidic taste can be solved. Also the whole de-fatted oil seeds flour, of high protein can be used as source of protein supplement in many developing countries.

Comminuted meat products are widely consumed throughout the world. In view of the high cost and scarcity of meat in some countries there is an increasing interest in the use of plant proteins as functional ingredient in meat products. The growing industry based on the functional properties of soy protein has stimulated an interest in the potential use of other oil seeds in meat products (Dench et al., 1981).

Sudan has nutritional problems in various parts of the country, most restricted to infants and young children, due to the unequitable distribution of food in all economic strata and to ignorance, and traditions associated with child feeding. The infant and child population do suffer from protein calorie malnutrition of fairly high magnitude (Yousif, et al., 1973).

Sudan has a great potential in the production of protein concentrates. There are areas and population in the country, where
availability of nutritious foods especially from animal origins are highly inadequate.

Production of inexpensive food from such protein concentrate has great potential. At the same time, Sudan is one of the largest producers of cotton in the world. The country has also a significant production of groundnut and sesame. Fortunately, all these sources are excellent raw materials for production of protein concentrates and isolates (Yousif et al., 1973).

The Objective of this Study:

To study the effect of addition of white and red sesame flour to wheat flour on bread making quality.
CHAPTER TWO
LITERATURE REVIEW

2.1 Wheat

Wheat belongs to the family Gramineae, and the genus triticum. There are several species of wheat, but those of commercial importance are derived from three botanical species.

1. *Triticum aestivum*: This species provides the bulk of wheat used for bread making, besides cakes and biscuits.

2. *Triticum durum*: Durum wheat used for production of semolina for manufacture of pasta products.


The grain of wheat consists of carbohydrates, nitrogenous compounds, mainly protein, lipids, mineral matter and water, together with small quantities of vitamins, enzymes and other substances, some of which are important nutrients in the human dietary (Anon, 1987; Bushuk, 1986).
The composition of wheat flour varies considerably according to the class of wheat, its origin and the proportion of outer part removed by particular milling process.

Most of the wheat flour used in Sudan in bread making is from imported wheat which is milled locally.

2.2 Sesame

The genus sesamum belongs to the family pedaliaceae and order Tubiflorae (Nayer and Mehra, 1970).

The sesame seeds are important source of edible oil and protein (Haller, et al., 1942).

Sesame is one of the important main sources of vegetable oils in the Sudan. Sesame is grown almost exclusively under rain condition in an area of approximately 1.5 million feddans. Part of the produce is processed for local consumption but the bulk of the seed and the seed cake are exported.

The varieties grown fall under two major groups; colored and white seeded. The white seed is preferred in the world market as it is used largely in confectionery

Sesame seeds are important dietary source of protein in areas where they are grown. Their protein has a good balance of amino acids with a chemical score of 62% and net protein utilization of 54%.
2.3 Chemical composition of sesame seeds:

2.3.1 Moisture content:

Johnson and Raymond (1964) reported a value of 5.47% moisture content for sesame seed while Khalid (1994) showed that the moisture content ranged between 3.4% and 5.7%. El-Nadeef (1990) reported that the moisture content of sesame seeds samples ranged from 1.5 to 2.5%.

Ali (2000) reported that sesame seed cakes (white and brown) gave an average value of 5.8% and 5.3% respectively.

2.3.2 Lipids:

Air-dried sesame seed usually has an oil content between 44-54% but oil content as low as 35% and as high as 58% was known, the most outstanding characteristic of the oil is its stability, which is due to natural antioxidants (El-Tinay et al., 1976).

The oil content varies with genetic and environmental factors, as wide range of the soil content of sesame seed from 37 to 63% was reported by Bernardini (1986).

Sabah El-Kheir (1994) reported oil content of sesame cultivars as ranging from 47 to 54%. Weiss (1983) reported that lipids of sesame seeds are mostly composed of neutral triglycerides with small
quantities of phosphatides (0.03 to 0.13%) and unsaponifiable matters (1.2%).

2.3.3 Sesame protein:

Joshi (1961) and Lyon (1972) reported that the average protein content in sesame seeds ranges from 19 to 31%. The protein content the oil-free residue varied from 54 to 60% in the local varieties, as reported by El-Tinay et al. (1976).

Meksongsee and Swatditat (1974) indicated that the protein content of the defatted flour of brown and white sesame seed was 55.2 and 50.4% respectively.

Rivas et al. (1981) classified the sesame proteins to globulins (67.3%), prolamin (1.3%), albumin(8.6%) and glutelin (6.9). Sesame proteins are rich in sulfur-containing amino acids, particularly methionine (Rao and Rao, 1981). Evans and Bandemer (1967) reported protein nutritive value of sesame as 15 to 42 relative to casein as 100.

2.3.4 Carbohydrates:

Joshi (1961) reported that the carbohydrate content of sesame seeds is comparable to that of groundnut seeds and is higher than that of soybean seeds. Sesame seeds contain 21 – 25% carbohydrates, most
of the sugars are reducing type. Defatted sesame flour contains more sugar than sesame seeds.

2.3.5 Crude fiber:

Johnson and Raymond (1964) found that the crude fiber content in sesame seeds ranged from 9.1 to 11.5%. However, El Nadeef (1990) reported that the fiber content of sesame seeds ranged between 5.2 and 7.6%.

2.3.6 Ash:

Sawaya et al. (1985) reported that sesame seed contains about 3% ash while Rivero (1983) reported a value of 6.93% ash content.

Sabah El Kheir (1994) showed that the total ash content of sesame cultivars ranged from 8.1 to 13.5%. However, Ali (2000) reported that sesame seed cakes (white and brown) gave average values of 16 and 9.6% respectively.

2.3.7 Minerals:

Sesame seed is a good source of certain minerals particularly calcium, phosphorus and iron. Deosthale (1981) reported 1% calcium and .07% phosphorus in the seeds, calcium is mostly present in the seed coat, which is lost during dehulling.

Ponerose-Schneier and Eerdman (1989) reported the bioavailability of calcium from food products, as follows: non fat dry
milk 100%, while wheat bread 95%, almond powder 60%, sesame seeds 65% and spinach 47%.

2.3.8 Vitamins:

Sesame seeds are important source of certain vitamins, particularly niacin, folic acid and tocopherols, (vitamin E include several tocopherols), sesame oil is rich in tocopherols, while vitamin A is very low (Gopalan et al., 1982 and Weiss, 1983).

2.3.9 Anti-nutritional factors:

Gopalan et al. (1982) reported 1.7% oxalic acid in the seeds. Sesame seeds contain a substantial amount of phosphorus, however most of phosphorus is tied up as phytic acid or as phytine and formation of such complexes decrease the bioavailability of these minerals.

2.4 Sesame processing:

2.4.1 Dehulling:

Dehulling sesame seed is essential to improve the quality of utilization of the meal as a source of human food (Hui, 1996). Sastry et al. (1974) noticed that the sesame seeds are mostly processed or used without removing the cuticle or the seed coat. The presence of cuticle contributes to the colour, bitterness and high fiber and oxalate contents of the seeds. The bitterness may be due to binding of calcium
by oxalic acid. Dehulling of the sesame seed is, therefore, essential to improve its quality and utilization as a source of human food. Dehulling is an integral part of modern oil extraction plants, it is also recommended to produce a high-quality oil and meal.

Most commonly used method of decuticulizing of seeds is to soak the seeds and move the cuticle manually by light pounding or by rubbing on a stone or wooden block. Ramachandra et al. (1970) have reported Alye-treatment process for dehulling of sesame. In this process, seeds are washed with cold water, the ruptured seed coats are separated by scrubbing in a suitable equipment, the dehulled seeds (kernels) are then dried.

The dehulled seeds contain significantly more fat and less crude fiber, calcium, iron, thiamin, riboflavin and slightly less phosphorus than the whole seeds.

2.4.2 Oil extraction and purification:

Commercially, sesame seeds are extracted using a continuous screw press, hydraulic press, prepress solvent extraction or direct solvent extraction method as in the case of the other oil seeds (Godin and Spensley, 1971).
2.4.3 Sesame cake and meal:

Sesame cake is obtained as a byproduct after extraction of oil, when powdered, the cake is converted into a meal or flour, four types of meal which can be obtained from sesame seeds are; whole seed meal, dehulled seed meal, defatted whole seed meal and dehulled-defatted meal. The meals or flours obtained from dehulled seeds contain more proteins, phosphorus, and less ash, crude fiber, calcium and oxalic acid than those obtained from whole seeds (Hui, 1996).

Sastry et al. (1969) remarked that heat treatment did not affect the amount of total protein and lysine. Ali (1974) determines the chemical composition of oil seed cakes of cotton, groundnut and sesame. The protein contents of cottonseed-cake, groundnut and sesame seed-cake were 29.3, 26.3 and 25.6% respectively. The residual oil content of the three cakes were 10.92, 10.52 and 11.08%, while the carbohydrates were 84.63, 73.50 and 86.52% respectively.

2.5 Protein concentrates and isolates:

Hui (1996) stated that sesame is widely processed into several high protein products, such as flakes, flour protein concentrate and isolates.

The protein concentrate and protein isolate contain respectively, 70 and 90% protein.
Unlike many oil seeds, protein concentrate and isolate prepared from dehulled, defatted sesame flour do not contain any undesirable pigments of flavor or toxin (Toma et al., 1979a, Johnson et al., 1979). Rivas et al. (1981) reported that the chemical composition of defatted sesame flour, protein concentrate and protein isolate were significantly different from each other, the protein isolate contained very high level of protein and was almost free from oil, ash, crude fiber and phytate phosphorus with very low levels of nitrogen-free extract.

The chemical composition of protein concentrate was intermediate between that of defatted meal and protein isolate.

2.6 Utilization of sesame products:

2.6.1 Human food:

Small quantity of hulled seed is used as topping for bread and confectionary. The main use of sesame seed in the United State and Western World is limited to oil extraction, sesame meal flour, topping for baked products and manufacture of confection specialties. In developing countries sesame is used on a much larger scale to include the production of sesame butter and sesame sweets (Toma et al., 1979b).
Hui (1996) stated that in India sesame is used to manufacture traditional confections, also sesame meal is used extensively in human foods, especially as protein supplement for soy and legume proteins. There is also increasing investment in fortifying bread and cookies by replacing a portion of wheat flour with sesame meal. Also the seeds milled and mixed with brown sugar are eaten by nursing mother to encourage their milk production.

Oil is the major product of sesame seed processing, most of the oil produced is used for culinary purposes (Maiti et al., 1988).

The use of sesame flour or meal in fortifying some feeds is common because of its high protein content. The use of sesame meal in the diet of children suffering from kwashiorkor has been found to be beneficial (Rooney et al., 1972).

Brito and Nunez (1982) reported that sesame flour has been recommended as a protein supplement for cereal flours and as methionine supplement for soy and legume proteins. Sesame flour has been used as a methionine supplement in the preparation of fermented foods (vada and dosa), the most popular south India dishes (Chopra et al., 1982).

Gruz and Hedrick (1985) prepared fermented salami containing 9 to 27% sesame flour, the results indicated that defatted sesame meal
could be used up to 18% level without any detrimental effect on sensory attributes of salami. Blends of peanut/chickpea, rice/chickpea, peanut/soybean, sunflower/maize, cowpea/rice have all shown improved nutritional qualities with supplementation of sesame meal, even more significant, however, is finding that a simple blend of one part each of sesame and soy protein has about the same protein nutritive value, as casein, the main protein of milk (Hui, 1996).

2.7 Cereal brans incorporation:

Cereal brans have been incorporated into food for their functional characteristics – such as binding, stabilizing and texture building. Incorporation of fibrous material into bread products started in the seventies and was investigated by many workers since then.

2.7.1 Incorporation of white wheat bran:

Pomeranz et al. (1977) studied incorporation of white wheat bran as a source of dietary fiber in bread. They found that addition of bran to the bread formulation at replacement level above 7% increased water absorption, decreased bread volume, impaired crumb texture, modified taste and bread colour and reduces softness.
2.7.2 Incorporation of triticale bran:

Lorenz (1976), studied the feasibility of using triticale bran and rye bran for production of fiber bread. He found that at up to 15% replacement level water absorption increased and so the mixing time. Proof time of the dough deceased and this was attributed to the high amylase activity in the bran. The breads produced with fine bran were softer than the control.

Blends of wheat and triticale in 3:1, 1:1 and 1:3 proportions were used for bread, cookie and chapatti making. The loaf volume and crumb texture of triticale bread was improved with the increased proportion of wheat flour. Blends up to 1:1 ratio gave very good bread and good cookies while only blend of 1:3 ratio gave a good chapatti (Sekhon et al., 1980).

2.7.3 Incorporation of other cereals and cereal by-products from an economical point of view:

It was investigated by many workers in Sudan, thus saving the hard currency furnished for the imports of wheat. Mustafa (1976) and Badi (1979) produced bread from 1:9 sorghum-to-wheat. The sorghum was decorticated prior to milling to avoid the presences of the black specks and the dark colour of the bread.
The feasibility of adding bran from wheat, tritacle and millet at levels of 5 – 20% to different types of wheat flour to produce new type of Sudanese bread was investigated by Halim (1983). The presence of bran in the dough increased the water absorption and decreased mixing time. Proof time was decreased for dough of strong flour and bran. The effects on the crumb colour and flavour of breads baked with blends of strong, medium and weak flours respectively and up to 10% with wheat bran and those with triticale bran were minimal. Addition of millet bran produced poor quality bread in terms of crumb colour, flavour and texture. A noticeable decrease was noticed in loaf volume for bread with wheat bran and strong flour, while for bread made from medium and weak flour there was a slight increase in loaf volume. For bread made with triticale bran and either of these flours there was no change in volume.

2.7.4 Other fibrous materials such as cellulose and non-cereal sources:

Cellulose and non-cereal sources were used to produce high-fiber bread. Water absorption and mixing time of the doughs with cellulose 3-15% replacement was increased. Acceptable bread was produced with up to 7% of cellulose (Pomeranz et al., 1977).
Volpe and Lehmann (1977) also found that replacement of cellulose up to 10% using sponge dough method with gluten supplementation has increased the water absorption. The volume and grain of the bread produced were slightly inferior but in overall the bread was acceptable.

Satin et al. (1978) studied the effect of adding sugar beet pulp, hulls of yellow field pea, alfalfa, and cellulose to wheat flour for bread preparation, at replacement levels of 7.5%. Water absorption and mixing time were increased moderately in doughs with pea hulls and alfalfa. Doughs with beet pulp and cellulose showed high water absorption, but mixing time was increased for the beet pulp dough only. The crumb colour of bread with cellulose or pea hull was not affected, while that of beet pulp and alfalfa was darker than the control.

The effect of adding 3 and 6% of potato flours to wheat flour (extraction rate 93.3%) was studied by Elias et al. (1976). The addition of potato flour has increased the water absorption, dough stability and development time. Bread with high scores of acceptability was produced.
Jeffers et al. (1978) found that incorporation of wheat and corn flours with legumes flours has improved the nutritional value and quality of the bread.

Baking trial with sweet lupin flour is described, 0, 5, 10 or 20% sweet lupin flour was used in dough. Water absorption, mixing time and tolerance index of dough increased with increasing lupin seed flour level, whereas dough stability decreased. Addition of 5% lupin seed flour had little effect on bread quality and 10% lupin flour slightly impaired specific volume and quality (Compos and El-Dash, 1978).

Toma et al. (1979b) used potato peels, removed by four different peeling methods, to replace 5 - 15% of wheat flour in bread making. The water absorption and developing time of the dough was increased due to incorporation. Only the bread made with lye- treated peels was acceptable, while for other types of peels the characteristics of the bread were severely affected.

Gobo holocellulose and konjac powder, which are fibrous materials obtained from edible plants in Japan, were incorporated in wheat bread with levels of 5 - 15%. Bread with 5% incorporation was similar to the control in terms of volume, crumb, texture and taste (Nagi et al., 1980).
Finely and Hanamato (1980) incorporated bran from dried brewer's spent grain at replacement levels of 6 and 12%. Water absorption and mixing time were increased thus producing bread with less volume and darker colour.

Mixture of wheat flour and potato flour were prepared containing potato flour at levels of 0, 2, 4, 6, 8 and 10%. The farinograph properties of wheat flour were affected by addition of potato flour. Water absorption increased gradually from 62% for wheat flour to 79% for blend with 8% potato flour. Other parameters such as development time, weakening of dough were adversely modified by addition of potato flour. Substitution of potato flour produced increase in water absorption and loaf volume (Yanez et al., 1981).

Gronman (1981) studied the effect of addition of milk protein to flour blends comprising of 40% barley and 60% wheat flour for bread making. The volume was increased and the crumb became softer.

The effects of using purified rice bran fibre treated with diastase, pectinase, hot water, hot alcohol, hot acid and hot alkali, on the quality of the bread were studied. The addition of 1% of the diastase, hot water and hot alcohol could not be recommended for
bread making. Addition of 5% from diastase, hot acid and hot alkali gave good taste and flavour but had no effect on grain and softness of the bread (Fukui, 1982).

Dreese and Hoseney (1982) minimized the deleterious effects attributed to bran from dried brewer's spent grain on the characteristics of bread, by addition of surfactant or increasing shortening.

Bread from wheat flour and cooked potato mash flour at 15% replacement and with potato flour from dried chips were acceptable. While bread from wheat flour and drum dried flake potato flour had unacceptable flavour, dark colour, firm crumb (Chandra and Shurpalekar, 1984).

A blend of 70% of wheat flour, 27% of rice flour and 3% of soy flour made acceptable bread. A more economical blend, producing acceptable bread, is 50, 10 and 40% of wheat, rice and cassava flour respectively. Rice starch used at 20% with 75% wheat flour yielded acceptable bread (Bean and Nishita, 1985).

Wang et al. (2002) investigated the effect of addition of carob fibre, inulin and pea fibre on bread quality. These fibres had no negative effects on the rheological properties of the doughs or quality and overall acceptability of the resulting breads.
Bread from white grain sorghum and exogenous gluten protein was investigated by Carson and Sun (2000). Exogenous gluten protein when added without wheat flour into the sorghum flour resulted in an inappropriate gluten network for bread making. At fixed gluten protein levels, as sorghum flour increased the water absorption decreased slightly, dough strength and extensibility decreased and the mixing time increased.

Wheat-cocoyam composite flour was used with different proportions for bread making. The extensibility and resistance to force of the dough decreased with the increasing levels of cocoyam in the blend. Mixing tolerance index indicated the poor quality of the composite flour beyond 20% replacement. Beyond 20% replacement level the bread was unattractive and lacking the required quality attributes. (Bamidele and Nwanya, 2001).

Bread made from wheat, potato and cocoyam at different substitution levels were evaluated. The main visible quality defects produced in the bread were the decreased loaf volume and the gradual darkening of the crumb colour as substitution level was increased. Sensory evaluation showed that at 20% and 30% substitution the appearance, texture, crust colour and overall acceptability, compared favourably with the control, but differed significantly in appearance.
and taste for the 40% substitution. Almost for all the 50% substitution, bread was inferior in quality except for the crust colour (Okorie et al., 2001).

Effect of cysteine on bakery products from wheat – sorghum blends was investigated. Bread prepared with 5% sorghum and 3 ppm cysteine gave acceptable bread. High quality bread was obtained from blend of 10% sorghum and 60ppm cysteine. High quality biscuit was prepared by addition of 20% sorghum flour and 60 ppm cysteine to wheat flour (Elkhalifa and Eltinay, 2002).

Addition of millet and faterita (sorghum) malts to wheat flour for bread making resulted in increase in specific volume of bread. Addition of Tabat (sorghum) malt resulted in decrease of the specific volume of the bread (Elshewayia, 2003).

Technological aspects related to incorporation of Gongolase and Guddiem at 5, 10, 15% for bread flour and 15, 20, 25% for biscuits flours were studied. The water absorption of the gongolase blend increased in contrast to the guddiem blend, where the water absorption decreased. Dough development time increased in bread and biscuit blends with increasing percentage of gongolase incorporation. Dough development time was un-affected by guddiem incorporation in bread, while it increased in biscuit blends. The bread specific
volume decreased with increasing incorporation of gongolase. In guddiem bread, the bread volume increased with 5% incorporation and decreased with 10, 15%. Overall, sensory evaluation showed that guddiem and gongolase bread of 5% were acceptable, while those of higher percentage were of inferior quality (El Tom, 2004).

Incorporating tamarind kernel powder in bread decreased its specific volume and increased bread hardness and protein content. Nevertheless the taste and flavour were slightly affected even up to 15% incorporation (Bhattacharya et al., 1994).

**2.7.5 Incorporation of fiber from leguminous sources:**

Dubois (1978) reported that bran of soybean diluted the flour protein – gluten - thus causing weakening of the cells and reduced the gas retention. These effects lead to decrease in bread volume.

Substitution of up to 5% soy concentrate or soy isolate for wheat flour in bread making did not affect the rheological properties of the dough. Good quality bread was produced, in terms of bread volume and crumb colour which were better than wheat flour bread or soy flour bread. The addition of the soy concentrate and soy isolate nutritionally improved the bread (Onayemi and Lorenz, 1978).

Faba bean flour and faba bean protein concentrate were shown to be suitable protein additives for breads, cookies and pasta products.
The faba bean products affected by farinograph and amylograph characteristics and doughs with wheat flour. Bread dough mixing becomes critical and doughs were sticky and difficult to handle when the amount of those products reached 10% of the blend. Overall, bread quality was quite acceptable with up to 10% of the faba bean products. The faba bean protein concentrate performed better than the flour (Lorenz et al., 1979).

Replacement of wheat flour with defatted soyabean or peanut flour (5 - 10%) affected the water absorption and extensibility of the bread dough, thus resulting in decrease in volume of the bread (Rao and Vakil, 1980).

Collins et al. (1982) reported that the incorporation of 4% of peanut hull flour into wheat bread formula did not affect the bread characteristics. Higher levels of peanut hull flour were found to be unsuitable as all the bread characteristics were impaired.

Bread was prepared by adding soya flour at 8, 10, 12, 14 and 16% level to wheat flour. With up to 10% addition, bread of satisfactory quality was obtained and at 12% substitution bread was of fair quality. The 12% substitution bread could be improved by including 5% sugar and fat in small scale bakeries (Selvaraj and Shurplaekar, 1982).
Bread made from wheat flour and enriched with defatted soya bean meal at replacement levels of 2, 4, 6, 8, 10 and 12%. The incorporation of soya at 10 and 12% levels in the dough made it difficult to work with. Addition of soya caused darkening of the crumb, coarser texture and decreased loaf volume. Protein content of the bread increased from 13.4% to 18% by the addition of the soya meal (Yanez et al., 1982).

Soy hulls can be added to bread at 5% flour replacement without causing any deleterious effects on baking performance and overall acceptability of white bread (Johnson et al., 1985).

Pigeon pea flour was substituted at levels of 5, 10, 15, 20 and 25% to wheat flour and whole wheat meal for bread and chapatti making. The bread from 10% pigeon pea flour blend with 2 – 3% vital gluten and 0.5% Sodium Stearoyl-2-lactylate (SSL) had high loaf volume and loaf quality. Blends with 15% pigeon pea flour were acceptable for chapatti and 30% pigeon pea flour with 0.25% SSL were acceptable for cookie making (Harinder et al., 1999).

Enriching bread, prepared from whole meal wheat flour, with debittered lupin seed flour and decorticated pigeon pea flour respectively increased the water absorption of the first and decreased the water absorption of the latter. The dough stability decreased even
with high levels of incorporation, about 10%, of debittered lupin seed flour. Acceptable bread was produced with low levels of incorporation (Siddig, 1999).

The sensory properties of bread supplemented with lupin seed products were investigated by Mubarak (2001). Water absorption, development time and dough weakening were significantly increased as the lupin products levels increased in all doughs, nevertheless the dough stability decreased. Addition of lupin products increased the content of protein and total essential amino acids, the addition also improved in vitro protein digestibility.

Full fat lupin, soya and triticale flour were added to medium strength wheat flour at replacement levels of 5 and 10%. At 5 and 10% replacement the lupin and soya increased the stability and the tolerance index of the dough. The bread volume was decreased with increasing levels of the lupin and soya flour due to the dilution of the gluten structure. The volume of the bread was increased as the level of the triticale flour increased due to the fortification of the gluten structure by the gluten added. Acceptable bread was produced in term of texture and crumb structure (Doxastakis et al., 2002).

Organoleptic and nutritional evaluation of wheat breads supplemented with soybean and barely flour at 5, 10, 15 and 20% levels
were carried out. Addition of 15% barely flour, 10% soy flour, 15% barely and soy flour (full fat or defatted) to wheat flour produced acceptable bread. Substitution of soy full fat or defatted with barely to wheat flour separately or in combinations at 20% levels gave unacceptable breads (Shfali et al., 2002).

Addition of barely flour and soy flour, (full fat or defatted) at 5, 10, 15 and 20% to wheat flour to produce breads were investigated. The gluten content of flour blends decreased and the water absorption capacity increased with the increase in the level of addition of soybean and barely flours separately as well as in combination with the bread flour. Breads prepared from 20% levels were organolepticaly unacceptable but nutritionally superior. Supplementation with 10 and 15% of this cereal – pulse increased the total protein, total lysine, dietary fibre and produced acceptable quality bread (Shfali et al., 2002).

Enriching bread, prepared from whole meal wheat flour, with leguminous bran, such as faba bean, chick pea, pigeon pea and soya bean increased the water absorption of the dough and decreased the dough stability which ultimately led to decrease in bread volume (El Awad, 2003).
The sensory attribute of breads supplemented with native and germinated moth bean, horse gram and cowpea seed flours at 5, 10 and 15% replacement levels were investigated. Bread supplemented with native and horse gram and cowpea seed flours at all replacement levels had lower organoleptic scores. However, bread supplemented with germinated moth bean, horse gram and cowpea seed flours at 10% replacement level obtained the maximum organoleptic scores. The germinated flour of these legumes improved the crust colour (Deshpande et al., 2003).

2.7.6 Supplementation of bread with high protein sources:

White skin groundnuts were deffated to produce flour with 55 - 60% protein. This flour replaced 12.5% of wheat flour in bread, 100% in muffins and 10, 15, or 50% in biscuits. The bread volume was not affected while the total solids, protein and fiber content were increased. The crust colour of supplemented bakery items is darker brown, texture is course for bread and harder for cookies. The net protein increased to 4% in bread to 30% for muffins (Ory and Conkerton, 1983).

Breads made with 2, 4, 6, 8, 10 and 12% torula yeast (single cell protein) flour were evaluated. Taste panel found that bread with 8% replacement was acceptable. (Lin et al., 1986).
El-Adaway (1997), added four types of sesame products to red wheat flour to produce blends with 14, 16, 18 and 20% protein levels. The water absorption, dough development time and dough weakening were increased whereas the dough stability was decreased as the level of protein increased in all blends. Bread characteristics were acceptable up to 18% sesame protein isolate while for the sesame meal and sesame concentrate blends up to 14%. Addition of the sesame proteins increased the total essential amino acids especially lysine. The in vitro protein digestibility was improved.

Firmino et al. (1998) used sesame protein concentrate in bread formula with replacement level of 10%. The bread produced was excellent in term of colour and good for other bread characteristics.

Dehulled and defatted sesame flour was used at replacement levels of 10, 20 and 30%. The water absorption increased with increased incorporation levels, so as for the dough development time. The dough stability decreased with increasing levels of incorporation. Bread containing 10% dehulled and defatted sesame flour was highly accepted as compared to other ratios (Sirelkhatim, 2005).

Commercial whey protein concentrate treated with heat or with high hydrostatic pressure was incorporated by replacement levels of 5 and 10% into wheat – based products. Wheat flour with 10% untreated
commercial whey protein concentrate produced wet and sticky bread dough and small loaf. Handling properties of dough was improved and bread volume was increased when heat or high hydrostatic pressure commercial whey protein concentrate was incorporated. Biscuits diameters decreased with increasing levels of heat or high hydrostatic pressure commercial whey protein concentrate incorporation. Incorporation of 10% commercial whey protein concentrates increased the protein content of bread up to 20.2% and increased the proportion of essential amino acids (Kadharmestan et al., 1998).

Pumpkin seed products (raw, roasted, autoclaved, germinated, fermented, pumpkin protein concentrate and pumpkin protein isolate) were incorporated into wheat flour for bread making. Pumpkin seed products can be added up to 17% protein level for raw, roasted, autoclaved pumpkin meal, 19% level for germinated, fermented and pumpkin protein concentrate and 21% level for pumpkin protein isolate with detrimental effect on the dough or loaf quality i.e., crust colour, crumb colour, texture and flavour. The addition of pumpkin seeds protein increased the protein content, mineral content, the lysine level and the in-vitro protein digestibility (El-Soukkary, 2001).
2.7.8 Incorporating fiber into bakery products other than bread:

It has been reported in the literature that products such as cakes and biscuits are less sensitive to changes in flavour, colour and texture which are brought about by incorporation of fibrous materials.

Wheat bran and middling were successfully incorporated at replacement levels of 12 and 16% into cakes without affecting their quality. (Rajchel et al., 1975).

Khan et al. (1976) found that up to 10% coconut residue can successfully be incorporated into sugar-snap cookies without impairing their organoleptic properties.

Prentice et al. (1978) reported that finely milled brewer's spent grain could successfully replace up to 15% of the flour in muffins and cookies.

Cakes containing up to 30% of wheat and corn brans were found to be acceptable, while cakes with soya and oats brans have poor flavour (Shafer and Zabik, 1979).

High levels of cellulose replacement, more than 10%, in sugar-snap cookies affected the cookie spread, crispness, colour and sensory qualities (Gorczyca et al., 1979).

Cakes and sugar-snap cookies of acceptable quality are produced with incorporation of heated Navy bean hull, while those
produced when incorporating unheated Navy bean hull were of inferior quality (Defouw et al., 1982).

Biscuit with 20, 40 and 60% red sesame meal, white sesame meal and decorticated red sesame meal were prepared. Biscuits made from white sesame meal showed higher spread ratio compared to the other two types. High acceptability was for biscuits with 20 and 40% decorticated red sesame meal. Acceptable biscuit was obtained for those with 20% white sesame meal and 20% red sesame meal incorporation. Biscuit with 20% red sesame meal and the other with 20% white sesame meal had higher in vitro digestibility of protein 95.47 and 95.90% respectively (El Sheikh, 2004).
CHAPTER THREE
MATERIALS AND METHODS

3.1 Materials:

3.1.1 Sesame seeds:

The sesame seeds (white and red) were obtained from the local market.

3.1.2 Wheat flour:

The wheat flour was obtained from Sayga Flour mills,

3.1.3 Bread ingredients:

Sugar, yeast, salt and oil were obtained from the local market.

3.1.4 Chemicals and reagents:

All the chemicals and reagents were obtained from Seiseban Company, Department of Food Science and Technology (University of Khartoum) and Department of Food Industries (Industrial Research and Consultancy Center).

3.2 Methods:

3.2.1 Preparation of sesame flour:

According to the method described by Alopo (2001) one kg of seeds were soaked in 15% brine (NaCl) for 10 minutes at 60°C. The soaked seeds were dehulled by using porcelain mortar, the hulls were separated from the kernels using tap water. The kernels were dried in oven at 60°C for 5 hr and milled using laboratory mill. In order to
obtain sesame cake the oil was extracted from the paste by hexane (40-60°C) and dried in an oven. The extracted cake was sieved into sieve of 60 mesh.

3.2.2 Preparation of bread samples:

The bread samples were prepared according to Badi et al., (1978) method, the bread control were prepared by the formula:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour</td>
<td>250g</td>
</tr>
<tr>
<td>Yeast</td>
<td>3g</td>
</tr>
<tr>
<td>Salt</td>
<td>1.5g</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>0.2g</td>
</tr>
<tr>
<td>Water</td>
<td>Variable</td>
</tr>
</tbody>
</table>

Sesame flour sample were substituted in ratio of 5, 10 and 15 of wheat flour for bread making. All the ingredients mentioned were weighed and made into dough in dough mixer for 5 minutes at medium speed. The dough was allowed to rest for 10 minutes at room temperature (38 ± 2°C), then scaled to three portions of 120 grams each. The three dough portions were rounded into balls and allowed to rest for another 10 minutes, then moulded, put into pans and placed in the fermentation cabinet for final proof. The fermented dough samples were baked in oven at 250°C with saturated steam for 25 minutes. The loaves were left to cool, sliced with an electric knife, some slices were
kept in polyethylene bags for sensory evaluation and the others were
dried at room temperature for chemical analysis.

3.2.3 Physical and chemical analysis:

3.2.3.1 Physical analysis:

3.2.3.1.1 Determination of gluten content:

The gluten was determined according to Pearson (1970)
method. Ten grams of flour were weighed, then 5 ml of water was
added and allowed to stand in a beaker for one hour. The starch was
washed away gently under running water. The residue of moist gluten
was squeezed as dry as possible and rolled into a ball placed in a
porcelain dish and was weighed as wet gluten, then it was dried in
oven at 100°C for (24 hr) and weighed as dry gluten.

Calculation:

\[
\text{Wet gluten \%} = \frac{\text{Weight of wet gluten} \times 100}{\text{Weight of sample}}
\]

\[
\text{Dry gluten \%} = \frac{\text{Weight of dry gluten} \times 100}{\text{Weight of sample}}
\]

3.2.3.1.2 Falling Number:

Falling number was determined according to the falling number
methods described by the ICC (1968) standard No. 107. Flour samples
were weighed and transferred into a viscometer tube. 25 ml of distilled
water was added to the sample and the tube was stoppered with a rubber. The sample was shaken vigorously until a uniform suspension was obtained.

Sesame flour samples were substituted in ratios of 5, 10 and 15% of wheat flour for bread making. The amount of sesame flour was mixed with the water required for the test, then added to the flour in the viscometer tube. The viscometer stirrers with the viscometer tube were placed in a water bath through the hole of the falling number apparatus. The time in seconds to stirr and to allow the viscometer stirrer to fall through the homogenous solution was recorded as falling number.

3.2.3.1.3 Rheological properties of the dough:

The rheological properties of the dough prepared from wheat flour (control) and sesame flour with concentrations 5, 10 and 15% were estimated using the Brabender farinograph according to the method of ICC Standard (1972) No. 115/1.

The sample (300g) was placed into farinograph where the temperature was adjusted to 30°C. The burette was filled with distilled water. The quantity of water, which made a curve reached (500 f.u) line and made a defined consistency indicates the measuring parameters from the farinograph as the water absorption. During
further kneading the diagram is recorded and the following parameters were measured:

- Dough development time; which describes the time in which the curve reaches the maximum dough consistency.

- The dough stability; which indicates the differences between the departure time and the arrival time, where the arrival time describes the differences between zero minute and the point at which the top of the curve first intersects the 500 f. U line.

- Dough weakening; which is obtained in farinograph units after 12 minutes of the development time.

3.2.4 The chemical analysis:

The moisture, ash, oil, protein and fiber of wheat flour, sesame seeds and sesame flour (white and red) were carried out according to AOAC methods (1990).

3.2.4.1 Moisture content:

Two grams from each sample were placed in pre-heated, closed steel dishes and placed at 105°C in an oven and dried for 12 hr and transferred to a dessicator to cool and then weighed until constant weight was obtained. The moisture content was calculated according to the following equation:
Moisture % = \frac{Wt_1 - W_2}{Sample weight}

Where:

W_1 = Weight of sample + crucible before oven drying.
W_2 = Weight of sample + crucible after oven drying.

3.2.4.2 Ash content:

Two grams of sample were weighed in a crucible and placed at 600°C in a muffle furnace for 12 hr. The crucible was transferred directly to a dessicator, cooled and weighed.

\text{Ash %} = \frac{Wt_1 - W_2}{Sample weight} \times 100

Where:
W_1 = Weight of crucible with sample.
W_2 = Weight of empty crucible.

3.2.4.3 Oil content:

The oil was determined on five gram sample. Extraction of the fat from each sample was carried out by soxhelt using hexane. After evaporating the solvent, the oil was dried in the oven at 105°C for two hours, then allowed to cool in a dessicator, and finally weighed until constant weight was obtained.

\text{Oil content %} = \frac{W_2 - Wt_1}{S} \times 100

Where
Wt_1 = Weight of empty receiver.
W_2 = Weight of receiver + oil.
S = original weight of sample.
3.2.4.4 Protein content:

0.2 gram sample were weighed and poured in clean dry kjeldhal flask. One tablet each of copper sulfate and sodium sulfate were added. Concentrated H$_2$SO$_4$ (3.5 ml) was also added to flask. The flask was heated until clear solution was obtained (2.3 hours) and left for another 30 minutes. The flask was removed and allowed to cool.

The digested sample was poured in a volumetric flask (100 ml) and diluted with distilled water. 15 ml of 40% NaOH were added, the diluted sample was received in conical flask (100 ml) containing 10 ml of 2% boric acid plus 3 drops of indicator (methyl red). The distillation was continued until the volume in the flask was 50 ml then the flask was removed from the distillator. The distillate was titrated with 0.1 NHCl until the end point (red colour) was obtained. The protein content was calculated by the following equation.

\[
N\% = \frac{TF \times N(HCl) \times 14 \times 100}{1000 \times \text{weight of sample}}
\]

Where:

TF = Reading of titration.

14 = Equivalent weight of nitrogen.

Protein % = N% × 6.25.

6.25 = Protein factor.
3.2.4.5 Crude fiber:

Two grams of the defatted sample were placed in 1000 ml conical flask and 200 ml 0.255N sulphuric acid were added, then boiled for 30 minutes. The flask was rotated, and the contents of the flask was filtered through a Buchner funnel with Whatman filter paper quality No. (1), the residue in the filter paper was washed with 200 ml of 0.313N sodium hydroxide.

The solution in the original flask was boiled for another thirty minutes. The solution was then filtered through a weighed filter paper in Buchner funnel and treated by using the following steps: Firstly, with distilled water.

Secondly, with 1% HCl and then with the distilled water and finally with alcohol and ether. The filter paper content was put in an oven at 105°C and placed until constant weight was obtained. The crucible was placed in a furnace at 600°C for two hours then it was re–weighed. The crude fiber was obtained from the following equation.

\[
\text{Crude fiber\%} = \frac{\text{Weight (after moisture removing – after ashing)}}{\text{Weight of sample}}
\]
3.3.4 Bread tests:

3.3.4.1 Bread volume:

Bread volume was determined by the seed displacement method according to Pyler (1973) the loaf was placed in a container of known volume into which small seeds (millet seeds) were added until the container is full. The volume of seeds displaced by the loaf was considered as the loaf volume.

3.3.4.2 Bread specific volume:

The specific volume of the bread was calculated according to the AACC method (1986) by dividing volume (cm$^3$) by weight (g).

3.3.4.3 Sensory evaluation:

Ten panelists from Food Research Centre Staff were asked to evaluate crumb color, crust color, texture, odour, taste and general appearance in bread samples according to the ranking method described by (Ihekoronye and Ngoddy, 1985).

3.3.4.4 In-vitro protein digestibility (IVPD):

IVPD was determined by the method of Maliwal (1983) as described by Monjula (1991). A known weight of the sample containing 16 mg nitrogen was taken in triplicate and hydrolyzed with 1 mg pepsin in 15 ml of 0.1N HCl at 37°C for 2 hours. The reaction was terminated by addition of 15ml of 10% w/v trichloro-acetic acid
(TCA). The mixture was filtered through Whatman No. 1 filter paper.

The TCA soluble fraction was saved for nitrogen estimation using micro – Kjedhal method. The digestibility was calculated by the following formula:

\[
\text{Protein digestibility\%} = \frac{\text{Protein in supernatant} \times 100}{\text{Protein in sample}}
\]

\[
\text{Protein in supernatant\%} = \frac{T \times TV \times N \times 14 \times F \times 100}{a \times b \times 1000}
\]

Where:

\( T \) = Titre reading.
\( TV \) = Total volume of liquid extracted.
\( N \) = Normality of the acid.
\( 14 \) = Nitrogen equivalent weight.
\( F \) = Protein factor.
\( a \) = No. of mls of liquid.
\( b \) = No. of gms of sample.

3.3.5 Statistical analysis:

Data obtained was subjected to statistical package for social science (SPSS). Means (±SD) were tested using one factor analysis of variance, and then separated using Duncan’s Multiple Range Test (Mead and Gurnow, 1983).
CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Proximate Composition:

4.1.1 The proximate composition of wheat flour:

The proximate composition of wheat flour used in bread making is shown in Table (1). Moisture content was 9.95%, ash content 0.6%, oil content 1.47%, crude fibre 0.4% and the protein content which was 12.39% is within the range reported by Yamazaki and Donelson (1983) of about 8.1 -15.5%. Kent and Ever (1994) reported that the protein content of wheat flour ranged from 8 -13.8%.

4.1.2 The proximate composition of white and red sesame seeds:

The proximate composition of white and red sesame seeds that were later milled into flours used in bread making is shown in Table (2), Appendix (1). The moisture content of both white and red sesame seeds were 1.6 and 2 % respectively, these values were lower than that reported by Khalid (1994) which were 3.4 – 5.7% and within the ranges 1.5 – 2.5% reported by El Nadeef (1990). This could be due to the fact that the sesame seeds were bought from the local market and thus lost part of their moisture during storage.
Table (1): Chemical Composition of Wheat Flour (72% extraction).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Moisture (%</th>
<th>Ash (%)</th>
<th>Protein (%)</th>
<th>Oil (%)</th>
<th>Crude fibre (%)</th>
<th>Wet gluten (%)</th>
<th>Dry gluten (%)</th>
<th>CHO (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content as %</td>
<td>9.95</td>
<td>0.6</td>
<td>12.39</td>
<td>1.46</td>
<td>0.4</td>
<td>35.67</td>
<td>13.67</td>
<td>75.71*</td>
</tr>
</tbody>
</table>

* By difference.

Table (2): Chemical Composition of White and Red Sesame Seeds.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Moisture %</th>
<th>Ash %</th>
<th>Protein %</th>
<th>Oil %</th>
<th>Crude Fibre %</th>
<th>CHO %</th>
</tr>
</thead>
<tbody>
<tr>
<td>White sesame</td>
<td>1.60±0.00b</td>
<td>6.96±0.2a</td>
<td>33.63±0.0a</td>
<td>44 ±0.00b</td>
<td>13.48±0.0a</td>
<td>6.89±0.03b</td>
</tr>
<tr>
<td>Red sesame</td>
<td>2.00±0.00a</td>
<td>6.14±0.1b</td>
<td>27.12±0.0b</td>
<td>52±0.00a</td>
<td>7.20±0.00b</td>
<td>11.66±0.0a</td>
</tr>
</tbody>
</table>

Mean values (±SD) having different superscript letters in a column differ significantly (P ≥ 0.05).
The ash content of white and red sesame seeds were lower than the range of 8.1 – 13.5% reported by Sabah ElKheir (1994).

The oil content of the white and red sesame seeds were within the range of 37 – 63% reported by Bernardini (1986) and within the range of 47- 54% in red sesame seeds reported by Sabah ElKheir (1994).

The protein contents of the white and red sesame seeds were higher than the ranges reported by Joshi (1961) and Lyon (1972) which was 19 – 31%. Nevertheless, the value of the protein was within the range of 33.3- 44% in white sesame seeds reported by Sabah ElKheir (1994).

The carbohydrate contents of the white and red sesame seeds were lower than the range of 21 – 25% reported by Joshi (1961).

The noticed difference in the proximate composition values of the sesame seeds from that reported in the literature could be related to the fact that genetic and environmental factors affect the physical and chemical composition (Yen et al., 1986).

4.1.3 The proximate composition of sesame flour:

The proximate composition of sesame flour used in the bread making is shown in Table (3), Appendix (2). The moisture content of the flours extracted from the white and red sesame seeds were beyond the range of 5.5 – 5.8% as reported by Ali (2000). This could be
Table (3)  Chemical Composition of White and Red Sesame flours.

<table>
<thead>
<tr>
<th>Cultivator</th>
<th>Moisture %</th>
<th>Ash %</th>
<th>Protein %</th>
<th>Oil%</th>
<th>Crude Fibre %</th>
<th>CHO %</th>
</tr>
</thead>
<tbody>
<tr>
<td>White sesame</td>
<td>5.20±0.00b</td>
<td>8.37±0.03b</td>
<td>56.40±0.0a</td>
<td>1.50±0.00a</td>
<td>7.98±0.03a</td>
<td>28.90±0.00b</td>
</tr>
<tr>
<td>Red sesame</td>
<td>6.25±0.00a</td>
<td>10.04±0.00a</td>
<td>49.21±0.00b</td>
<td>1.52±0.02a</td>
<td>4.19±0.04b</td>
<td>38.85±0.00a</td>
</tr>
</tbody>
</table>

Mean values (±SD) having different superscript letters in a column differ significantly (P ≥ 0.05)
attributed to the fact that the moisture content of the seeds was already outside the range reported in addition to that the milling of the sesame seeds was not carried out under controlled conditions.

The ash content of white sesame flour was lower than the range of 9.7-16.7% and within the range in red sesame flour reported by Ali (2000).

The protein content of white and red sesame flours were higher than the range of 44.6 - 45.3% reported by Ali (2000).

While the literature provides information on the proximate composition of sesame seeds, the fat content, fiber content and carbohydrate contents of the sesame flours in general are lacking.

4.2 Rheological Results:

4.2.1 The farinograph data:

The farinograph data for wheat flour, white and red sesame flour blends are given in Table (4), Figs. (3, 4, 5, 6, 7, 8 and 9)

4.2.1.1 The water absorption of the dough:

The water absorption of the dough increased with increasing levels of replacement of the wheat flour with white or red sesame flours. This is probably due to the presences of fibrous materials, which is known for its water absorbing characteristics. The absorption, of the dough containing white sesame flour, was higher than that
Table (4) Rheological properties of doughs prepared from wheat flour and white and red sesame flours.

<table>
<thead>
<tr>
<th>Dough</th>
<th>Water absorption (%)</th>
<th>Dough development time (min)</th>
<th>Dough stability (min)</th>
<th>Degree of weakening (fu)</th>
<th>Farinograph quality No. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>65.2</td>
<td>11.7</td>
<td>17.5</td>
<td>6</td>
<td>200</td>
</tr>
<tr>
<td>CWS₁</td>
<td>66.3</td>
<td>10.3</td>
<td>12.7</td>
<td>6</td>
<td>144</td>
</tr>
<tr>
<td>CWS₂</td>
<td>67.7</td>
<td>7.3</td>
<td>7.3</td>
<td>18</td>
<td>125</td>
</tr>
<tr>
<td>CWS₃</td>
<td>68.4</td>
<td>6.0</td>
<td>2.9</td>
<td>65</td>
<td>76</td>
</tr>
<tr>
<td>CRS₁</td>
<td>65.8</td>
<td>10.5</td>
<td>9.6</td>
<td>10</td>
<td>157</td>
</tr>
<tr>
<td>CRS₂</td>
<td>66.7</td>
<td>8.2</td>
<td>6.8</td>
<td>15</td>
<td>127</td>
</tr>
<tr>
<td>CRS₃</td>
<td>67.1</td>
<td>5.7</td>
<td>3.2</td>
<td>75</td>
<td>79</td>
</tr>
</tbody>
</table>

**Key**
- **C**: Control (wheat flour only).
- **CWS₁**: wheat flour + 5% white sesame flour.
- **CWS₂**: wheat flour + 10% white sesame flour.
- **CWS₃**: wheat flour + 15% white sesame flour.
- **CRS₁**: wheat flour + 5% red sesame flour.
- **CRS₂**: wheat flour + 10% red sesame flour.
- **CRS₃**: wheat flour + 15% red sesame flour.
with red sesame flour, this is in agreement with the proximate composition data, where white sesame flour contained more fiber than red sesame flour.

4.2.1.2 The degree of weakening:

The degree of weakening increased as the replacement levels of the white and red sesame flours increased. This is an indication of dilution of gluten forming protein caused by the incorporation of sesame flours.

4.2.1.3 The stability of the dough:

The presence of the sesame flours in the dough decreased its stability which is considered to be a factor of gluten quantity and quality.

4.2.1.4 The development time of the dough:

Comparing development time of blends with white and red sesame flours indicated that blends with white sesame flour have shorter time than that with red sesame flour up to 10% incorporation. Although the fiber content of white sesame flour was higher than the red (Table 2), one would expect a longer development time, but this could be referred to high alpha amylase and protease activity in the white sesame flour. At higher replacement level of 15% the increase
of the fibrous material could have caused gas retention thus longer development time.

**4.2.1.5 Falling number:**

The falling number between 200 – 300 is the range for optimum alpha – amylase activity for wheat flour used for bread making. The wheat flour used in this study was for general use and the falling number is shown in Table (5) is 373, indicating a low alpha amylase activity than that of wheat flour for bread making.

Incorporation of sesame flour diluted the gluten forming protein of the wheat flour, thus resulting in low alpha-amylase activity. This dilution of gluten would cause the decrease in bread volume, Table (6).

The falling number of white and red sesame flour blends showed a decrease with increasing levels of incorporations, postulating a higher enzymatic activity and thus an increase in bread volume. Nevertheless, this was not the case and there was a decrease in bread volume with increasing levels of replacement. This could be attributed to a decrease in gas retention brought about by the high level of the fiber content of the sesame flours.
Table (5): Falling number of dough.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Falling number</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>373&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>CWS&lt;sub&gt;1&lt;/sub&gt;</td>
<td>400&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>CWS&lt;sub&gt;2&lt;/sub&gt;</td>
<td>393&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>CWS&lt;sub&gt;3&lt;/sub&gt;</td>
<td>381&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRS&lt;sub&gt;1&lt;/sub&gt;</td>
<td>420&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRS&lt;sub&gt;2&lt;/sub&gt;</td>
<td>401&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRS&lt;sub&gt;3&lt;/sub&gt;</td>
<td>390&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Mean values (±SD) having different superscript letters in a column differ significantly (P ≥ 0.05)

**Key**
- C : Control bread (wheat flour only).
- CWS<sub>1</sub> : Bread made with wheat flour + 5% white sesame flour.
- CWS<sub>2</sub> : Bread made with wheat flour + 10% white sesame flour.
- CWS<sub>3</sub> : Bread made with wheat flour + 15% white sesame flour.
- CRS<sub>1</sub> : Bread made with wheat flour + 5% red sesame flour.
- CRS<sub>2</sub> : Bread made with wheat flour + 10% red sesame flour.
- CRS<sub>3</sub> : Bread made with wheat flour + 15% red sesame flour.
4.3 Bread Quality:

4.3.1 Specific Volume of the bread:

The specific volume of bread with wheat flour (control) and bread made of blends of wheat and sesame flours are shown in Table (6), Appendix (10). The specific volumes of bread decreased significantly ($P \leq 0.05$) with increasing levels of replacement of wheat flour with both white and red sesame flours. This is in agreement with the farinograph data which indicated a high absorption and thus a potential decrease in volume.

The specific volume of bread made from blends of wheat and white sesame flour, were higher than that made from blends of wheat and red sesame flours. This indicated a high alpha amylase and protease activity in the white sesame flour. This is in agreement with the falling number results, and the farinograph results which indicated a shorter development time, for the white sesame blend dough as compared to the red sesame dough.

The specific volume of bread at 10% and 15% level of replacement for the white and red sesame showed no significant difference within each category.
Table (6): Specific volume of breads

<table>
<thead>
<tr>
<th>Sample</th>
<th>Weight (gm)</th>
<th>Volume (cm³)</th>
<th>Specific volume (cm³/gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>110.067 ± 0.38b</td>
<td>395.0 ± 5.00a</td>
<td>3.583 ± 0.08a</td>
</tr>
<tr>
<td>CWS₁</td>
<td>112.933 ± 0.04a</td>
<td>341.7 ± 14.4b</td>
<td>3.090 ± 0.03b</td>
</tr>
<tr>
<td>CWS₂</td>
<td>112.500 ± 0.36a</td>
<td>341.7 ± 2.89b</td>
<td>3.010 ± 0.03c</td>
</tr>
<tr>
<td>CWS₃</td>
<td>112.567 ± 1.53a</td>
<td>316.7 ± 7.46c</td>
<td>2.810 ± 0.03c</td>
</tr>
<tr>
<td>CRS₁</td>
<td>111.200 ± 0.46b</td>
<td>311.7 ± 2.89c</td>
<td>2.803 ± 0.02c</td>
</tr>
<tr>
<td>CRS₂</td>
<td>108.233 ± 1.50c</td>
<td>261.7 ± 2.89d</td>
<td>2.417 ± 0.04d</td>
</tr>
<tr>
<td>CRS₃</td>
<td>104.667 ± 4.0d</td>
<td>251.7 ± 12.6d</td>
<td>2.400 ± 0.03d</td>
</tr>
</tbody>
</table>

Mean values (±SD) having different superscript letters in a column differ significantly (P ≥ 0.05)

**Key**

C : Control bread (wheat flour only).
CWS₁ : Bread made with wheat flour + 5% white sesame flour.
CWS₂ : Bread made with wheat flour + 10% white sesame flour.
CWS₃ : Bread made with wheat flour + 15% white sesame flour.
CRS₁ : Bread made with wheat flour + 5% red sesame flour.
CRS₂ : Bread made with wheat flour + 10% red sesame flour.
CRS₃ : Bread made with wheat flour + 15% red sesame flour.
4.3.2 Protein Content:

The incorporation of sesame flours up to 10% level increased the protein content significantly ($P \leq 0.05$) as shown in Table (7), Appendix (11)

Replacement with 5% white sesame and red sesame flours increased the protein content of the bread by about 16.4% and 15.7% respectively. This is in agreement with the fact that the protein content of the white sesame is higher than the red sesame flour as shown in Table (3). The increase in protein content is proportional to the level of replacement.

4.3.3 In vitro protein digestibility:

The in vitro digestibility of bread made with wheat and sesame flours (Table 8), Appendix (12) showed significant increase ($P \leq 0.05$) for all levels of replacement (5, 10 and 15%).

Bread with 15% replacement with white or red sesame flour were found to be superior in terms of in vitro protein digestibility.

From a nutritional point of view, one can state that bread made from wheat and sesame flours is a good source of digestible protein as well as a good source of carbohydrate.
Table (7): Protein content of breads.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Protein %</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>14.44 ± 0.04&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>CWS&lt;sub&gt;1&lt;/sub&gt;</td>
<td>16.90 ± 0.18&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>CWS&lt;sub&gt;2&lt;/sub&gt;</td>
<td>19.70 ± 0.07&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>CWS&lt;sub&gt;3&lt;/sub&gt;</td>
<td>21.67 ± 0.31&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRS&lt;sub&gt;1&lt;/sub&gt;</td>
<td>16.69 ± 0.33&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRS&lt;sub&gt;2&lt;/sub&gt;</td>
<td>19.13 ± 0.50&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRS&lt;sub&gt;3&lt;/sub&gt;</td>
<td>21.23 ± 0.22&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Table (8): In vitro Protein digestibility of breads.

<table>
<thead>
<tr>
<th>Sample</th>
<th>In vitro protein digestibility %</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>90.00 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>CWS&lt;sub&gt;1&lt;/sub&gt;</td>
<td>93.82 ± 0.02&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>CWS&lt;sub&gt;2&lt;/sub&gt;</td>
<td>94.67 ± 0.03&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>CWS&lt;sub&gt;3&lt;/sub&gt;</td>
<td>95.71 ± 0.01&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRS&lt;sub&gt;1&lt;/sub&gt;</td>
<td>93.05 ± 0.05&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRS&lt;sub&gt;2&lt;/sub&gt;</td>
<td>94.22 ± 0.01&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>CRS&lt;sub&gt;3&lt;/sub&gt;</td>
<td>95.00 ± 0.00&lt;sup&gt;h&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Mean values (±SD) having different superscript letters in a column differ significantly (P ≥ 0.05)

**Key**
- C : Control bread (wheat flour only).
- CWS<sub>1</sub> : Bread made with wheat flour + 5% white sesame flour.
- CWS<sub>2</sub> : Bread made with wheat flour + 10% white sesame flour.
- CWS<sub>3</sub> : Bread made with wheat flour + 15% white sesame flour.
- CRS<sub>1</sub> : Bread made with wheat flour + 5% red sesame flour.
- CRS<sub>2</sub> : Bread made with wheat flour + 10% red sesame flour.
- CRS<sub>3</sub> : Bread made with wheat flour + 15% red sesame flour.
4.3.4 Sensory Evaluation:

For bread made from wheat flour and white sesame flour Table (9), Figs. (13 and 14) the crumb and crust colour were darkened with increasing levels of replacement. Nevertheless, the colour was still lighter than that of whole wheat bread.

For bread made with wheat flour and red sesame flour with different replacement levels, the results of sensory evaluation were shown in Table (10), Figs. (15 and 16) As expected since red sesame was dark, the crust and crumb colour were darker than those with white sesame flour, but similar to the colour of whole wheat bran bread.

Other bread characteristics such as, texture, taste and aroma were acceptable up to 10% replacement levels for both types of sesame flours. Replacement with 15% sesame flours, both white and red, impaired these characteristics.

Although the quality of the bread was affected significantly by the incorporation of sesame flours, the product with 5% white sesame flour replacement was not much different from the control.
Table (9) Sensory evaluation of breads made with wheat flour and white sesame flours.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Crust colour</th>
<th>Crumb colour</th>
<th>Texture</th>
<th>Taste</th>
<th>Aroma</th>
<th>General appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.5±0.97&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.8±0.42&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.6±0.84&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.0±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.5±0.97&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.4±1.26&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>B</td>
<td>3.0±0.82&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.8±0.42&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.5±0.71&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.0±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.6±0.52&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.7±0.48&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>C</td>
<td>2.2±0.63&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.3±0.67&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.5±0.71&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.0±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.1±0.88&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.3±0.67&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>D</td>
<td>1.5±0.85&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.2±0.63&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.3±0.67&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.1±0.32&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.9±1.29&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.3±0.67&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Key
A : Control bread (wheat flour only).
B : Bread made with wheat flour + 5% white sesame flour.
C : Bread made with wheat flour + 10% white sesame flour.
D : Bread made with wheat flour + 15% white sesame flour.

Table (10): Sensory evaluation of breads made with wheat flour and red sesame flours.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Crust colour</th>
<th>Crumb colour</th>
<th>Texture</th>
<th>Taste</th>
<th>Aroma</th>
<th>General appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.0±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.0±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.0±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.0±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.0±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.0±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>B</td>
<td>3.0±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.0±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.0±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.0±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.0±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.0±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>C</td>
<td>2.0±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.0±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.0±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.0±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.0±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.0±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>D</td>
<td>1.0±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.0±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.0±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.0±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.0±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.0±0.00&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Mean values (±SD) having different superscript letters in a column differ significantly (P ≥ 0.05)

Key
A : Control bread (wheat flour only).
B : Bread made with wheat flour + 5% red sesame flour.
C : Bread made with wheat flour + 10% red sesame flour.
D : Bread made with wheat flour + 15% red sesame flour.
CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion:
1. The study showed that it is possible to produce bread of acceptable quality from wheat flour and white or red sesame flour, with replacement level of 5% and 10%.
2. The bread with 15% white or red sesame flour had high nutritive value and higher protein and \textit{in vitro} digestibility as compared to the 5% and 10%, incorporation, nevertheless although this level of replacement improved the quality of the bread but it was organoleptically unacceptable.

5.2 Recommendations:

Investigate the possibility of addition of external gluten – improving protein to improve the volume of bread made from wheat and sesame flour.

Further study is needed to study the effect of adding protein concentrates and isolates of sesame seeds to wheat flour on bread quality.
REFERENCES


Appendix (1): Chemical composition of white and red sesame seeds
Appendix (2): Chemical composition of white and red sesame flour
Appendix (3): Rheological properties of dough prepared from wheat flour.
Appendix (4): Rheological properties of dough prepared from wheat flour with 5% white sesame flour.
Appendix (5): Rheological properties of dough prepared from wheat flour with 10% white sesame flour.
Appendix (6): Rheological properties of dough prepared from wheat flour with 15% white sesame flour.
Appendix (7): Rheological properties of dough prepared from wheat flour with 5% red sesame flour.
Appendix (8): Rheological properties of dough prepared from wheat flour with 10% red sesame flour.
Appendix (9): Rheological properties of dough prepared from wheat flour with 15% red sesame flour.
Appendix (10): Specific volume of bread
Appendix (11): Protein of bread

Appendix (12): *In vitro* protein digestibility of bread
Appendix (13): Photograph of bread made wheat flour with white sesame flour.

Appendix (14): Photograph of bread made wheat flour with white sesame flour.
Appendix (15): Photograph of bread made from wheat flour with red sesame flour.

Appendix (16): Photograph of bread made from wheat flour with red sesame flour.