Effect of Germinated and Ungerminated Soybean Flour on the Rheological Properties of Wheat Bread Dough

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Abstract

Bread is consumed worldwide in relatively large amounts (Bakke and Vickers, 2007).It is a popular food produced in Nigeria from wheat flour, yeast, sugar, water, sodium chloride and fat (Onigbogi and Ogundele, 2005).

It is however, relatively expensive, being made from imported wheat that is not cultivated in the tropics for climatic reasons (Edema et al., 2005). Efforts have been made to promote the use of composite flours in which flour from locally grown crops and high protein seeds replace a portion of wheat flour for use in bread, thereby decreasing the demand for imported wheat and producing protein enriched bread (Giami et al., 2004).

Different levels of success have been recorded with the use of flours from legume in baked goods (Kure et al., 1998; Dhingra and Jood, 2002; Basman et al., 2003).

Grain legumes or pulses (including soybeans) are rich and low-cost sources of dietary proteins and nutrients for a large part of the world's population (Egounlety and Aworh, 2003). These grain legumes contribute significantly towards protein, mineral and B-complex vitamin needs of people in developing countries (Dhingra and Jood, 2002) and play an important role in the traditional diets of many regions throughout the world (Messina, 1995). Soybeans is an excellent source of protein (about 35-40%), hence the seed is the richest in food value of all plant foods consumed in the world (Kure et al., 1998). It is a very rich source of vegetable protein for all including growing children (Dandago and Igwe, 2006); and it has been identified as a suitable protein rich crop that could improve the nutritional and economic status of the general population in developing countries (Babajide et al., 2003). Soybeans have great potential in overcoming protein-calorie malnutrition.

Key Words: Composite bread, Germination, Protein enrichment, Amino acid profile, Grain legumes, Protein-calorie balance

Germination processes have been developed to overcome these disadvantages of soybean seed used in food products (Zhu et al., 2005). Germination is a complex metabolic process during which the lipids, carbohydrates, and storage proteins within the seed are broken down in order to obtain the energy and amino acids necessary for the plant's development (Jachmanian et al., 1995).Germination affects the anti -nutritional factors of the legume, although there is some disagreement as to the ultimate consequences, because the effect depends on the type of legume and on the conditions and duration of the germinating process (Zhu et al., 2005).

INTRODUCTION

One of the most important goals of any country is to give her citizens a diet which is adequate nutritionally (Malomo, 1982). Protein-energy malnutrition (PEM), a natural ramification of poverty, continues to be a perennial source of concern to a large segment of the world's population (Chopra and Sharma, 1992). In many developing counties, such as Nigeria, malnutrition is a common dietary problem (Mbaeyi and Ani, 2005). Infants and children from developing countries and elderly people from all around the world are the two main groups suffering from protein-energy malnutrition (Lesourd and Mazari, 1997). Animals are rich sources of protein for human consumption, but unfortunately the animal protein is becoming unaffordable for low income earners with the result that protein-energy malnutrition is becoming a household norm in Nigeria (Dandago, 1995).

Some studies have been carried out on the effects of germination on the chemical composition, biochemical constituents, anti-nutritional factors as well as functional properties of soybeans flour. Despite the studies on the effect of these processes on soybeans, information regarding the use of germinated soybean flour in bread making is scarce.

Therefore, the main objective of this research was to obtain composite flour with improved nutritional value for bread baking.

The specific objectives are as follows:

To determine the effect of germination on the nutritional quality of soy flour.

To determine the effect of germinated soy flour on the rheological properties of soy-wheat dough

MATERIALS AND METHODS

PROCUREMENT OF MATERIAL

The samples of commercially grown varieties of soybean were obtained from local market in Ota. All the grains were graded, sorted, and cleaned to remove defective seeds, dirt, debris and other foreign materials. Wheat flour (Honeywell), instant dry yeast, margarine, salt sugar, non-fat dry milk, vegetable oil, baking powder were also obtained from a local supermarket in Ota, Nigeria.

PREPARATION OF NON-GERMINATED SOY FLOUR

The cleaned, sorted and graded raw soybean grains were milled into coarse particles, winnowed to remove hull, milled into flour and the obtained flour was sieved in a standard sieve to obtain flour of 500µm particle size (Fig 1).

GERMINATION OF SOYBEANS

The germination procedure for seeds was as follows: the seeds were washed with 0.7% sodium hypochlorite, soaked in distilled water at room temperature for 6 hours, and shaken every 30 min. The water was then drained off, and the seeds were then transferred and spread on trays which were covered by muslin clothes. The muslin clothes allowed oxygen to enter for the germinating seed while minimizing contamination. The soybeans were germinated at 25 °C ± 3, for 72 hours and seeds were sprayed daily with distilled water in order to maintain an adequate hydration level. The seeds were weighed prior to soaking, and after soaking before the germination operation.

The muslin clothes allowed oxygen to enter for the germinating seed while minimizing contamination. The seeds were weighed prior to soaking, and after soaking before the germination operation.

PREPARATION OF GERMINATED FLOUR SAMPLES

Flours from germinated beans were produced by drying the bean seeds in a hot air oven at 65oC to about 10 percent moisture content. The dried beans were then dehulled, winnowed and milled using a locally fabricated attrition mill. The obtained flour was also sieved in a standard sieve to obtain flour of 500µm particle size (Fig 2).

PREPARATION OF PLAIN AND BLENDED FLOURS

Non-germinated and germinated soy flour were blended with wheat flour at different levels (5, 10 and 15% respectively).

The soy/wheat blends were called NGSW 1, 2, and 3; and GSW 1, 2, and 3 as follows:

NGSW1 (95:5 wheat flour: non-germinated soybean flour);

NGSW2 (90:10 wheat flour: non-germinated soybean flour);

NGSW3 (85:15 wheat flour: non-germinated soybean flour);

GSW 1 (95:5 wheat flour: germinated soybean flour);

GSW 2 (90:10 wheat flour: soybean flour);

GSW 3 (85:15 wheat flour: germinated soybean flour) (Fig. 3).

The control was 100% wheat-bread flour. Three replicate blends, for flour testing and baking, were prepared for each treatment and analyzed independently.

STORAGE OF SAMPLES

All flour samples were stored in Ziploc bags in a deep freezer prior to analysis.

Soybeans

↓

Sorting and Grading

↓

Cleaning

↓

Milling

(into coarse particles)

↓

Winnowing

↓

Milling

(into fine particles)

↓

Packaging

↓

Storage

Figure 1: Flow diagram of non-germinated soybean flour production.

Soybeans

↓

Sorting and Grading

↓

Washing

↓

Soaking

(6 hours)

↓

Draining and Spreading on trays

↓

Germinating

(25 °C, 72 h.)

↓

Drying

(65 oC to 10% moisture content)

↓

Cooling

↓

Dehulling

(By hand)

↓

Winnowing

↓

Milling (Attrition mill)

↓

Packaging

↓

Storage

Figure 2: Flow diagram of germinated soybean flour production.

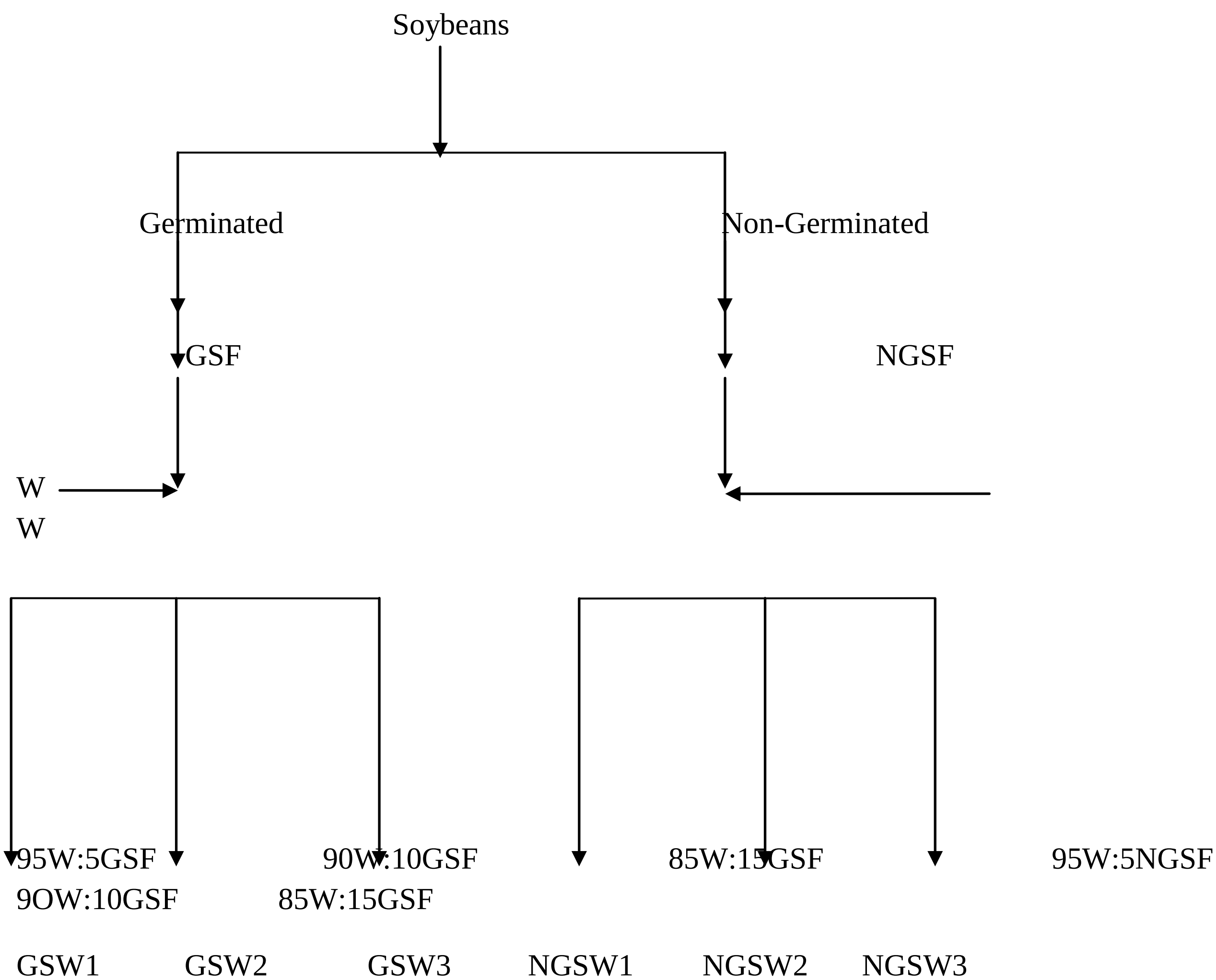


Figure 3: Flow diagram for the production of flour blends.

Figure legend:

GSF=Germinated Soybean flour; NGSF = Non-germinated Soybean flour; W = Wheat flour; GSW1= 95%wheatflour + 5% germinated soybean flour; GSW2= 90%wheatflour + 10%germinated soybean flour; GSW3= 85%wheatflour + 15%germinated soybean flour; NGSW1= 95%wheatflour + 5% non-germinated soybean flour; NGSW2= 90%wheatflour + 10% non-germinated soybean flour; NGSW3= 85%wheatflour + 15% non-germinated soybean flour.

ANALYTICAL PROCEDURES

PROXIMATE COMPOSITION.

The proximate chemical composition analyses were performed in the Food Chemistry Laboratory, and Central Research laboratory of The Bells University of Technology, Ota. Moisture content of the samples was determined by oven-drying at 105 ± 1 °C for 4 hours (AOAC, 1995). Fat content was measured by extraction with diethyl ether in a Soxhlet system (Foss soxtecTm 2055 fat extractor) using 2g of the sample. Proteins were analysed as total nitrogen content by the Kjeldahl procedure (AOAC, 1995) using a Foss TecatorTm protein digestor and KJECTEC 2200 distillation apparatus, and the conversion factor used to transform nitrogen into protein was 5.71 for soybean flour, 5.70 for wheat flour and 5.705 for flour blends. Crude fibre was determined using the method described by Pearson (1973). Finally, ash content was determined by incineration of samples at 550 °C in a muffle furnace for 1 hour. (AOAC, 1995) and total available carbohydrates were estimated by difference.

All the determinations were made in triplicates in accordance with the established procedures (AOAC, 1985).

WET GLUTEN DETERMINATION

AACC method No. 10-11 (AACC, 1984) was used for gluten estimation in plain and blended flours. A weighed sample (25 g, 14% moisture) was transferred into a clean dry mixing bowl and

13.5 mL of water was added. The contents were formed into a stiff dough ball. The dough ball was dipped into water for half an hour and then washed by hand under tap water until free from starch. The wet gluten thus obtained was weighed and its weight expressed as a percentage of the original flour sample (25 g).

DOUGH RHEOLOGICAL TESTING/MEASUREMENTS

FARINOGRAPH TESTING

The control flour (wheat flour) and flour blends were tested utilizing the Brabender Farinograph-E (First Blends Ltd., Ikeja, Lagos State) according to AACC Approved Method No. 54-21 (AACC, 2000). The dough development time, dough water absorption, mixing tolerance index (MTI), and stability profiles were calculated.

The dough development time (DDT) is time for the dough to reach maximum consistency (peak); stability is the time that the top portion of the curve is above the 500 BU line; mixing tolerance index (MTI) is the drop in BU from the top of the curve at DDT to the top of the curve 5 minutes after DDT.

EXTENSOGRAPH TESTING

The dough extensibility of flour samples was determined using the Brabender Extensograph-E (First Blends Ltd., Ikeja, Lagos State) according to AACC 54-10 (AACC, 2000). The following parameters were measured from the extensograph curve using the Extensogram-E software (v.2.4.4): Rmax {the maximum height (maximum resistance) of the curve; E {a measure of the extensibility of the sample in cm}; A {the area under the curve in cm2}.

BAKING PROCEDURE

Ingredients such as sugar, fat, salt and yeast were then added in appropriate proportions to each of the flour blends and the control flour (table 1).The amount of water added to each was determined based on the water absorption values obtained from the farinograph to obtain dough of good consistency. The dough obtained in each case was scaled into baking pan, and left to proof for at 38°C in a proofing cabinet (MIWE GR D-97450). Proofing was considered satisfactory when dough height had risen to 1cm above the top of the pan. Bread loaves were subsequently baked at 180 °C for 30 minutes in an electric oven (MIWE Oven CO 11206). The baked loaves were later depanned, cooled and used for subsequent analysis. The baking procedure is described in figure 4.

Table 1: Formulation for control and composite bread

	Soybean Flour {%}	Soybean flour {g}	Wheat flour {g}	Yeast {g}	Fat {g}	Sugar {g}	Salt {g}
NGSWB1	5	40	760	10	32	108.8	14.4
NGSWB2	10	80	720	10	32	108.8	14.4
NGSWB3	15	120	680	10	32	108.8	14.4
GSWB1	5	40	760	10	32	108.8	14.4

GSWB2	10	80	720	10	32	108.8	14.4
GSWB3	15	120	680	10	32	108.8	14.4
WB	0	0	800	10	32	108.8	14.4

The amount of water added was determined based on the water absorption values obtained from the farinograph.

LEGENDS: GSWB=Germinated Soy-Wheat Bread; NGSFWB= Non-germinated Soy-Wheat Bread and; WB=100% Wheat Bread

Mixing of Ingredients

↓

Scaling

↓

Panning

↓

Proofing

(40 oC for 40 minutes)

↓

Baking

(180 oC for 30 minutes)

↓

Depanning

↓

Cooling

Figure 4: Flow diagram for bread making.

BREAD FIRMNESS

Bread firmness were measured on freshly baked bread loaves using a TVT-300XP texture analyzer (First Blends Ltd., Ikeja, Lagos State) which has a cylinder probe with a 1 kg load cell. The weighted probe which was positioned vertically over the surface of the test sample (six centre slices from the bread loaves) was allowed to fall unto the sample and the depth of penetration after a fixed period of time was determined. The bread macro software provided by the texture analyzer was used to collect the data and the results were presented in terms of hardness.

PHYSICAL MEASUREMENTS ON BREAD

The loaf weight, volume, specific volume, density and height were determined with Tex-vol instrument BVM-L370 (First Blends Ltd., Ikeja, Lagos State).

RESULTS AND DISCUSSION

EFFECT OF GERMINATION ON THE NUTRITIONAL COMPOSITION OF SOYBEAN FLOUR, FLOUR BLENDS AND BREAD

The proximate chemical compositions of flour from both non-germinated and germinated soybeans are presented in Table 2. The effect of germination on the nutrients was significant ($P<0.05$). Crude protein increased by 9.4% while fat content decreased by 53% and carbohydrates content decreased by 17.3%. The observed decreases in the carbohydrate and fat content could be attributed to their use in the germination process as energy sources (Komberg and Beevers, 1957). The increase in respiration rate during germination brings about the release of energy from the breakdown of carbon compounds (Enujiugha et al., 2003). The increase in protein content observed may be due to the synthesis of enzymes or a compositional change following the degradation of other components. Other researchers (Mostapha et al., 1987; Bau et al., 1997) have also observed significant increases in protein content with seed germination. Moisture content, crude fibre and ash of the raw soybean also increased significantly upon germination.

Table 3 includes the results of the proximate composition of the flour blends. There were significant increases ($P<0.05$) in the levels of crude protein and fat contents as the level of substitution with both non-germinated and germinated soybean flours increased in the mixture, while carbohydrates contents showed a reverse trend. The moisture contents, which were generally low, varied only slightly but significantly, decreasing from 12.75% to 11.53% and 10.86% in the un-substituted whole wheat bread and that with 15% non-germinated soybean flour and 15% germinated soybean flour respectively. Ash content also increased significantly with increasing substitution with both types of flour.

The changes in the proximate composition of bread made from the various blends followed similar patterns with that of the flour blends as shown in table 4.

Table 2: Proximate composition (%) of non-germinated and germinated soybean flour.

	Non-germinated Seeds	Germinated seeds
Moisture Content	3.48±0.03	4.91±0.12
Crude Protein	36.46±0.06	39.87±0.21
Crude fat	23.23±0.54	15.19±0.02
Crude fibre	4.71± 0.01	10.37±0.02
Ash	7.94 ±0.24	9.65±0.29
Carbohydrate by difference	24.18± 0.06	20.62±0.13

Mean of triplicate determinations ± standard error

Table 3: Proximate composition (%) of flour samples

	NGSF	GSF	NGSW1	NGSW2	NGSW3	GSW1		GSW3	W
Moisture Content	3.48±0.03	4.91±0.12	11.68±0.04	11.60± 0.00	11.53±0.01	11.1	11.08±0.01	10.86±0.02	12.75±0.05
Crude Protein	36.46±0.06	39.87±0.21	14.35±0.05	16.13	17.90±0.01	15.03±0.03	16.90±0.12	17.93±0.02	15.47±0.04
Crude fat	23.23±0.54	15.19±0.02	2.02±0.09	3.49± 0.23	4.18±0.02	1.7	1.89±0.03	2.96±0.03	0.66±0.00
Crude fibre	4.71±0.12	10.37±0.00	0.02±0.00	0.07± 0.00	0.15±0.01	1.0	1.09±0.01	1.10±0.00	0.45±0.03
Ash	7.94±0.24	9.65±0.29	3.03±0.02	5.95± 0.03	7.09±0.02	4.0	4.51±0.02	5.14±0.22	1.80±0.08
Carbohydrate by difference	24.18±0.05	20.62±0.01	68.91±0.01	62.76± 0.01	59.15±0.03	67.0	64.53±0.02	62.01±0.01	68.87±0.03

Mean of triplicate determinations ± standard error

LEGEND: NGSF (non-germinated soybean flour)

GSF (germinated soybean flour)

NGSW1 (95:5 wheat flour: non-germinated soybean flour);

NGSW2 (90:10 wheat flour: non-germinated soybean flour);

NGSW3 (85:15 wheat flour: non-germinated soybean flour);

GSW 1 (95:5 wheat flour: germinated soybean flour);

GSW 2 (90:10 wheat flour: soybean flour);

GSW 3 (85:15 wheat flour: germinated soybean flour)

W (Wheat flour)

Table 4: Proximate composition (%) of bread loaves from Wheat-Non Germinated Soybean Flour Blends and Wheat-Germinated Soybean Flour Blends.

	NGSWB1	NGSWB2	NGSWB3	GSWB1	GSWB2	GSWB3	WB
Moisture Content	29.35±0.20	28.45± 0.03	30.50±0.23	29.50±0.06	28.85±0.01	31.55±0.32	30.95±0.06
Crude Protein	9.40±0.54	11.45±0.11	11.70±0.35	10.55±0.27	10.64±0.01	11.80±0.35	9.13±0.0
Crude fat	2.21±0.01	2.81±0.02	3.16±0.02	2.83±0.00	2.89±0.01	2.94±0.00	2.03±0.0
Crude fibre	1.31±0.02	1.47±0.02	1.51±0.01	1.61±0.00	1.88±0.02	1.97±0.00	0.62±0.0
Ash	2.22±0.02	2.29±0.01	2.68±0.04	2.30±0.01	2.40±0.01	2.62±0.02	
Carbohydrates by difference	55.51±0.02	53.53±0.02	50.55±0.02	53.21±0.02	53.24±0.02	49.12±0.01	54.47±0.03

LEGEND: NGSWB1 (95:5 wheat flour: non-germinated soybean bread);

NGSWB2 (90:10 wheat flour: non-germinated soybean bread);

NGSWB3 (85:15 wheat flour: non-germinated soybean bread);

GSWB 1 (95:5 wheat flour: germinated soybean bread);

GSWB 2 (90:10 wheat flour: soybean bread);

GSWB 3 (85:15 wheat flour: germinated soybean bread)

WB (Wheat Bread)

EFFECT OF SOYBEAN FLOUR SUBSTITUTION ON THE WET GLUTEN CONTENT OF FLOUR BLENDS

Wheat flour exhibited wet gluten contents of 33.9%, which decreased upon blending with both germinated and non-germinated soybean flour (Table 6). However, germinated soybean flour exhibited lower values of wet gluten when compared to non-germinated soybean flour of the same substitution level. Wheat flour blended with germinated soyflour at a substitution level of 15% had the lowest wet gluten content (20.0%).

The gluten content is a direct indicator of flour strength and bread making potentialities (Dhingra and Jood, 2003). The quantity and quality of gluten is responsible for better gas production and retention capacity and forms a cellular network of crumb which imparts desirable characteristics to bread (Anjum & Walker, 2000; Belderok, 2000). Various workers have also observed that the contents of wet gluten decrease on increasing the levels of soyflour in white wheat flour (Rastogi & Singh, 1989; Singh et al., 1990; Misra et al., 1991).

Table 6: Wet gluten content of wheat flour and flour blends

SAMPLE	Wet gluten {%}
NGSWB1	31.6
NGSWB2	26.4
NGSWB3	20.0
GSWB1	32.0

GSWB2	30.0
GSWB3	27.2
WB	32.9

LEGEND: NGSW1 (95:5 wheat flour: non-germinated soybean flour);

NGSW2 (90:10 wheat flour: non-germinated soybean flour)

NGSW3 (85:15 wheat flour: non-germinated soybean flour);

GSW 1 (95:5 wheat flour: germinated soybean flour);

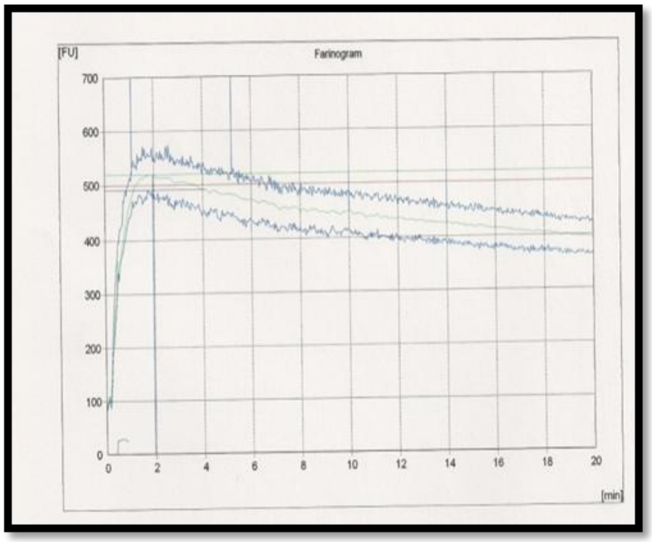
GSW 2 (90:10 wheat flour: soybean flour);

GSW 3 (85:15 wheat flour: germinated soybean flour)

W (Wheat flour)

EFFECT OF SOYFLOUR SUBSTITUTION ON DOUGH RHEOLOGY

FARINOGRAPH DETERMINATIONS



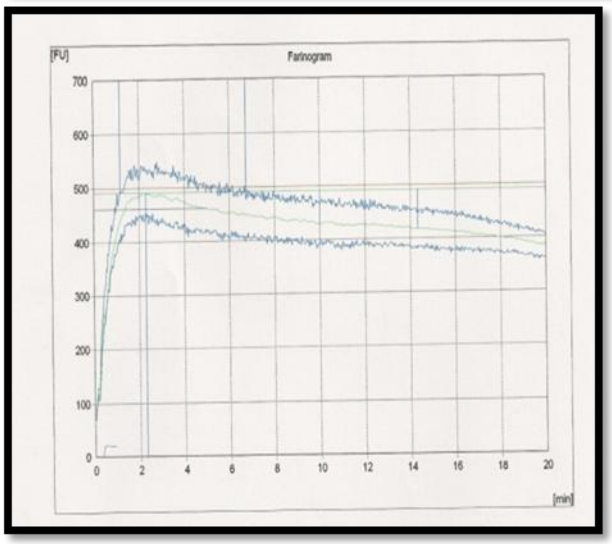
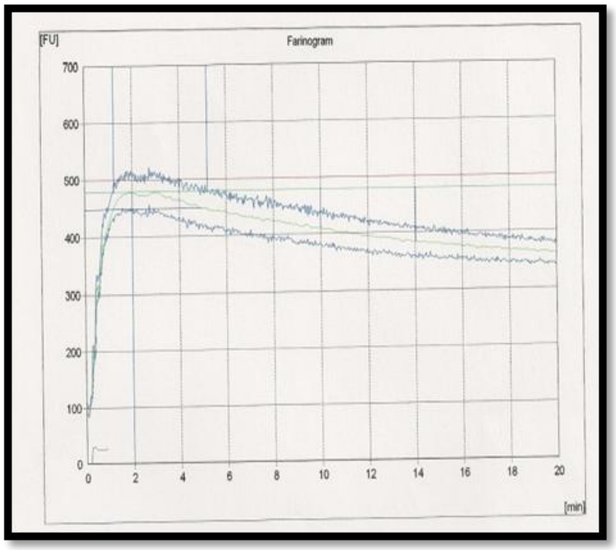


FIG. 5: CONTROL 100 % WHEAT FLOUR (Farinogram) Fig. 6: 5% non-germinated soybean flour - wheat flour (farinogram)

Y axis – Torque; X axis – time



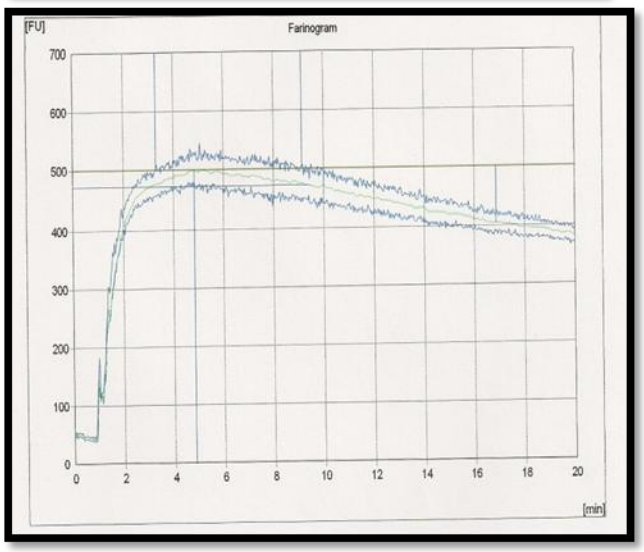
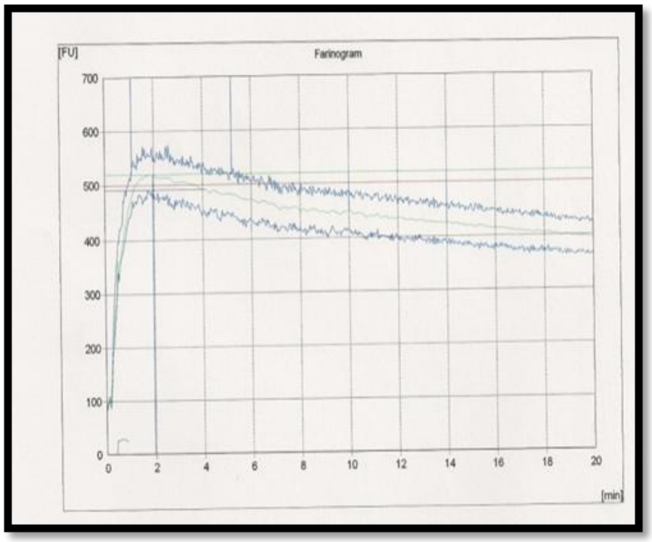
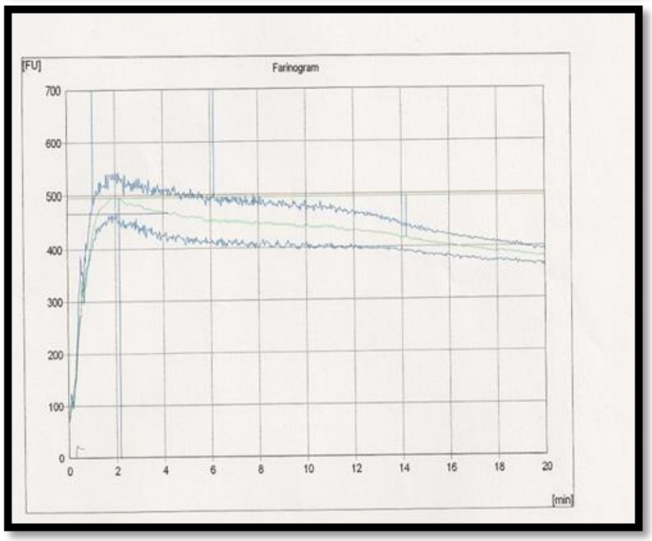


Fig. 7: 10% non-germinated soybean flour - wheat flour (farinogram) Fig. 8: 15% non-germinated soybean flour - wheat flour (farinogram)

Y axis – Torque; X axis- mixing time

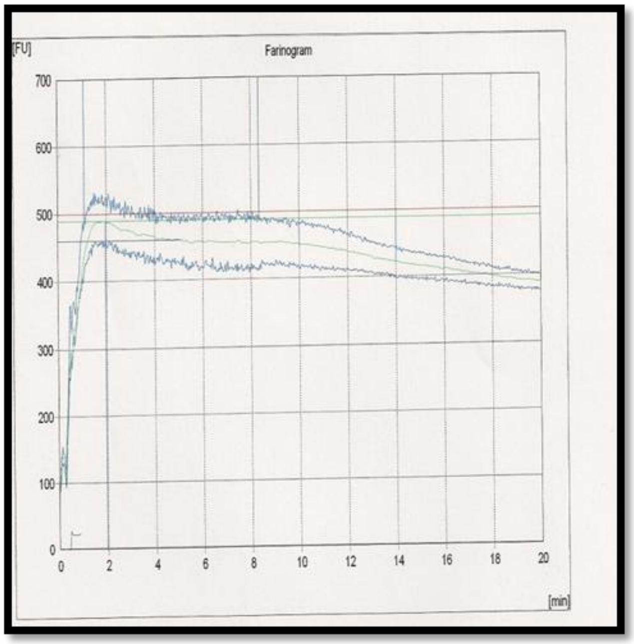




CONTROL: 100% WHEAT FLOUR

Fig. 9: 5% germinated soybean flour - wheat flour (farinogram)

Y axis – Torque; X axis- mixing time



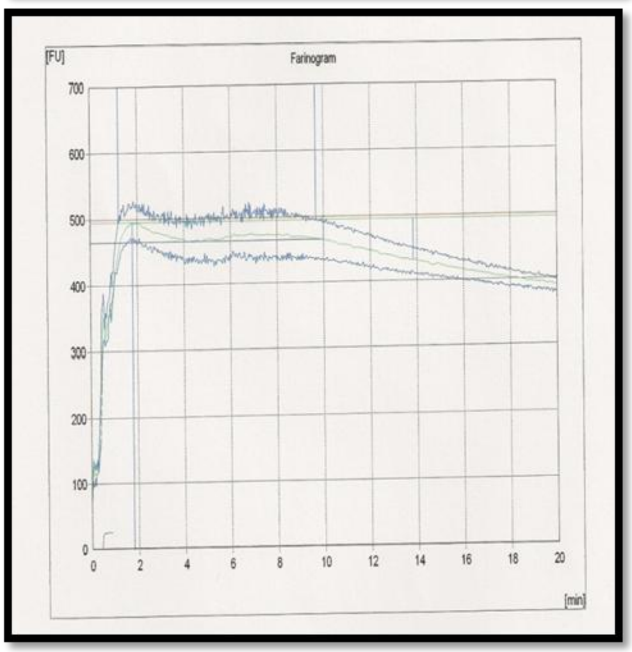


Fig. 10: 10% germinated soybean flour - wheat flour (farinogram) Fig. 11: 15% germinated soybean flour - wheat flour (farinogram)

Y axis – Torque; X axis- mixing time

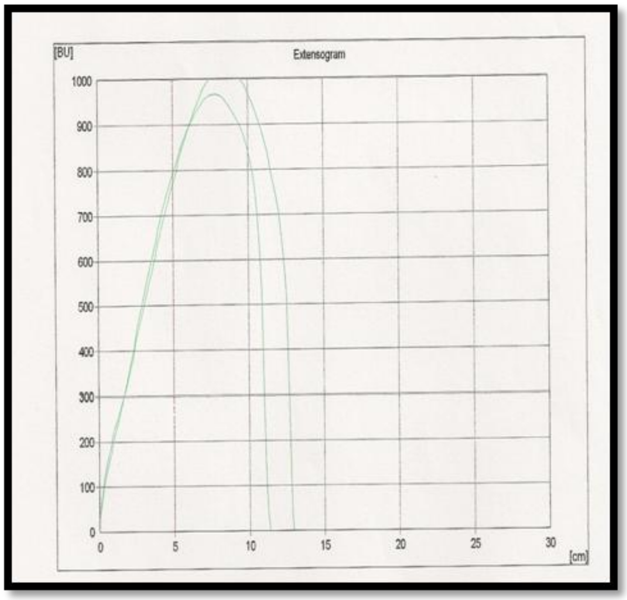
Table 7: Summary of farinograph parameters for wheat flour and flour blends

	Water Absorption {%}	Dough Developmennt Time {min}	Dough Stability {min}
NGSW1	59.3	2.0	4.1
NGSW2	59.1	2.0	4.0
NGSW3	61.0	4.9	5.8
GSW1	59.4	2.2	5.1
GSW2	60.5	2.0	7.2
GSW3	62.8	1.8	8.5
W	58.8	2.3	5.6

LEGEND: NGSW1 (95:5 wheat flour: non-germinated soybean flour);
NGSW2 (90:10 wheat flour: non-germinated soybean flour);
NGSW3 (85:15 wheat flour: non-germinated soybean flour);
GSW 1 (95:5 wheat flour: germinated soybean flour);
GSW 2 (90:10 wheat flour: soybean flour);
GSW 3 (85:15 wheat flour: germinated so

W (Wheat flour)

4.4.2. EXTENSOGRAPH DETERMINATION



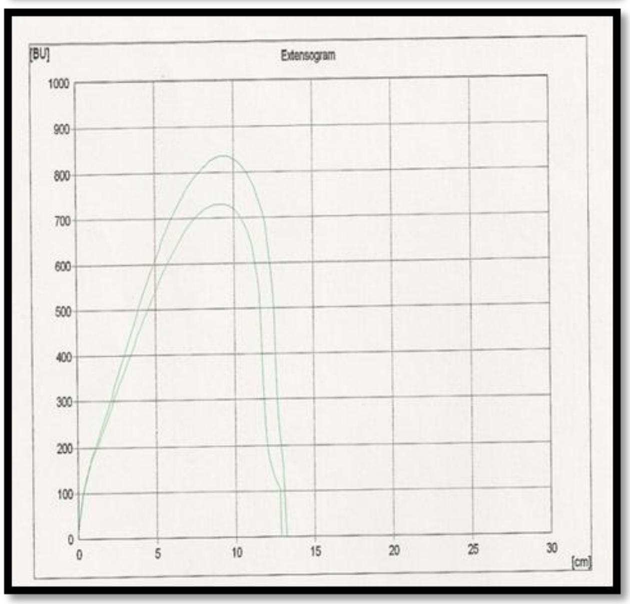
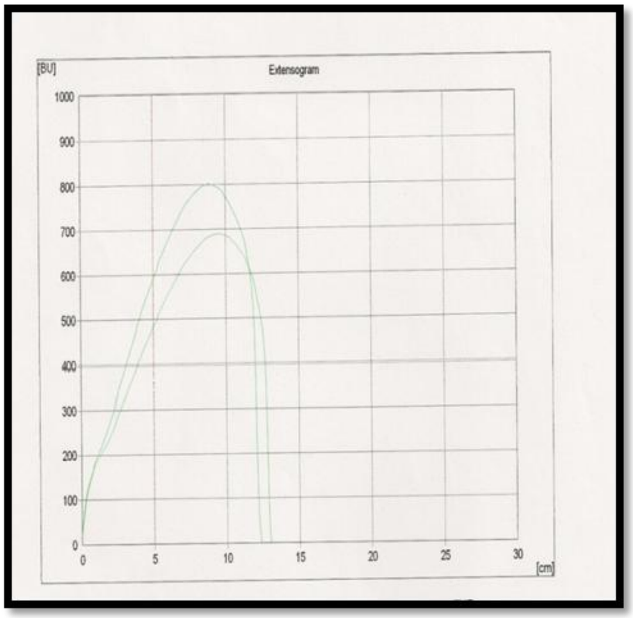


Fig. 12: 100% Wheat flour (extensogram)

Fig. 13: 5% non-germinated soybean flour - wheat flour (extensogram)

Y axis - Resistance to extension; X axis – Extensibility



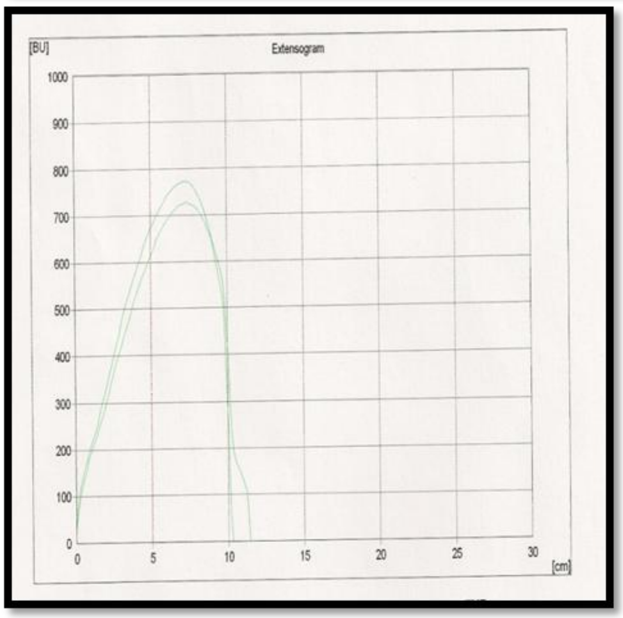
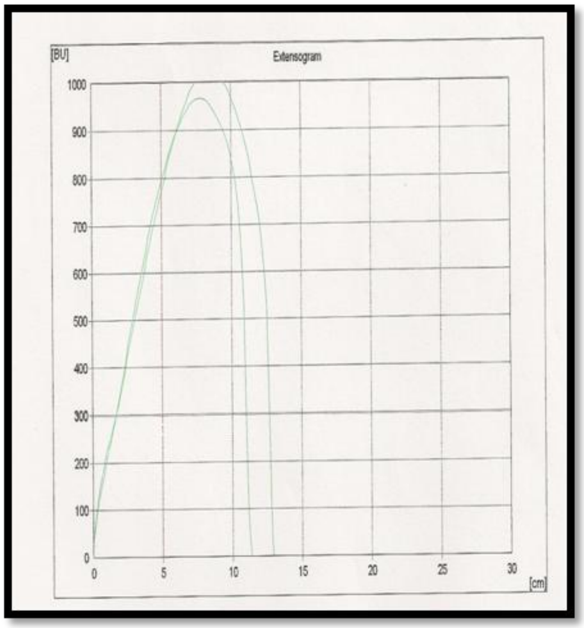
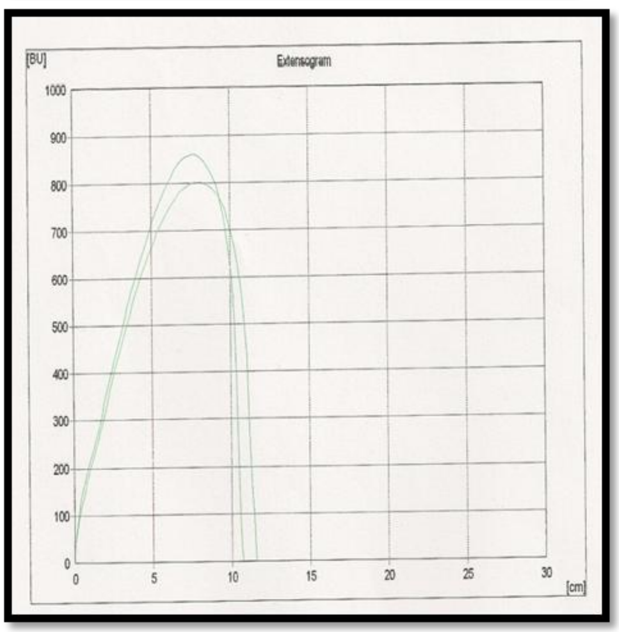


Fig. 14: 10% non-germinated soybean flour - wheat flour (extensogram) Fig. 15: 15% non-germinated soybean flour - wheat flour (extensogram)

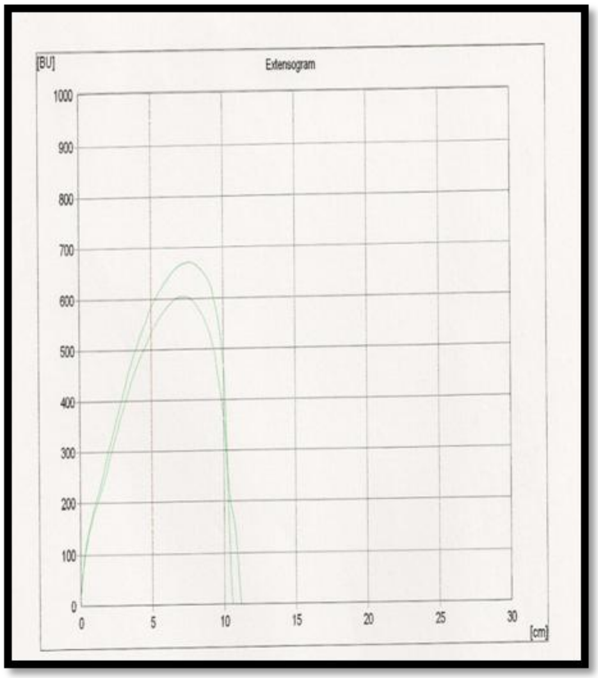
Y axis - Resistance to extension; X axis - Extensibility





100% WHEAT FLOUR Fig. 16: 5% germinated soybean flour - wheat flour (extensogram)

Y axis - Resistance to extension; X axis - Extensibility



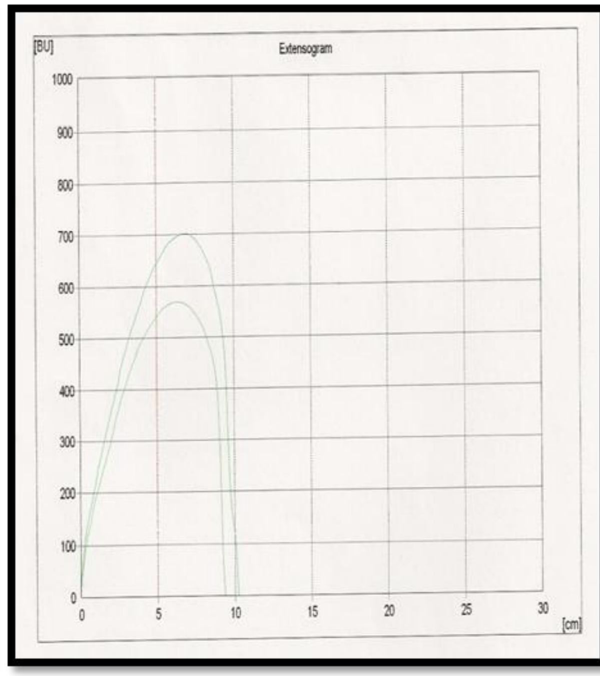


Fig. 17: 10% germinated soybean flour - wheat flour (Extensogram) Fig. 18: 15% germinated soybean flour - wheat flour (extensogram)

Y axis - Resistance to extension; X axis - Extensibility

Table 8: Summary of extensograph parameters for wheat flour and flour blends

	Water Absorption {%}	Energy {cm2}	Resistance to Extension {BU}	Extensibility {min}
NGSW1	55.7	123	580	131
NGSW2	54.7	116	542	127
NGSW3	53.7	96	648	109
GSW1	57.5	113	695	112
GSW2	59.5	86	564	109
GSW3	61.3	80	596	98
W	57.0	147	789	122

Energy is given as area under the curve

LEGEND: NGSW1 (95:5 wheat flour: non-germinated soybean flour);

NGSW2 (90:10 wheat flour: non-germinated soybean flour);

NGSW3 (85:15 wheat flour: non-germinated soybean flour);

GSW 1 (95:5 wheat flour: germinated soybean flour);

GSW 2 (90:10 wheat flour: soybean flour);

GSW 3 (85:15 wheat flour: germinated soybean flour)

W (Wheat flour)

4.4.3. EFFECT OF SOYBEAN FLOUR SUBSTITUTION ON FARINOGRAPH PARAMETERS

The water absorption capacity of wheat flour was 58.8% (as determined from the farinogram) which increased upon increasing levels of substitution of wheat flour with flour from both germinated sand non-germinated soybeans seeds (Table 7). This increase might be because of more water retention by these blends as a result of higher protein content as compared with wheat flour. The highest value was found in flour blends with flour from germinated soybeans at 15% substitution (62.8%) which also gave the highest protein content (17.93%). Selvaraj & Shurpalekar (1982) also showed that water absorption increased by about 1% for every 2% increase of soyflour in wheat flour.

Contrary to expectation, the dough stability did not decrease with increasing levels of substitution with both germinated and non-germinated soybean flour. Further research will be needed to determine why this did not occur.

EFFECT OF SOYBEAN FLOUR SUBSTITUTION ON EXTENSOGRAPH PARAMETERS

Extensibility, as measured by the extensograph procedure, decreased as the substituted levels of both germinated and non-germinated soybean flour increased (Table 8). This is in agreement with the findings of Ribotta et al.,2005 who reported the incorporation of high levels of soy products had negative effects on extensibility properties of dough. Wheat gluten is responsible for dough extensibility. Roccia et al., 2009 also reported that soy protein produced more resistant but less extensible mixtures and that these effects were more evident when soy level increased. The area under the curve (A) significantly decreased. The reduction of the area under the extension curve, is a measure of the energy required for extension and is taken as a measure of flour's strength (Hoseney, 1994) and this indicated a weakening effect of gluten by soy protein.

EFFECT OF SOYBEAN FLOUR SUBSTITUTION ON BREAD FIRMNESS.

Bread firmness was expressed as hardness. It was generally observed that increasing levels of substitution of wheat flour with flour from germinated and non-germinated soybeans seeds increased the hardness of loaves obtained. However, bread substituted with from flour of germinated soybeans showed greater hardness than those substituted with flour from non-germinated soybeans.

EFFECT OF SOYBEAN FLOUR SUBSTITUTION ON LOAF VOLUME

Loaf volume is one of the major quality indicators for bread and is influenced by many factors including wheat flour compositions, additives and dough fermentation conditions (Nemeth et al., 1996; Bail et al., 1999; Havet et al., 2000; Rosell et al., 2001).

A significant reduction in loaf volume was observed as the level of substitution with both germinated soybean and non-germinated soyflours increased (Table 9). The highest reduction in loaf volume was in bread made from wheat flour blended with germinated soybean flour at the 15% level which had a loaf volume that was reduced by 24% as compared with the control bread without soyflour.

It could be that a dilution effect on gluten with the addition of non-wheat flour to wheat flour and less retention of CO_2 gas caused the depression in loaf volume (Sharma and Chauhan,2000). Similar values to those shown in Table 9 for loaf volume were reported by Ereifej and Shibli (1993) and Indrani & Rao (1992) in whole wheat flour breads. Another reason for the decrease in loaf volume could be the presence of relatively high concentrations of low molecular weight thiols, especially reduced glutathione, which activates proteolytic enzymes, thereby causing a detrimental effect on loaf volume (Indrani & Rao, 1992). Specific loaf volume is obtained by dividing the loaf volume by the loaf weight and results indicated a decrease in specific loaf volume on increasing the levels of non-wheat flours compared with the control (Table 9). The poor quality and quantity of gluten in cereal-pulse blended breads may be responsible for retention of CO_2 gas in the fermented dough and low specific loaf volume.

Table 9: Physical and rheological measurements of bread loaves.

	WEIGHT	VOLUME	SPECIFIC VOLUME	DENSITY	HEIGHT	TOTAL HARDNESS
NGSWB1	605	2875.4	4.8	0.2	217.2	220.00
NGSWB2	608	2709.9	4.5	0.2	218.8	229.75
NGSWB3	607	2364.6	3.9	0.3	226.1	370.00
GSWB1	604	2992.4	5.0	0.2	219.8	246.00
GSWB2	615	2921.3	4.8	0.2	216.2	232.75
GSWB3	615	2641.2	4.3	0.2	223.6	391.25
WB	606	2937.1	4.9	0.2	220.0	222.25

LEGEND: NGSWB1 (95:5 wheat flour: non-germinated soybean bread);

NGSWB2 (90:10 wheat flour: non-germinated soybean bread);

NGSWB3 (85:15 wheat flour: non-germinated soybean bread);

GSWB 1 (95:5 wheat flour: germinated soybean bread);

GSWB 2 (90:10 wheat flour: soybean bread);

GSWB 3 (85:15 wheat flour: germinated soybean bread)

WB (Wheat Bread)

CONCLUSION AND RECOMMENDATIONS

The results obtained from this study indicated that more nutritious bread, in which anti-nutritional factors have been reduced, can be produced from germinated soy-wheat composite flour. However, since non-germinated flour gave better rheological properties than germinated flour (especially above 5% substitution level of germinated soybean flour) and bread produced from the different non-germinated flour showed better textural properties and greater loaf volume; it can be inferred that non-germinated soybean flour would be more desirable by bakers.

From the ongoing, it can be concluded that germinated soybean flour was not desirable to be used as composite flour in bread making beyond 5% substitution levels for consumer acceptability.

It is recommended that the rheological qualities which were lower in bread made from germinated soybean and wheat blends than in un-substituted wheat bread could be improved upon by the addition of appropriate additives. These potentials, if properly harnessed could help in improving the nutritional quality of bread, decrease the cost of production and consequently contribute in ensuring food security.

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