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EFFECT OF BLANCHING AND UNBLANCHING ON RHEOLOGICAL PROPERTIES OF SWEET-POTATO BREAD

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ABSTRACT

The effect of blanching and unblanching on rheological properties of sweet-potato bread, and textural effect at different substitution levels (10%, 20% and 30%) were investigated. The proximate analysis, functional properties and rheological properties were carried out on the flour; the data's obtained from the results were subjected to Analysis of variance. Result showed that there was no significant difference in the protein, fat and carbohydrate content of sweet potato flour, but there was significant difference (P≤0.05) in the ash, moisture and crude fiber. There was no significant difference (P≤0.05) in the bulk density of the sweet-potato flour. The result also showed that the protein and ash of sweet-potato bread decreased significantly (P≤0.05) with increased proportion of sweet potato flour. The substitution of sweet-potato flour into wheat flour affected the rheological and textural properties of wheat flour; the rate of water absorption of the wheat flour increased as sweet-potato substitution levels increased this was due to high starch content of sweet potato. Also, the dough stability time of the substituted sweet potato flours was lesser than that of the wheat flour. The 10% substitution level had the highest dough consistency (525BU). In addition, the sensory evaluation showed that there was significant difference between the organoleptic properties of wheat bread to that of substituted breads. 10% blanched sweet-potato bread had the highest consumer acceptability, while the 30% unblanched had the lowest rating due to appearance and hardness.

Keywords: Rheological properties, textural properties, water absorption capacity, proximate composition, dough consistency, wheat gluten

INTRODUCTION

Blanching is a special heat treatment to inactivate enzymes. It is also a unit operation prior to freezing, canning, or drying in which they are heated for the purpose of inactivating enzymes, modifying texture preserving color, flavor, and nutritional value; and removing trapped air. The process involves the treatment by means of some form of unsteady heat transfer (conduction and convection) either by steam or hot/boiling water. Time and temperature regime of blanching depends on the nature and the source of the material and the final processing to be employed [1]. Blanching is not indiscriminate heating fresh cut potato turn brown when iron-containing chemicals in the potato react with oxygen in the air .The chemical reaction is called 'oxidation'. There are several ways to inhibit oxidation; Chemical anti-oxidants can be added to food. Lemon juice, for example, will inhibit potatoes the browning of a freshly cut potatoes because lemons are high in citric acid, an anti-oxidant. Sulphur dioxide, used in the commercial processing of many foods, does the same thing. Removing the air (and thus the oxygen) from food can also inhibit oxidation. When you cut open a potato, an enzyme (tyrosinase) in the flesh reacts with oxygen to turn polyphenols into melanin. Blanching inhibits enzymes that degrade provitamin A such as lipoxygenases and peroxidases [2]. The effect of blanching on vegetables consists in inhibiting enzymes such as

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peroxidases, lipoxygenases and chloropyllases and protases are responsible, stabilizing the nutritional values of the product, preventing the oxidizing activity of ascorbic acid [3], [4], [5],[6].

Hot water and steam are the most commonly used heating media for blanching in industry, but microwave and hot gas blanching have also been studied. Different hot water and steam blanchers have been designed to improve product quality, increase yield, and facilitate processing of products with different thermal properties and geometries. Hot water and steam are the most commonly used heating media for blanching in industry, but microwave and hot gas blanching have also been studied. Different hot water and steam blanchers have been designed to improve product quality, increase yield, and facilitate processing of products with different thermal properties and geometries. Gas removal is the main benefit of blanching before canning because it allows easier can fill, reduces strain on can during heating, and reduces can corrosion. Although, in this case, enzyme inactivation also takes place, it is not relevant because any remaining activity is destroyed on retorting, [7]. Blanching facilitates peeling and dicing, and is also accompanied by microbial load reduction. Fruits are usually not blanched, or blanched under mild (low temperature) conditions prior to freezing because blanching produces undesirable texture changes.

Sweet potato (*ipomoea batatas)* is a very important crop in the developing world and traditionally, but less important in some part of the world .Sweet potato ranks the seventh most important food crop in the world and fourth in tropical countries . In comparison to other major staple food crops, sweet potato has the following positive attributes: wide production geography, adaptability to marginal condition, short production cycle, high nutritional value and sensory versatility in terms of flesh colors, taste and texture. Depending on the flesh color, sweet potatoes are rich in ß -carotene, anthocyanin, total phenolic, dietary fiber, ascorbic acid, folic acid and minerals [8].

Therefore, sweet potato has an exciting potential for contributing to the human diets around the world. However, the world trends in sweet potato production and consumption do not support the position of this highly nutritious vegetable. In the United States, the annual per capita consumption of sweet potato was declined in the last decades from 12 kg to 2 kg while the potato consumption was increased to over 60 kg. The situation can be attributable to the inadequacy in sweet potato manufacturing technologies for processed products, and the increased demand of consumers for convenient products. Research efforts have demonstrated that sweet potatoes can be made into liquid and semi-solid food products such as beverages, soups, baby foods, ice cream, baked products, restructured fries, breakfast cereals, and various snack and dessert items and also composite flour. [8].

Potatoes are one of the most popular major food items consumed throughout the world because of their high yield, relatively low cost of production, and adaptability to a wide variety of soil and climate types. Potatoes are not an especially rich source of protein but contain good quality protein, dietary fiber, several minerals and trace elements, essential vitamins and little or no fat. The utilization of particular types of sweet potato for food depends mostly on local or regional food preferences. There have been several attempts to use sweet potato flour in different food products such as butter cookies, pretzels, cakes, hotcake mixes, and instant porridge and as a composite with wheat in the production of noodles and bread [9].

Sweet Potato is an important secondary crop in Indonesia, providing good yields to small farmers and fitting well into rice based cropping systems. East Java produces 10-20% of the sweet potato in Indonesia. Only 16% of sweet potato is consumed by the producers: 73.8% of production is for the market [10]. Sweet potato production in this area provides cash income from fresh root sales (for direct consumption or snack food production), fodder for cattle, plus the organic fertilizer from cattle partially fed on sweet potato vines.

Bread is an important staple food, the consumption of which is becoming steady even in the rural areas in Nigeria. It is however, relatively expensive, being made from imported wheat that is not cultivated in the tropics. The report of Olaye *et al, [11]* observed that, efforts have been made to promote the use of composite flours in which flour from locally grown crops replace a portion of wheat flour in bread production. The purpose is to reduce the quantity of imported wheat flour and increase the use of locally made flours in bread production. This will further help, in diversifying the use of both widely known and other unfamiliar locally available crops. Although, bread is not a traditional dietary item in most developing countries, its consumption is rapidly increasing and utilization of indigenous source of starch such as sweet potato could lead to reductions in importation of wheat grain [11].

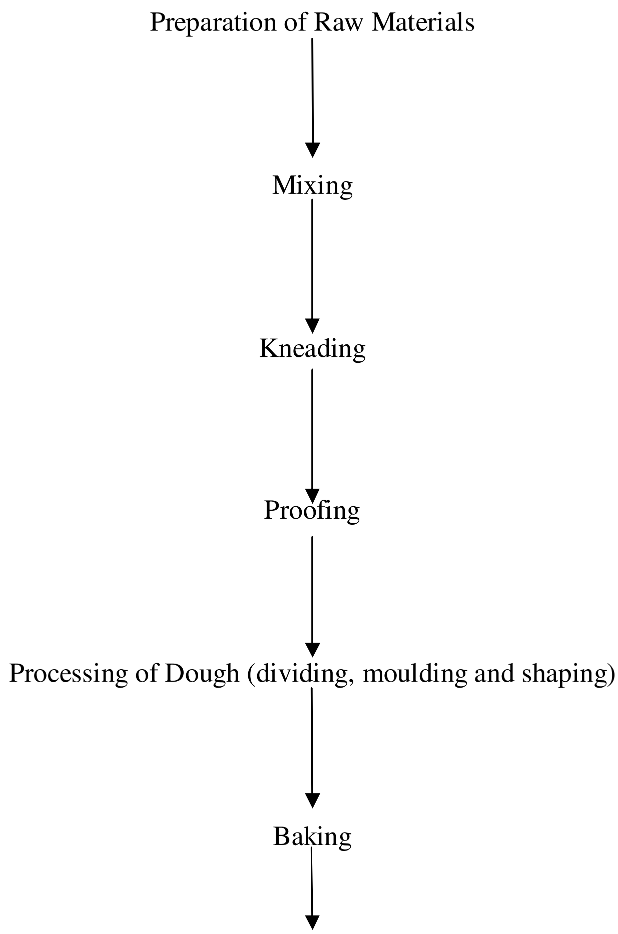

Figure1. Flow Diagram of Bread Production

It is also one of the least expensive foods and yet most staple in worldwide, flour, water, yeast and salt is the four basic ingredient of bread. Other ingredients, which are optional, include sugar (sucrose) fat, conditioner and preservative. Wheat flour is lacking in some essential amino acids such as lysine, methionine and threonine [12]. The deficient nutrients can be supplemented through the use of composite flour. Gluten is present in only wheat flour; the use of composite flour affects the texture of bread where strength is dependent on some appropriate level of gluten development [13]. Bread may be described as a fermented

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confectionary product produced mainly from wheat flour, water, yeast and salt by a series of process involving mixing, kneading, proofing, shaping and baking [13].

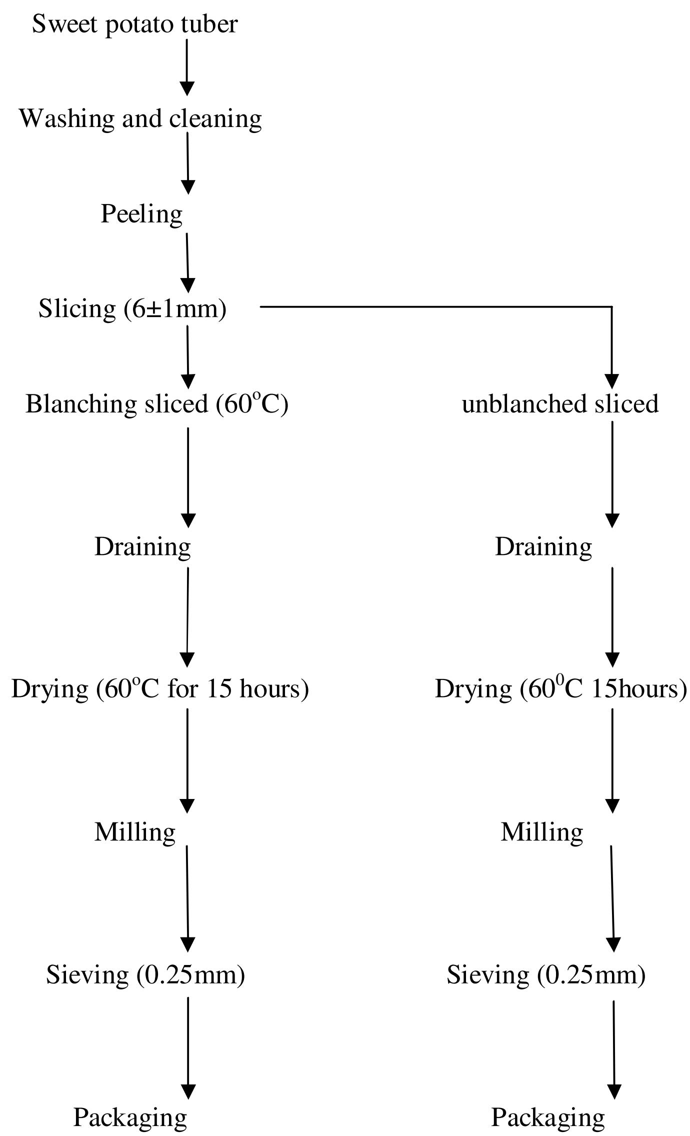

Figure 2. Flow chart for processing of blanched and unblanched sweet potato flour

Rheology, as a branch of physics, studies the deformation and flow of matter in response to an applied stress or strain. According to the materials' behavior, they can be classified as Newtonian or non-Newtonian [14]. The most of the foodstuffs exhibit properties of non-Newtonian viscoelastic systems [15]. Among them, the dough can be considered as the most unique system from the point of material science. Among the cereal technologists, rheology is widely recognized as a valuable tool in quality assessment of flour. Hence, in the cereal scientific community, rheological measurements are generally employed throughout the whole processing chain in order to monitor the mechanical properties, molecular structure and composition of the material, to imitate materials' behavior during processing and to anticipate the quality of the final product [16]. Rheology is particularly important technique in revealing the influence of flour constituents and additives on dough behavior during bread making. Determination of the rheological properties of dough is part of the quality assessment of flour. The rheological properties depend to a large extent on wheat variety, crop properties and the milling process. Gluten complex is a viscoelastic protein responsible for dough structure formation. Dough rheology allows better understanding of the way in which various elements act upon the technological process of bakery. When using the Farinograph Brabender and Flourgraph E6 mixer devices the flour is first mixed with water to form the dough and afterwards is kept under mechanical stress until its structure is destroyed. The maximum viscosity decreases with increasing protein content. This behavior is given by the other major component of the dough. [17].

Mixing of Ingredients (sweet potato flour + wheat flour)
↓
Kneading
↓
Scaling
↓
Panning
↓
Proofing
(40 ^{o}C for 90 minutes)
↓
Baking
(190 ^{o}C for 30 minutes)
↓
De-panning
↓
Cooling

Figure 3. Flow diagram of sweet potato flour (blanched and unblanched) with wheat flour in bread production

MATERIALS AND METHOD

Materials

The variety of sweet potato used was the yellow skin with cream flesh. It was purchased from Ile epo market in Lagos. Other ingredient (flour, sugar, margarine, salt and yeast) that was used for the bread production were sourced from an open market situated in Ota, in Nigeria

Equipment: oven, milling machine, weighing balance.

Methods

Production of Sweet Potato Flour

Sweet potato flour was produced following the method described by Adeleke and Odedeji, [18]. Sweet potato tubers were sorted and washed to remove sand, dirt and other adhering materials. The deemed tubers was peeled using a sharp stainless knife and sliced using a kitchen slicer to obtain a sliced thickness of 6 +1 mm. The slices was then washed in water

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and placed in a sieve to remove excess water. The slices was blanched at temperature 60^0C, for 15 minutes to inactivate the enzyme that causes browning before drying in the oven at 60^0c for 15 hours while the other part were not blanched. The dried slices were milled in a disc attrition machine to obtain flour. The flour is then sieved, packed in a polythene bag and stored at ambient temperature

POTATO-WHEAT COMPOSITE FLOUR FORMULATION

A straight dough process was used for the preparation of the sweet potato bread; the same method was used for the production of bread with blanched and unblanched sweet potato flour. Ingredients such as sugar, fat, salt and yeast was then added in appropriate proportions to each of the flour blends and the control flour (Table 1). All- purpose flour (Golden penny flour) was used in the bread production. The sweet potato flour (blanched and unblanched) was substituted based on flour basis into the bread dough (1%, 2% and 3%). Sweet potato flour (blanched and unblanched) substituted flours was mixed with bread ingredients individually in an automated mixer (3 minutes slow mixing and 12minutes of fast mixing). The resulting dough was scaled (260g) and then hand kneaded, shaped and panned. The dough was then subjected to proofing in a proofing chamber at 40^0C for 90minutes. The proved bread was then subjected to baking at 180^0C for 25 minutes. The baked bread samples were then de-panned and cooled at ambient temperatures and put in Ziploc bags prior to analysis.

PROXIMATE ANALYSIS ON SWEET POTATO FLOUR

Determination of Moisture Content

The Moisture Content was determined using procedure described by AOAC, [19] was used**.** The moisture content of each sample was determined by weighing 5g of the sample into a aluminium moisture can. The sample was then dried to constant weight at 105±2°C.

$$\text{Moisture content} = \frac{(\text{Weight of can} - \text{weight of empty can}) \times 100}{\text{Weight of sample}}$$

Determination of Crude Fat Content

Crude fat extracted in a Soxhlet extractor with hexane. 1g of sample was weighed into an extraction thimble and then stopped with grease-free cotton. Before extraction the round bottom cans was dried, cooled and weighed. The thimble was placed in extraction chamber and 80ml hexane was added to extract the fat. The extraction was carried out at 155^0C lasted for 1hour 40minutes after which the fat collected in the bottom cans were cooled in a desiccator.

$$\text{Crude Fat} = \frac{(\text{Weight of can} + \text{fat}) - \text{Weight of empty can} \times 100}{\text{Weight of sample}}$$

Determination of Crude Protein

The Protein Content was determined using a Foss Tecator^{Tm} protein digester and KJECTEC 2200 distillation apparatus (Kjeldahl method) according to the procedure of AOAC, [19]. Concentrated H_2SO_4 ($12cm^3$) and 2 tablets of catalyst were put into a Kjeldahl digestion flask containing 5g of the sample. The flask was placed in the digester in a fume cupboard and switched on and digestion was done for 45 minutes to obtain a clear colourless solution. The digest was distilled with 4% boric acid, 20% Sodium hydroxide solutions were automatically metered into it in the KJECTEC 2200 distillation equipment until distillation was completed.

The distillate was then titrated with 0.1M HCl until a violet colour formation indicating the end point. A blank was run under the same condition as with the sample. Total nitrogen content was then calculated according to the formula:

$$\text{Crude Protein} = \frac{(\text{Titre (of sample)} - \text{blank}) \times 0.01 \times 14.007 \times 6.25}{10 \times \text{weight of sample}}$$

Determination of ash Content

2g of samples were weighed into well incinerated crucibles and then ashes in a muffle furnace at 600^0C for 3 hours. The ash content was calculated as

$$\text{Ash Content} = \frac{(\text{Weight of crucible} + \text{Ash}) - \text{Weight of empty crucible} \times 100}{\text{Weight of sample}}$$

Determination of Crude Fiber

The crude fiber was determined according to the method described by AOAC, [19]. 2g of the sample were accurately weighed into flask and 100ml of 0.255 NH_2SO_4 was added. The mixture was heated under reflux for 30 minutes. The hot mixture was filtered through a fibre muslin cloth. The obtained filtrate was thrown off and the residue was returned to the fibre flask which 100ml of 0.313N NaOH was added and heated for another 30 minutes. The residue was removed and finally transferred into the crucible. The crucible and the residue were oven dried at 105^0C overnight to drive off the moisture. The oven dried crucible containing the residue were cooled in a desiccator and later weighed to obtain the W1.The crucible with W1 was transferred to the muffle furnace for ashing at 550^0C for 4 hours. The crucible containing white or grey ash were cooled in the desiccator and weighed to obtain W2.

The difference W1 – W2 gives the weight of fibre

$$\%\text{Fibre} = \frac{(w1 - w2) \times 100}{\text{Weight of sample}}$$

Determination of carbohydrate: Carbohydrate by difference.

FUNCTIONAL PROPERTIES OF SWEET POTATO FLOUR

Determination of Swelling Power and Solubility

This was determined by the method described of Loos et. al. [20].One gram of sample was weighed into a 100ml conical flask, 15ml of distilled water was added and mixed gently at low speed for 5mins.the slurry was heated in a thermostatted water bath (THELCO model 83,USA) AT 40mins. During heating the slurry was stirred gently to prevent lumps forming in the starch. The contents were transferred into pre-weighed centrifuge tubes and 7.5 ml distilled water was added. The tubes containing the paste were centrifuged at 2200 rpm for 20 min using SORVALL GLC – 1 centrifuge (model 06470, USA). The supernatant was decanted immediately after centrifuging into a pre – weighed can and dried at 100OC to constant weight. The weight of the sediment was taken and recorded.

Swelling power =Wt of sediment/ Sample wt-

Determination of Water Absorption Capacity (WAC)

This was determined using the method described by Sosulski [21]. To 1g of the sample was added 15ml of distilled water in a pre-weighed centrifuge tube. The tube with its content was

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agitated on a flask Gallenkamp shaker for 2min and centrifuged at 4000rpm for 20min on a SORVALL GLC-1 centrifuge (Model 06470, USA). The clear supernatant was discarded and the centrifuge tube was weighed with the sediment. The amount of water bound by the sample was determined by difference and expressed as the weight of water bound by 100g dry of flour.

Determination of Bulk Density [22]

10g of samples were weighed into a 50ml graduated measuring cylinder. The sample was packed by gently tapping the cylinder on the bench top for several times until there was no more decrease in volume. The volume of the compacted sample was recorded and the bulk density was calculated as follows.

Calculation:

$$\text{Bulk density (g/mg or g/cm3)} = \frac{\text{Weight of sample}}{\text{Volume of sample after tapping}}$$

DOUGH RHEOLOGICAL TESTING

Farinograph Testing

Farinograph Testing was carried out on control (All-purpose wheat flour) and enriched flour blends (0%, 1%,2%, 3%) with the use of a Brabender - Farinograph®-E [19]. The dough development time (DDT) was time for the dough to reach maximum consistency (peak); stability was 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

Extensograph Testing was carried out on control (All-purpose wheat flour) and enriched flour blends (0%, 1%,2%, 3%) with the use of a Brabender- Extensograph®-E [23]. A Brabender - Farinograph-E was used to mix the dough for 6 minutes after which the dough was subjected to proving at for 45 minutes after which the dough was stretched until rupture in the Extensograph®-E. This procedure was repeated twice after which a graph was plotted showing the exerted force as a function of the stretching length (time). The following parameters were determined from the graph;

1. Water absorption (%).
2. Energy (Area under the curve) (cm3).
3. Resistance to Extenison (BU).
4. Extensibility (mm).
5. Maximum (BU)
6. Ratio number.
7. Ratio number (Max.).

Wet Gluten Determination

A weighed sample (25 g) was transferred into a clean dry mixing bowl and 15 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).

$$\text{Wet Gluten} = \frac{\text{Weight of Gluten}}{\text{Initial Weight of Sample}} \times 100$$

ANALYSIS ON BREAD SAMPLE

Proximate analysis was also carried out on all the bread at 10%, 20%,30% sweet potato bread of blanched and unblanched .

Textural Analysis

Bread Firmness

Bread firmness was measured on freshly baked bread loaves using a TVT-300XP texture analyzer 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.

RESULT AND DISSCUSION

Effect of Blanching and Unblanching On Functional Properties of Sweet Potato Flour

The functional properties of the wheat, blanched and unblanched sweet potato flour are presented in Table 4. There were significant differences in the functional properties ($P \leq 0.05$) of the blanched and unblanched sweet-potato flour

There was a significant difference in the water absorption capacity of the blanched and unblanched sweet potato flour ($P \leq 0.05$). The unblanched sweet-potato flour had the highest value of 241.8%, while blanched sweet-potato flour had the value of 232.2%.Adebowale *et al.*, [24] reported that high water absorption capacity is also attributed to lose structure of starch polymers while low value indicates the compactness of the structure.

The result of bulk density showed that there was no significant difference between blanched and unblanched sweet-potato flour. Sweet potato flour had a higher bulk density compared with the control sample (100% wheat flour) which may be due to the heat treatment adopted during blanching. Bulk density is influenced by the particle size and density of the flour and it is very important in determining the packaging requirement, materials handling and application in wet processing in the food industry [25].

There was significant difference in the swelling power and solubility index of blanched and unblanched sweet-potato flour ($P \leq 0.05$). Swelling power is an indication of the absorption index of the granules during heating [20].

Effect of Blanching and Unblanching On Textural Properties of Sweet-Potato Bread

The textural properties of sweet-potato bread are represented in Table 5.

Bread firmness was expressed as hardness. It was generally observed that increasing levels of substitution of wheat flour with flour from blanched and unblanched sweet-potato flour

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increased the hardness of loaves obtained. However, bread substituted with flour from blanched sweet-potato showed greater hardness than those substituted with flour from unblanched sweet-potato flour.

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 [26],[27]. A significant reduction in loaf volume was observed as the level of substitution with both blanched sweet-potato flour and unblanched sweet-potato flour increased (Table 6).It was observed that addition of sweet potato flour caused an increase in weight of blanched and unblanched sweet-potato bread.

The density of the blanched sweet-potato bread remained unchanged, while there was increase in the density the unblanched sweet-potato bread. The springiness and cohesiveness of the blends were similar, but the bread made from 30% sweet-potato had a lower springiness and cohesiveness.

Effect of Blanching and Unblanching On Dough Rheological Properties of Sweet Potato Bread

Effect of Blanched and Unblanched Sweet-Potato on Farinograph Parameters

The effect of blanching on the rheological properties of sweet potato and wheat flour is summarised in Table 6.

The Farinograph water absorption, dough stability time, dough development time and time to breakdown for wheat flour (control) was 60.4.%, 2.60 min, 1..90 min and 2.9 min respectively (Table 6). In comparism with the control, water absorption increased upon increasing levels of substitution of wheat flour with flour from both blanched and unblanched sweet-potato flour. This increase might be because of the high starch content of sweet-potato flour.

The dough development time decreased as the substitution levels of sweet-potato flour increased.10% blanched sweet-potato had the highest value of development time which was 1.9min.Dough development time depends on the gluten quality, starch granule size and degree of starch damage. This is also the time needed for the flour dough to reach the maximum consistency [17].

The dough consistencies of the flours were within tolerable limits of 491 to 525 BU. Dough Stability is given by the time from when the farinograph trace touches the 500 BU line up to the break time. The dough stability increased as the substitution level of sweet-potato flour increased compared to wheat flour.

Effect of Blanched and Unblanched Sweet-Potato Flour on Extensograph Parameters

The Extensographic parameter of wheat (control) and sweet-potato blend is summarized in Table 7.

It was observed that the energy and extensibility decreased as the substituted levels of both blanched and unblanched sweet-potato flour increased, while on the other hand resistance to extension increased as the level of sweet-potato increased. The lower the extensographic energy, the less resistance and less stable the dough is during its processing .Increase in substitution level of blanched and unblanched sweet-potato flour decreased the extensographic energy. It was observed that the proving time of all the sweet-potato blends was the same with value of 45min.The energy in unblanched sweet-potato was higher than the blanched.

CONCLUSION

The experiment showed that blanching affect the quality characteristics (colour) of sweet potato flour produced. The proximate composition of blanched and unblanched sweet potato flour also changed significantly ($P \leq 0.05$).The fat, protein, ash, and crude fibre content in the blanched sweet potato flour reduced. This could be due to leaching out of nutrient during hot water blanching.

The rheological characteristic of wheat flour substituted with blanched and unblanched sweet potato flour was affected. Water absorption rate increased with increasing level of substitution of wheat flour with blanched and unblanched sweet-potato flour. However, a decrease in development time of substituted flour was observed.

The sensory characteristic of the various bread loaves differed significantly bread sample was significantly different ($P \leq 0.05$). 10% blanched sweet-potato bread had the highest overall acceptability. A discolouration in the bread produced from unblanched sweet potato flour was also observed.

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Appendix

Table 1. Bread Formulation with Blanched Sweet Potato Flour

	ENRICH {%}	PB {g}	WF {g}	Yeast {g}	Fat {g}	Sugar {g}	Salt {g}	Improver {g}	water {g}
WF	0	0	700	7	7	70	7	0.14	385
$WFPB_1$	1	70	630	7	7	70	7	0.14	395
$WFPB_2$	2	140	560	7	7	70	7	0.14	405
$WFPB_3$	3	210	490	7	7	70	7	0.14	415

WF: WHEAT FLOUR
$WFPB_1$: WHEAT FLOUR + 10% BLANCHED POTATO FLOUR
$WFPB_2$: WHEAT FLOUR + 20% BLANCHED POTATO FLOUR
$WFPB_3$: WHEAT FLOUR + 30% BLANCHED POTATO FLOUR

Table 2. Bread Formulation with Unblanched Sweet Potato Flour

	ENRICH {%}	PB {g}	WF {g}	Yeast {g}	Fat {g}	Sugar {g}	Salt {g}	Improver {g}	water {g}
WF	0	0	700	7	7	70	7	0.14	385
$WFPB_1$	1	70	630	7	7	70	7	0.14	395
$WFPB_2$	2	140	560	7	7	70	7	0.14	405
$WFPB_3$	3	210	490	7	7	70	7	0.14	415

WF: WHEAT FLOUR
$WFUB_1$: WHEAT FLOUR + 10% UNBLANCHED POTATO FLOUR
$WFUB_2$: WHEAT FLOUR + 20% UNBLANCHED POTATO FLOUR
$WFUB_3$: WHEAT FLOUR + 30% UNBLANCHED POTATO FLOUR

Table 3.

Parameters	Blanced	Unblanched	wheat
Protien	3.05 ± 0.02^a	3.10 ± 10.01^a	12.82 ± 0.04^b
Moisture	6.07 ± 0.02^b	5.72 ± 0.02^a	12.03 ± 0.01^c
Crude Fibre	0.51 ± 0.01^a	0.61 ± 0.01^b	0.83 ± 0.01^c
Fat	1.34 ± 0.01^a	1.38 ± 0.02^a	2.26 ± 0.03^b
Ash	2.12 ± 0.01^b	2.26 ± 0.01^c	0.94 ± 0.05^a
Carbohydrate	86.92 ± 0.03^b	86.92 ± 0.02^b	71.13 ± 0.09^a

Mean ± standard error

Table 4. Functional Properties on Sweet Potato and Wheat Flour

Parameters	*Blanced*	*Unblanched*	*Wheat*
Swelling Power	6.30±0.03 [a]	6.18±0.02[a]	39.55±0.41[b]
Solubility	22.92±0.03[b]	24.18±0.23[c]	4.59±0.42[a]
Bulk Density	0.72±0.01[ab]	0.76±0.01[b]	0.71±0.01[a]
Water Asorptiion	232.2±0.03[b]	241.7±0.21[c]	171.4±0.01[a]

Mean ± standard error

Table 5. Proximate Analysis on Sweet-Potato Bread

Samples	*Protein (%)*	*Ash (%)*	*Crude fibre*	*Fat (%)*	*Moisture (%)*	*Carbohydrate (%)*
WF	10.01±0.01[f]	1.71±0.02[c]	0.36±0.02[a]	2.01±0.01[a]	32.23±0.04[a]	53.69±0.02[f]
WFPB$_1$	8.52±0.03[d]	1.67±0.09[bc]	0.12±0.01[a]	2.27±0.02[b]	38.29±0.02[d]	49.20±0.12[d]
WFPB$_2$	7.72±0.02[c]	1.46±0.08[a]	0.16±0.03[b]	2.29±0.02[b]	37.88±0.01[b]	50.50±0.06[e]
WFPB$_3$	6.82±0.02[a]	1.54±0.01[b]	0.16±0.01[b]	2.30±0.01[b]	40.32±0.03[e]	48.87±0.01[c]
WFUB$_1$	8.54±0.03[d]	1.68±0.02[bc]	0.16±0.02[b]	2.40±10.01[c]	38.13±0.03[c]	48.31±0.02[b]
WFUB$_2$	8.52±0.02[d]	1.47±0.02[a]	.17±0.01[b]	02.45±0.01[c]	38.22±0.02[d]	49.23±0.05[d]
WFUB$_3$	7.02±0.02[b]	1.57±0.01[ab]	0.18±0.01[b]	2.51±0.02	40.82±0.02[f]	47.92±0.01[a]

Mean ± standard error

LEGEND

WF: WHEAT BREAD

WFPB$_1$: WHEAT FLOUR + 10% BLANCHED POTATO BREAD **WFUB$_1$**: WHEAT FLOUR + 10% UNBLANCHED POTATO BREAD

WFPB$_2$: WHEAT FLOUR + 20% BLANCHED POTATO BREAD **WFUB$_2$**: WHEAT FLOUR +20% UNBLANCHED POTATO BREAD

WFPB$_3$: WHEAT FLOUR +30% BLANCHED POTATO BREAD **WFUB$_3$**: WHEAT FLOUR + 30% UNBLANCHED POTATO BREAD

Table 6. Textural Properties of Sweet Potato Bread

	Weight (g)	*Volume (ml)*	*Specific volume(ml/g)*	*Density (g/ml)*	*Height (mm)*	*Total hardness*	*Springiness*	*Cohesiveness*
WF	303.1	1642.4	5.42	0.18	10.5	338.50	0.88	0.72
WFPB$_1$	307.1	1481.6	4.82	0.21	10.5	534.87	0.85	0.53
WFPB$_2$	309.1	1478.6	4.78	0.21	11.5	670.00	0.87	0.57
WFPB$_3$	312.9	1465.2	4.68	0.21	11.0	1514.50	0.90	0.72
WFUB$_1$	307.8	1696.9	5.51	0.81	10.5	368.00	0.86	0.70
WFUB$_2$	313.7	1389.8	4.43	0.23	10.5	670.00	0.85	0.66
WFUB$_3$	316.3	1164.7	3.68	0.27	11.5	676.00	0.90	0.72

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LEGEND

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$WFPB_2$: WHEAT FLOUR + 20% BLANCHED POTATO BREAD **$WFUB_2$**: WHEAT FLOUR +20% UNBLANCHED POTATO BREAD

$WFPB_3$: WHEAT FLOUR +30% BLANCHED POTATO BREAD **$WFUB_3$**: WHEAT FLOUR + 30% UNBLANCHED POTATO BREAD

Table 7. Farinograph Parameters for Sweet Potato and Wheat Flour Blend

Farinograpy Treatments	WF	$WFPB_1$	$WFPB_2$	$WFPB_3$	$WFUB_1$	$WFUB_2$	$WFUB_3$
Water absorption (500FU)	60.4	61.1	61.0	61.0	59.2	60.5	60.8
Water absorption (14%)	60.3	60.12	59.2	58.3	56.0	57.7	58.2
Water absorption (14%)	1.9	1.9	1.5	1.5	1.7	1.4	1.4
Stability (min)	2.6	2.3	4.7	8.4	2.3	5.6	9.1
Consistency (FU)	515	525	499	498	507	519	491
Tolerance index (MTI)(FU)	56	51	51	17	51	44	34
Time of breakdown	2.9	3.2	2.6	5.3	2.9	2.7	2.6
Farinograph quality number	29	32	26	53	29	27	26
Moisture content	13.9	13.2	12.4	11.2	11.2	12.0	11.0

LEGEND

WF: WHEAT FLOUR

$WFPB_1$: WHEAT FLOUR + 10% BLANCHED POTATO FLOUR **$WFUB_1$**: WHEAT FLOUR + 10% UNBLANCHED POTATO FLOUR

$WFPB_2$: WHEAT FLOUR + 20% BLANCHED POTATO FLOUR **$WFUB_2$**: WHEAT FLOUR +20% UNBLANCHED POTATO FLOUR

$WFPB_3$: WHEAT FLOUR +30% BLANCHED POTATO FLOUR **$WFUB_3$**: WHEAT FLOUR + 30% UNBLANCHED POTATO FLOUR

Table 8; Extensograpy Parameters of Sweet Potato and Wheat Flour Blend

Farinograpy Treatments	*WF*	*$WFPB_1$*	*$WFPB_2$*	*$WFPB_3$*	*$WFUB_1$*	*$WFUB_2$*	*$WFUB_3$*
Water absorption (500FU)	57.5	58.1	58.5	58.5	57.5	57.5	58.2
Proving time (min)	45	45	45	45	45	45	45
Energy (cm^2)	101	77	75	56	94	88	59
Resistance to extension (FU)	472	426	442	556	436	560	500
Extensibility (mm)	158	116	99	95	118	115	81
Maximum (BU)	612	540	613	435	569	587	569
Ratio number	3.9	4.7	6.2	4.6	3.7	5.0	7.0
Ratio number (MAX)	101	77	75	56	96	88	59

LEGEND

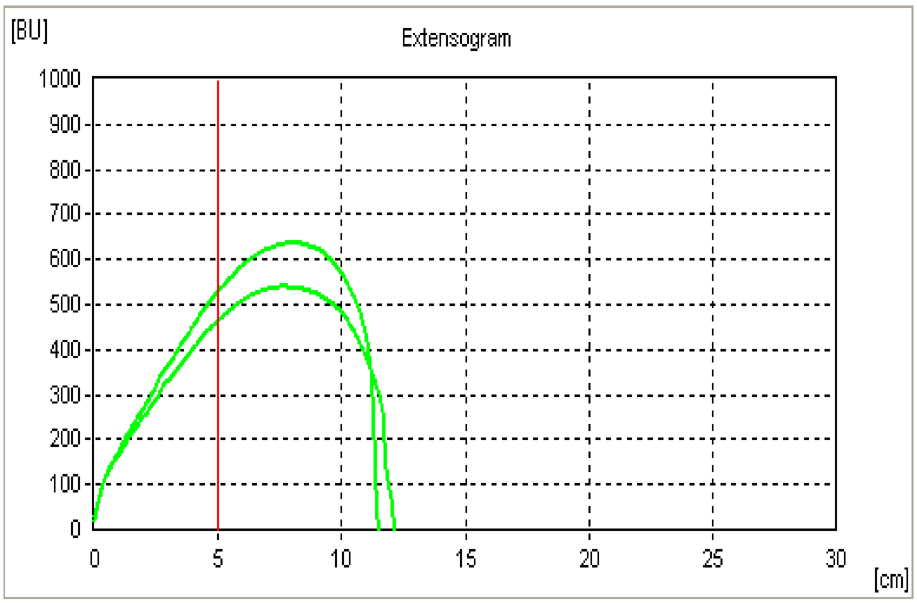
WF: WHEAT FLOUR

WFPB₁: WHEAT FLOUR + 10% BLANCHED POTATO FLOUR **WFUB₁**: WHEAT FLOUR + 10% UNBLANCHED POTATO FLOUR

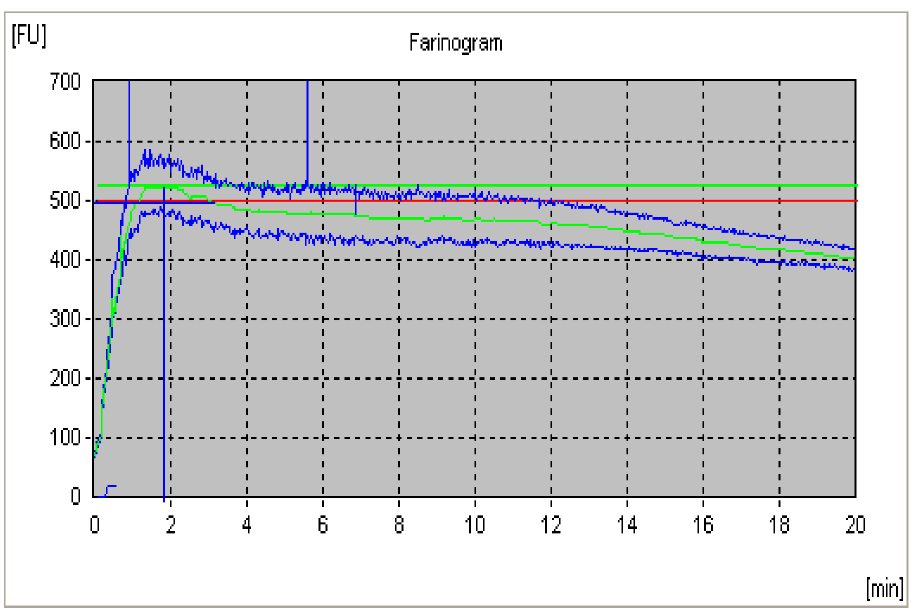
WFPB₂: WHEAT FLOUR + 20% BLANCHED POTATO FLOUR **WFUB₂**: WHEAT FLOUR +20% UNBLANCHED POTATO FLOUR

WFPB₃: WHEAT FLOUR +30% BLANCHED POTATO FLOUR **WFUB₃**: WHEAT FLOUR + 30% UNBLANCHED POTATO FLOUR

WHEAT+10% BLANCHED SWEET-POTATO FLOUR



WHEAT+20% BLANCHED SWEET-POTATO FLOUR



G(1). Farinograph Determination of Wheat Bread and blanched sweet-potato bread

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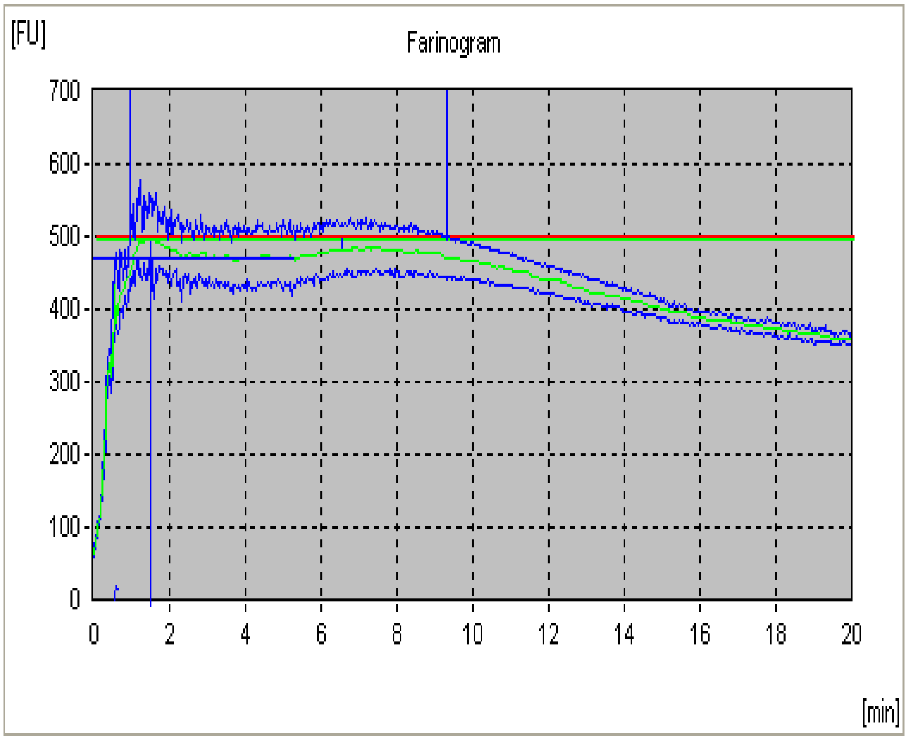
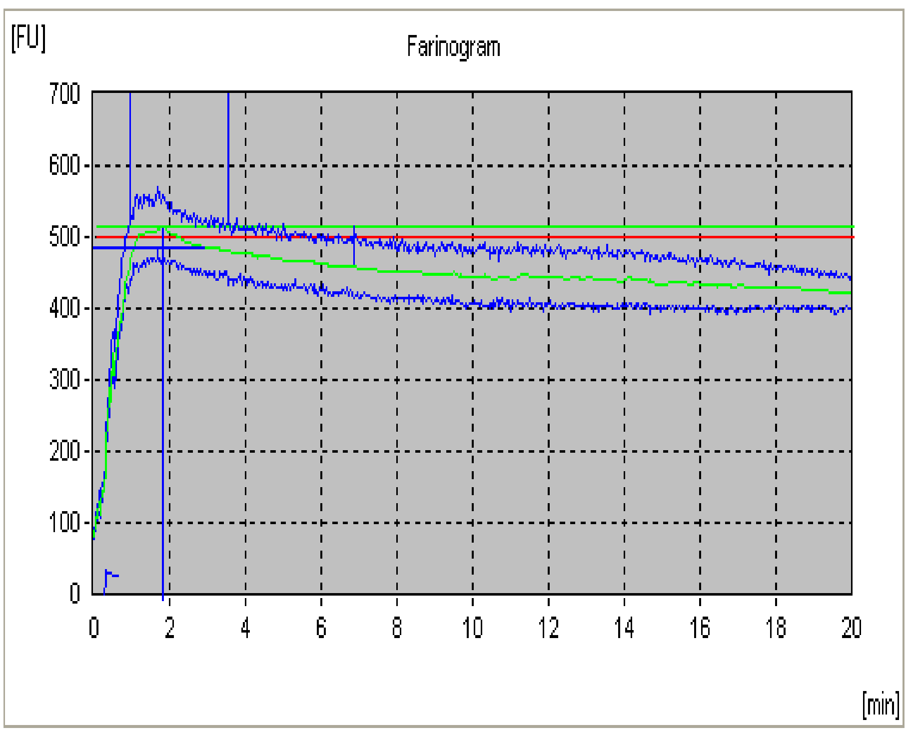
WHEAT+30%BLANCHED SWEET-POTATO

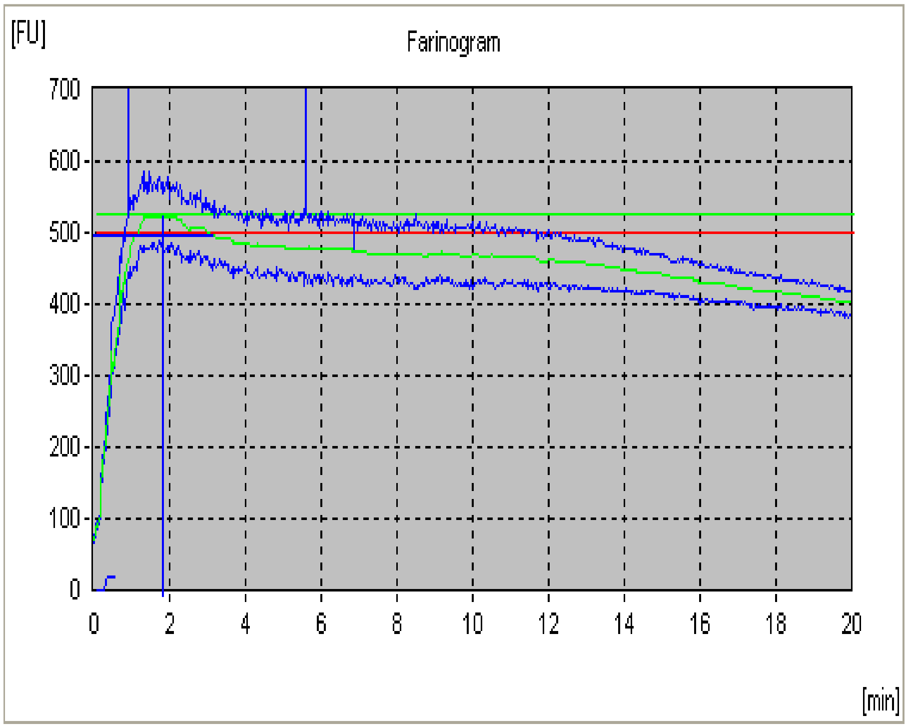


100% WHEAT

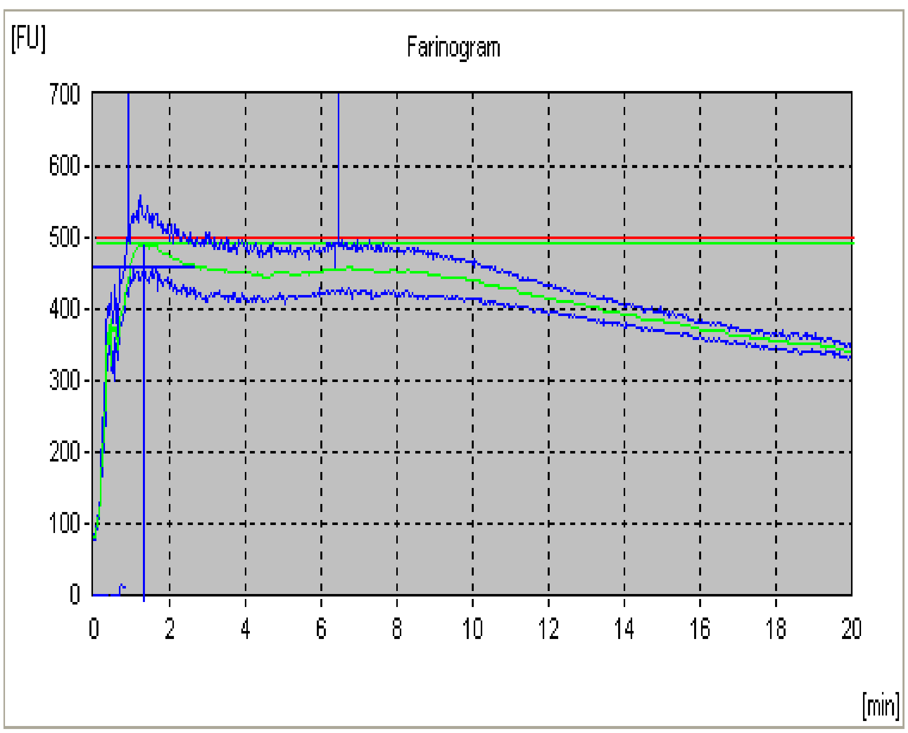


G (2). Farinograph Determination of Wheat Bread and blanched sweet-potato bread

WHEAT+10% BLANCHED SWEET-POTATO FLOUR



WHEAT+20% BLANCHED SWEET-POTATO FLOUR



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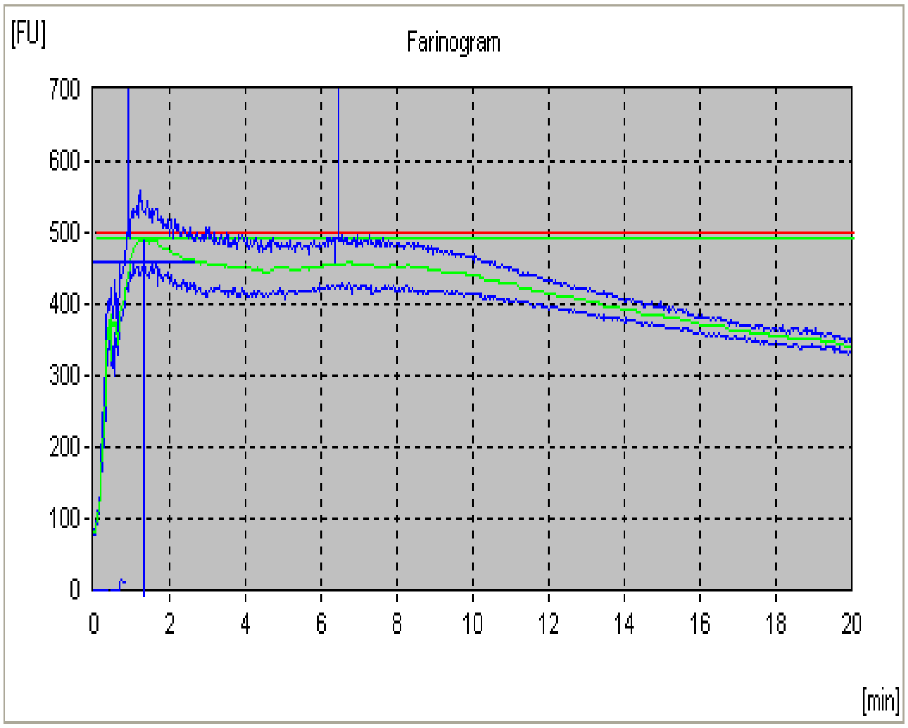
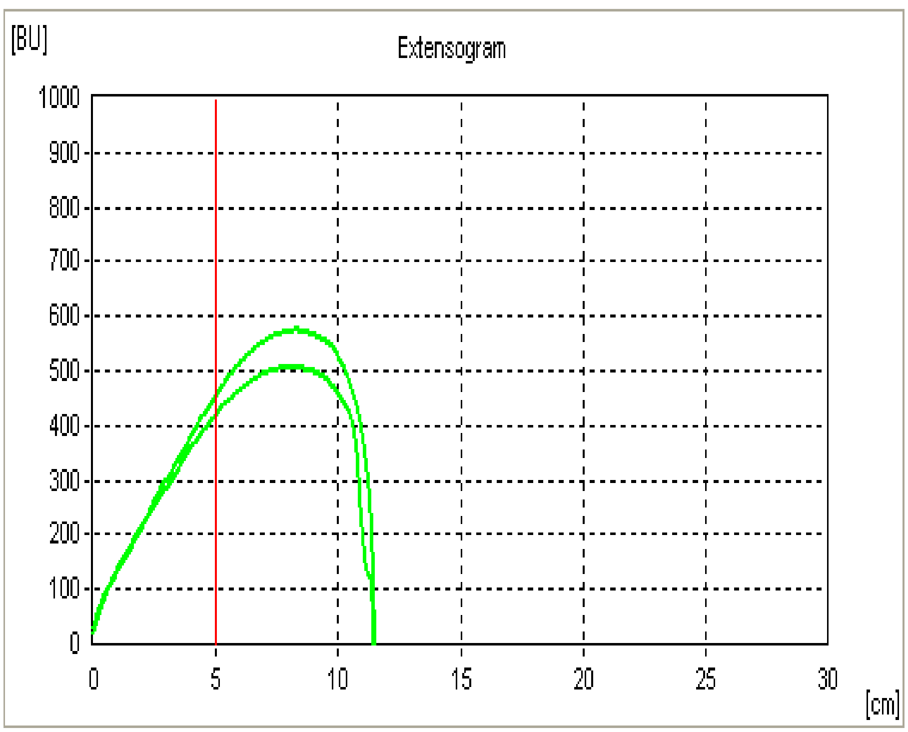
WHEAT+30% UNBLANCHED

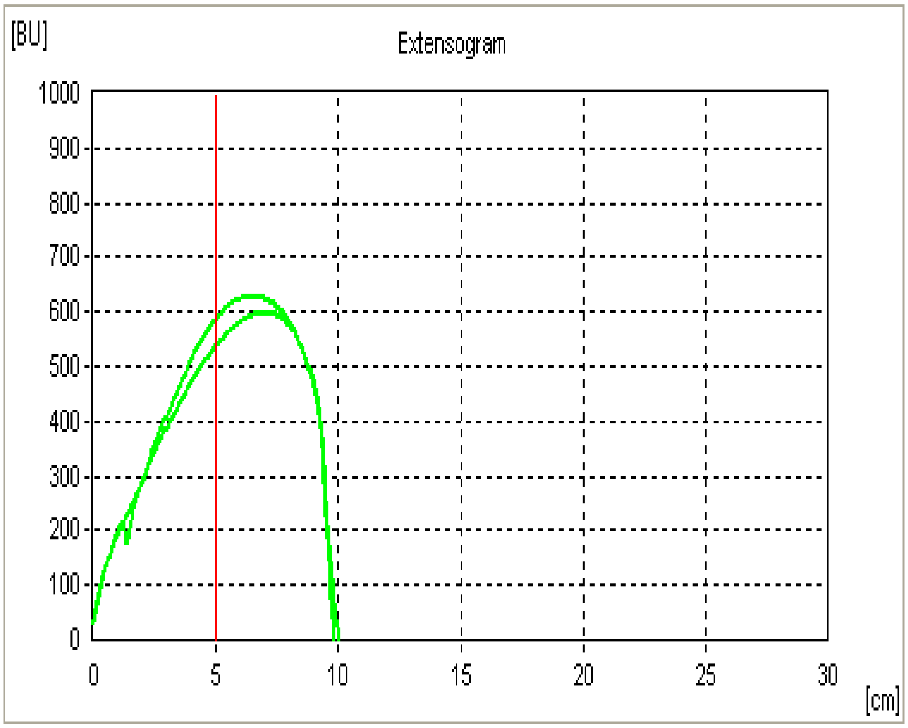


H(1). Extensograph Determination of Wheat and blanched sweet-potato bread

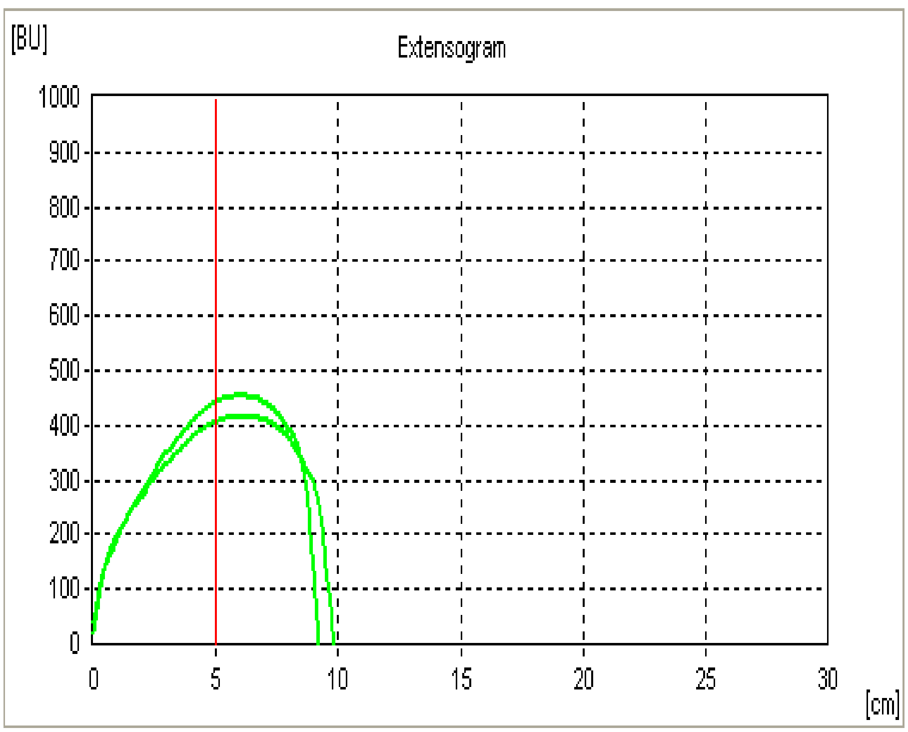
WHEAT+10% BLANCHED SWEET-POTATO FLOUR



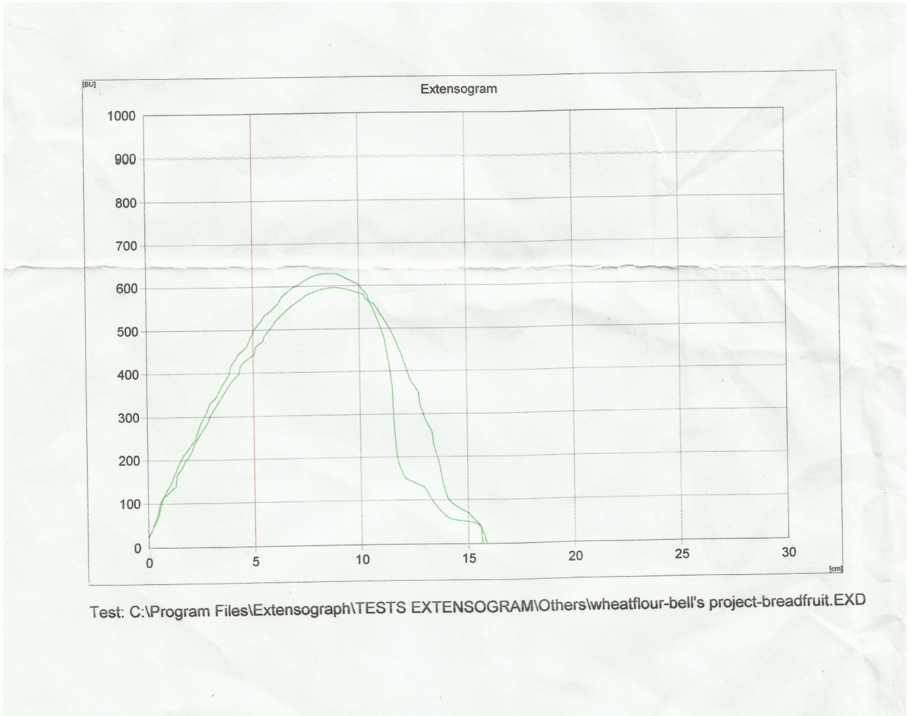
WHEAT+20% BLANCHED SWEET-POTATO FLOUR



30% BLANCHED SWEET-POTATO BREAD

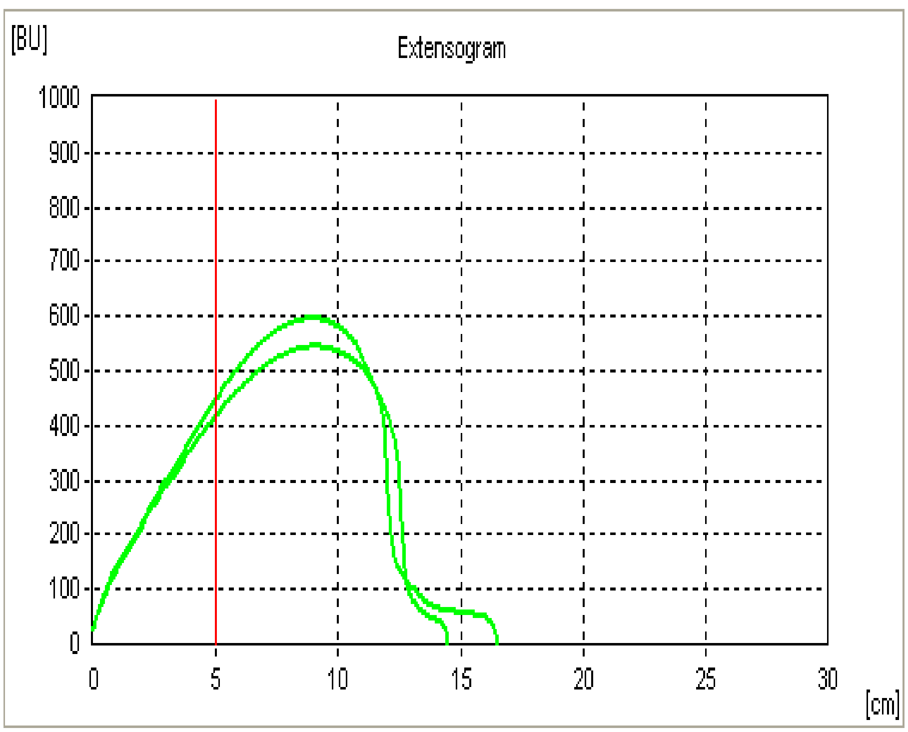


100% WHEAT BREAD

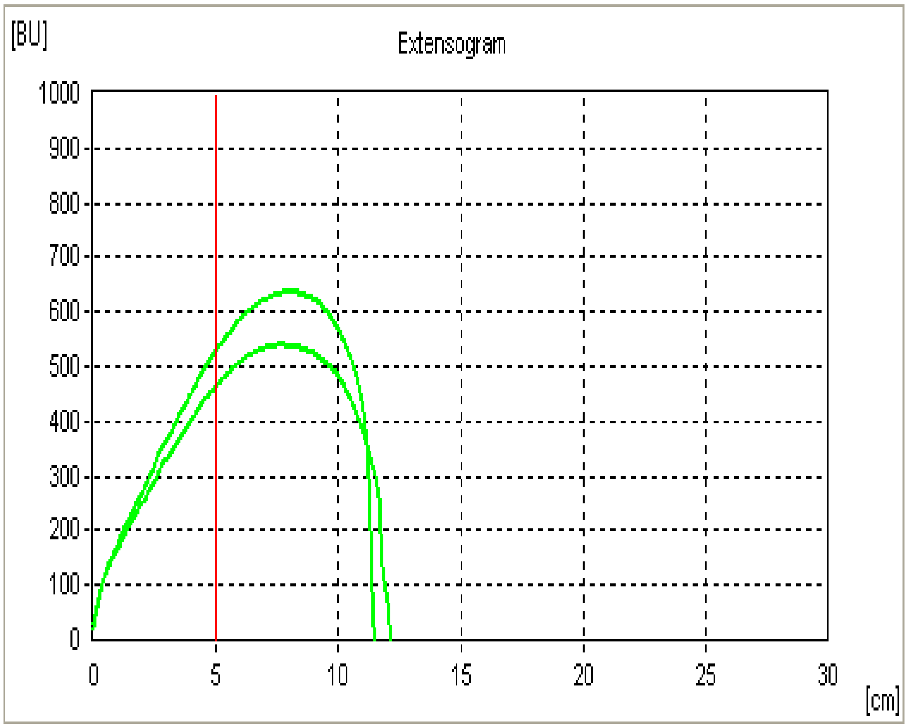


H(1). Extensograph Determination of Wheat and unblanched sweet-potato bread

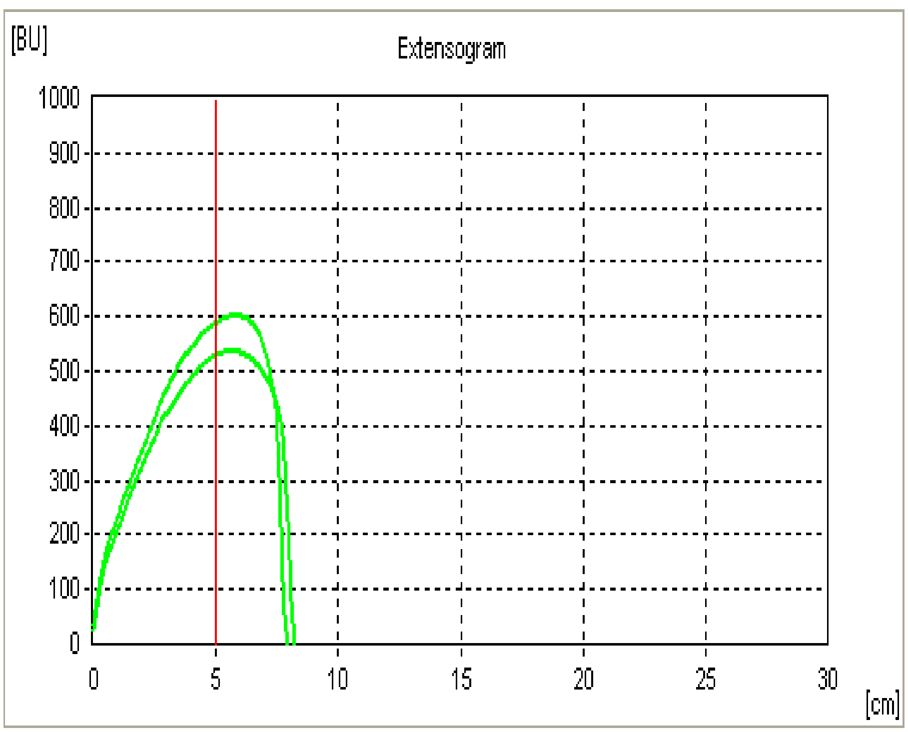
WHEAT+10% UNBLANCHED SWEET-POTATO BREAD



WHEAT+20% SWEET-POTATO BREAD



WHEAT+30% UNBLANCHED SWEET-POTATO BREAD



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I(1). Physical Appearance of sweet-potato bread

(2). Blanched Sweet Potato Bread

Unblanched Sweet-Potato Bread