

PRODUCTION OF FLOUR TYPES FROM BLACK BEAN (*PHASEOLUS VULGARIS*) AND EFFECT OF PH AND TEMPERATURE ON FUNCTIONAL PHYSICO-CHEMICAL PROPERTIES OF THE FLOURS

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ABSTRACT: *The Black bean (Phaseolus vulgaris) seeds were processed into full fat flour, defatted flour, protein concentrate and protein isolate. The physico-chemical and functional properties of some of the flour samples were investigated. The effects of pH and temperature on some functional properties of the samples were also examined. The protein content of the concentrate and isolate had a higher value of 47.50% and 78.01% respectively compared with full fat and defatted flour that had $22.70 \pm 0.00\%$ and $24.51 \pm 0.01\%$ respectively. The protein concentrate and isolate have no fat and fibre content. The protein, carbohydrate, moisture, fat and fibre content had significant difference on different flour samples at $p < 0.05$. The water absorption capacity had significant difference on the defatted and full fat flour at $p < 0.05$. The effect of temperature on the water absorption of the flours increased with increasing temperature. There is decrease in wettability with increase in temperature as well foaming capacity which increased with increasing temperature. The effect of pH had higher wettability and foaming capacity. pH lowered water absorption and swelling index of the defatted and full fat flour. The black bean flour had good functional properties and thereby can be used in the food system.*

KEYWORDS: Black bean, flour, protein isolate, physico - chemical, protein concentrate, functionality

INTRODUCTION

Legumes are the edible seeds of leguminous plants. Those used as food are divided into two groups, namely: the pulse and oil seed (Ihekoronye and Ngoddy, 1985). Leguminous plants play an important role in human nutrition. They provide a significant amount of food in developing countries. They, along with cereals, roots and vegetables constitute the staple foods that are consumed (Okaka *et al*, 2002). Studies have shown that foods of plant origin are capable of contributing appreciable quantities of nutrients including protein, needed by both children and adults if properly processed and blended (Okaka *et al*, 2002). Leguminous seeds are important sources of protein energy and other nutrients in the diet of large population groups around the world forming an excellent source of thiamine and contributing appreciable quantities of the other water soluble vitamins (riboflavin, niacin and pyridoxine) and of the minerals (phosphorus, iron, calcium and magnesium) (Ramcharan and Walker, 1985). Legumes have been underutilized because of the presence of anti-nutritional factors such as enzymes (trypsin, chymotrypsin, &-amylase) inhibitors, phytic acid, flatulence factors, saponins and toxic factors are the need for prolong cooking. These factors negatively affect the

nutritive value of beans through direct and indirect reactions, they inhibit protein and carbohydrate digestibility, induce pathological changes, inhibit a number of enzymes and bind nutrients making them unavailable (Bressani, 1993). Black beans (*Phaseolus vulgaris*) are one of the least exploited legumes in Nigeria despite its level of protein and common minerals such as phosphorous and iron (Enwere 1998). This low consumption of black bean has been attributed partly to its high content of anti-nutritional factors and hard-to-cook phenomenon which requires longtime of cooking for it to be safe and soft enough for consumption (El-Tabey Shebata 1992, Lyimo *et al*, 1992). Black beans, like most common legumes are consumed in different forms and used for the preparation of various diets in Nigeria. One very form of consumption of legumes is steamed paste gel of the legume ("Moinmoin"), which is prepared from the aqueous suspension of the milled legume after dehulling, either manually, or mechanically (McWatters 1983, Ehiwe and Reichart 1987).

Protein deficiency is the prevalent form of malnutrition in the countries. One of the ways is to increase the protein supply to make plant protein available for human consumption and develop the production of unconventional protein for foods. The constantly rising cost of conventional protein foods, particularly animal protein will be increasing exploited in developing countries. This search for nutritional balanced foods to make available to substantial proportion of the population has stimulated investigation into unusual sources of protein. Indeed, protein isolate and protein concentrate have been extensively studied as food and dietary supplements for several oil seeds such as sesame, soybean, and castor seed even wheat plantain composite flour. Many protein occur in cell conjugated with lipid, carbohydrate and other molecules, but only those conjugated proteins which are not really dissociated are isolated intact (Meyer, 1982) but with much difficulty without alteration of the molecules. The easiest method of separating protein from cellular structure of the seed is by extracting with aqueous solvent (Nielson, 2002) for successful utilization of food products, however the protein should possess a high degree of functionality which is governed by four major factors; color, flavor, texture and nutritive value.

There is little or no information on the chemical composition of Black bean and functionality of protein isolate and concentrate.

This study was therefore undertaken to provide information on the proximate composition of full fat, defatted flour, protein concentrate and isolate including the effect of pH and temperature on some of the functional properties of flour from the seeds of Black bean grown in Nigeria.

MATERIALS AND METHOD

Source of Materials

Black bean seeds used in the project work were obtained from Mbaise Local Government Area Imo State, Nigeria. Laboratory and other facilities used in the practical were sourced from central laboratory service unit of Food Science and Technology, F.U.T.O., Imo state.

Equipment

Equipment and instrument used in this study included the Sartorius digital weighing balance, cobalite oven, excello kjeldahl apparatus, soxhlet apparatus gallen camp electric muffle furnace, colab fume cupboard, electric water bath, colab electric centrifuge, Authur Thomas

laboratory mill, general laboratory glass wares, pH meter, thermometer and retort stand, stop watch etc.

Chemicals and Reagents

The chemicals and reagents used in the project were of analytical grade (Analar) and they include hydrochloric acid, ethanol, sodium hydroxide, sodium chloride, selenium crystals, methyl red, boric acid, bromo cresol green, sulphuric acid hexane, oil etc.

Sample Preparation

Prior to isolation of protein, Black bean seeds were processed. The method described by Okezie and Bello (1988) was employed. First, the bean seeds were sorted manually to remove extraneous materials like dirt, residue, shriveled and diseased seeds. The healthy wants were used.

Production of Full Fat Black Bean Flour

In the production of full fat black bean flour, dry seeds were soaked for 2hours in water at 1:5(w/v) ratios. After 2hours, the seeds were manually dehulled to separate the seeds coats from the cotyledon, the dehulled seeds were dried in the oven at temperature of 60⁰C for 8hours before they were ground with an attrition mill. The sample was sieved through a 0.5mm sieve to obtain flour sample for analysis.

Production of Defatted Black Bean Flour

The full fat flour sample was used in a muslin cloth and soaked in a solvent (hexane) at 1:5(w/v) ratio and allowed to stand overnight at room temperature. The next day the mixture was removed and untied for air drying. The defatted flour was air dried for 1hour and pulverized in a motor which was later used for analysis.

Protein Concentrate Determination

The protein concentrate determination was done following the method described by (Mune *et al*, 2013). Ten grams of the defatted sample was mixed with 100ml of NaCl solution (0.15m) and stirred at 35⁰C for 120 minutes. The pH was adjusted to 9 with 1N NaOH, and was further stirred for 30 minutes. The slurry was centrifuged at 2000rpm for 30mins using a centrifuge. The supernatants were treated with 95% (v/v) ethanol and the pH was adjusted to 4.5 using 1N HCl under stirring and the precipitated proteins were recovered by filtration. The protein concentrate was dried at 50⁰C for 48hours in an air convection oven.

Preparation of Protein Isolate of Black Beans Flour

One hundred grams of the defatted sample flour was suspended in 150ml of distilled water. The pH of the suspension was adjusted to 9 with 1N NaOH. The materials were stirred for 1hour by using a high speed stirrer and then centrifuge at 1000rpm for 20mins. The protein in extract was precipitated at pH 4.0 using 1N HCl. The precipitate was washed with distilled water and readjusted to pH 7.0 with 1N NaOH and dried in an oven at 55⁰C (Nath and Narasinga, 1981).

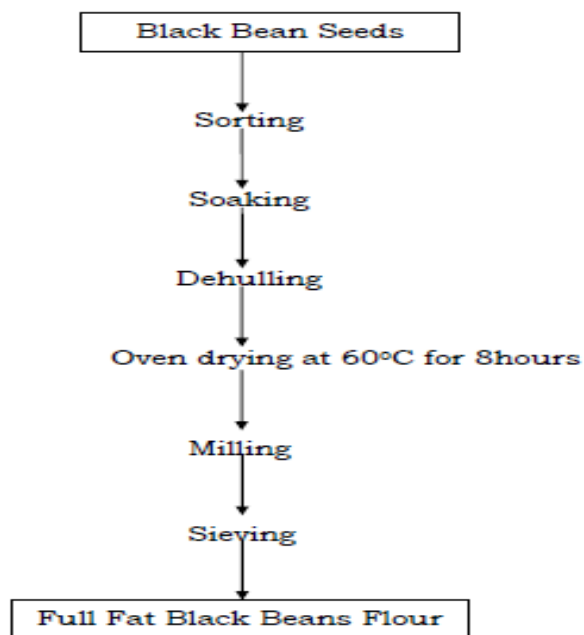


Fig. 1 Flow diagram for the production of dehulled full fat black beans flour

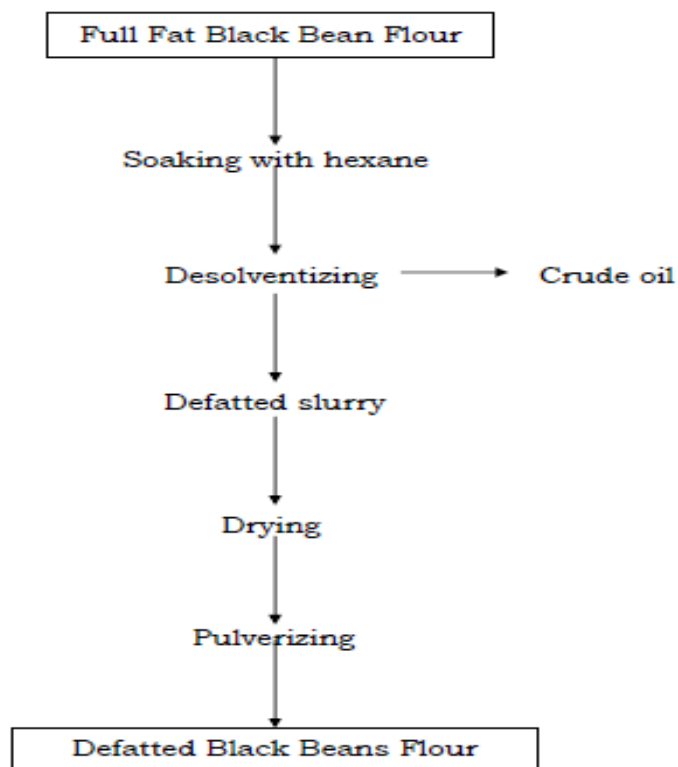


Fig. 2 Flow diagram for the production of defatted black beans flour

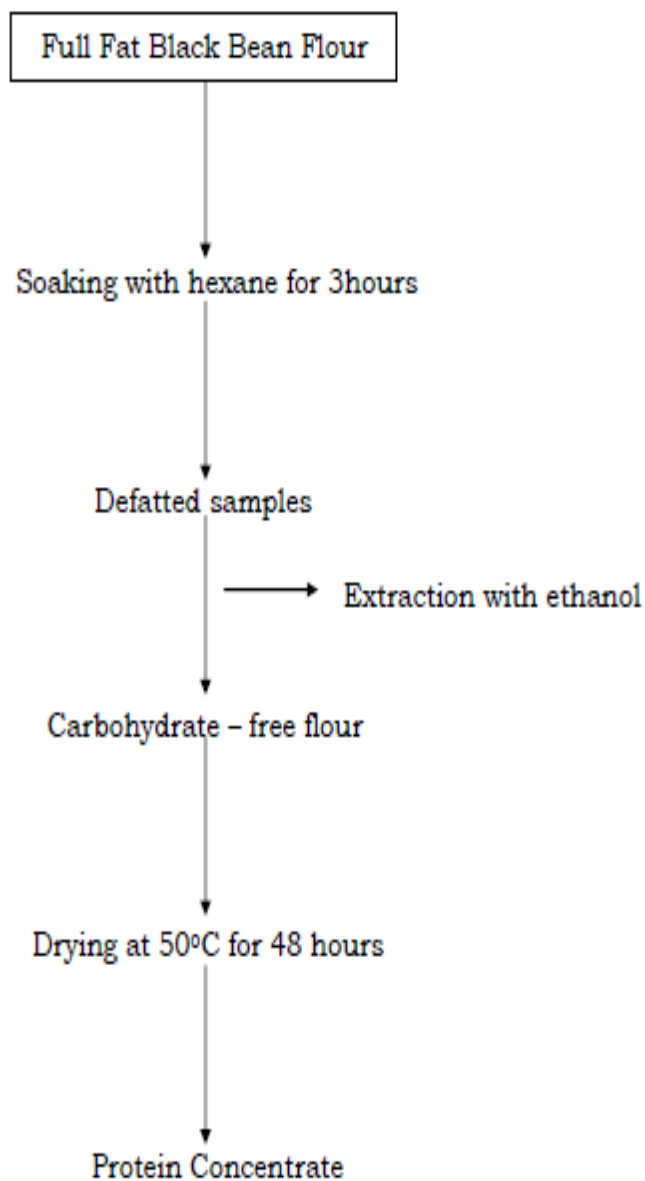


Fig. 3: Flow diagram for the production of protein concentrate from defatted Black beans flour.

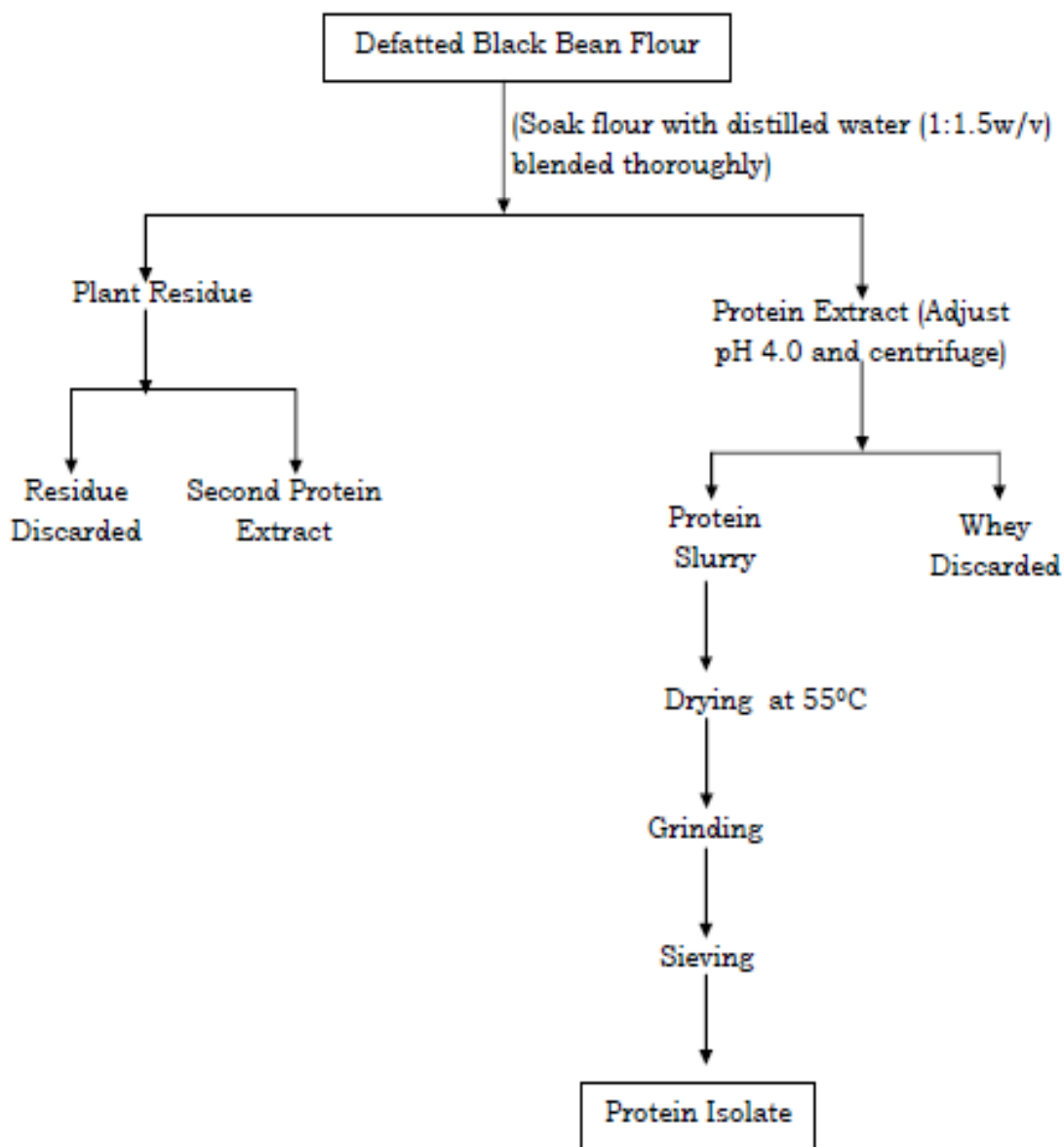


Fig. 4 Flow diagram for the production of isolated protein from defatted Black bean flour

METHODS

Seed Characteristics

The characteristics were determined following the procedure of Fashakin and Fasanya (1988). The raw seeds were randomly selected and then examined by subjective methods for shape, testa texture, seed colour, eye colour and testa attachment to the cotyledon. The degree of attachment was described as smooth or rough depending on how the seeds appear to the eye.

Seed Weight

Weight of 100 seeds randomly selected was determined by weighing (AOAC, 1984). The average seed weight was evaluated.

Seed Size

The size of the seed was dimensionally characterized by measuring each of ten randomly picked seeds for their length (L), width (W) and thickness (T) in mm using a vernier caliper of about 0.01mm precision (Zibokere 1994). The average seed size was calculated.

Proximate Composition

The procedure for the chemical analysis for the moisture, crude protein, ash, crude fibre, carbohydrate and fat contents were outlined by the Association of Official Analytical Chemists (AOAC 1990). The analyses were carried out in both full fat, defatted protein concentrate and protein isolate from black beans seeds and result obtained in triplicates.

Determination of Moisture Content

The gravimetric method as described by (AOAC, 1990) was used to measure the weight of the samples. Two grams of the samples was weighed into a previously weighed cleaned moisture can. The samples in the can were dried in the oven at 105°C for 3hours. It was cooled in a desiccator and weighed. It was returned to the oven for further drying. Drying, cooling and weighing were done at every 30minutes interval until there was constant weight of the samples. The weight of moisture loss was calculated and expressed as a percentage of the weight of samples analyzed. It was given by the expression below;

$$\% \text{ Moisture Content} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

Where W1 = weight of empty moisture can

W2 = weight of moisture can + sample before drying

W3 = weight of can + sample dried to a constant weight

Determination of Protein

The micro kjeldah method described by (AOAC, 2006) was used. Two grams of the sample was mixed with 10mls of concentrated sulphuric acid in a digestion flask. One gram of copper sulphate and ten grams of sodium sulphate was added into the flask and mixture heated inside a fume cupboard. The digest was transferred into a distillation flask and made up with 200ml of distilled water and mixed with 45% of NaOH solution. The mixture was distilled and the distillate collected into 4% boric acid.

$$\% \text{ Protein} = \% \text{ Nitrogen} \times 6.25$$

$$\% \text{ N} = \left[\frac{(100/w) \times (N \times 14 / 1000) \times V_t / V_a}{T-B} \right] \times 100$$

N = Normality of titrant (0.02N.H₂SO₄)

W = Weight of the samples (1g)

V_t = Total digest volume (100m/s)

V_a = Volume of digest analyzed (10m/s)

B = Blank

T = Sample tire value

Ash Determination

This was done by the furnace incineration gravimetric method (James, 1995; AOAC, 1984). Two grams of the processed samples was measured into a previously weighed porcelain crucible. The sample was burnt to ashes in the muffle furnace at 550°C for 5 hours. When it has become completely ashes, it was cooled in the desiccator and weighed. The weight of ash obtained was calculated by difference and expressed as a percentage of the weight of sample analyzed as shown below

$$\% \text{ Ash} = \frac{W_3 - W_1}{W_2 - W_1} \times \frac{100}{1}$$

Where W1 = weight of empty crucible

W2 = weight of crucible + food before drying and/or ashing

W3 = final weight of crucible + ash

Determination of Crude Fibre

The Weende method (James, 1995) was employed. 2g of the processed sample was boiled in 150ml of 1.25% H₂SO₄ solution for 30 minutes under reflux. The boiled samples were washed in several portions of hot water using two fold muslin cloth to trap the particles. It was returned to the flask and boiled again in 150ml of 1.25% NaOH for another 30 minutes under some conditions. After washing in several portions of hot water, the samples were allowed to drain dry before being transferred quantitatively to a weighed crucible where it was dried in the oven at 105°C to a constant weight. It was then taken to a muffle furnace in which it was burnt until only ash was left in it. By difference, the weight of the fibre was obtained and expressed as a percentage of the weight of sample analyzed. It was given by the formula below;

$$\% \text{ crude fibre} = \frac{100 (W_2 - W_3)}{\text{Weight of samples}}$$

Where W2 = Weight of crucible + sample after boiling, washing and drying

W3 = Weight of crucible + sample ash

Fat Determination

The solvent extraction gravimetric method (Kirk and Sawyer, 1980) was used. Two grams of the sample was wrapped in a porous paper (Whatman filter paper) and put in a thimble. The thimble was placed in a Soxhlet reflux flask and mounted into a weighed extraction flask containing 200ml of hexane. The upper end of the reflux was connected to a water condenser. The solvent (hexane) was heated, boiled, vaporized and condensed into the flask. Soon the sample in the thimble was covered with the solvent until the reflux flask filled up the siphoned over, carrying its oil extract down to the boiling flask. This process was allowed to run repeatedly for 4 hours before defatted sample was removed, the solvent recovered and the oil extract was left in the flask. The flask (containing the oil extract) was dried in the oven at 60°C for 30 minutes to remove any residual solvent. It was cooled in a desiccator and weighed. By difference, the weight oil/fat was determined and expressed as a percentage of the weight sample analyzed and given by the expression below;

$$\% Fat = \left[\frac{(W_2 - W_1)}{(\text{Weight of samples})} \times \frac{100}{1} \right]$$

Where W1 = Weight of empty extraction flask

W2 = Weight of flask + oil extract

Determination of Carbohydrate

Carbohydrate content was by difference. It was calculated using the formula below as described by (AOAC, 1990) and (James, 1995).

% Carbohydrate = 100 -% (moisture + crude protein + crude fat + crude fibre + ash).

Functional Properties of Flour Samples

The functional properties of Black bean flour samples were determined using the method specified by (Okaka and Potter, 1997), Okezie and Bello (1988) and Narranyana and Rao (1982).

Bulk Density

The method of Okaka and Potter (1997) was used. 2 grams of flour sample was measured into a calibrated measuring cylinder. The bottom of the cylinder was tapped repeatedly on a pad placed on a laboratory bench. Tapping was done until there was no further reduction in the volume occupied by the sample. The bulk density was determined as the ratio of the weight of the sample to its volume calculated as shown below;

$$\text{Bulk density} = \frac{W}{V}$$

Where W = weight of sample in gram

V = volume of sample in cubic centimeter.

3.6.2 Swelling Index

Swelling index was calculated using the method of Ukpabi and Ndinele (1990). 1 gram of the processed sample was weighed and dispersed into a test cube, leveled and the height noted. Distilled water (10m/s) was added and allowed to stand for 1hour. The height was then recorded and the swelling index calculated as the ratio of the height to the initial height

$$\text{Swelling index} = \frac{H_2}{H_1}$$

Where H2 = Final height

H1 = Initial height

Water Absorption Capacity

This is determined as the weight of water absorbed and held by 1 gram of the sample (Okaka and Potter, 1997). One gram of the sample was weighed and put into a test tube. 10m/s of distilled water was added to the sample and mixed well. The mixture was allowed to stand for 30minutes at room temperature. The mixture was centrifuged at 3500rpm for 30 minutes. The supernatant was decanted and measured. Therefore;

$$WAC = V_1 - V_2$$

Where WAC = water absorption capacity

V1 = Initial volume of distilled water

V2 = Final volume of distilled water

Oil Absorption Capacity

This was determined in the same way as water absorption capacity. However, a refined vegetable oil was used in place of water and the time allowed for absorption was longer (1hour at room temperature as against 30minutes for water). The oil absorption capacity was determined by difference, as the volume of oil absorbed and holds by 1 gram of the samples as shown below; Oil absorption capacity = (initial volume of oil) – (final volume of oil).

Gelation Capacity

Five grams of sample was weighed into a beaker with 20m/s of water and heated until gelling point. The temperature at which it gels was measured using a thermometer.

Emulsion Capacity

The method used was done by the method described by Okezie and Bello (1988). One gram of sample was mixed with 10m/s of distilled water in a test tube and shake for 30 seconds. 10m/s of refined oil was added and shake continuously until properly mixed. The test tube was left to stand for 30 minutes. The height of oil separated from the sample was measured. The emulsion capacity was expressed as the amount of oil emulsified and held per gram of the sample. It is shown below;

$$Emulsion\ Capacity = \frac{Emulsion\ height}{Water\ height} \times 100$$

Foaming Capacity

The method of Narranyana and Rao (1982) was used. One gram of sample was mixed with 10m/s of distilled water and blended for 5minutes. After the resulting mixture, the height of foam was recorded after 30 seconds. The foaming capacity was expressed as a percentage of foam produced after whipping. It is calculated as;

$$Foaming\ Capacity = \frac{(V_a - V_b)}{V_b} \times \frac{100}{1}$$

Where; V_a = height after whipping

V_b = height before whipping

Wettability

This was determined as the time (in seconds) taken by a unit weight (1g) of the flour sample to get completely wet on the sample of water under laboratory condition. The method used was described by Okezie and Bello (1988). About 500m/s of water was measured into a clean glass

beaker (600ml capacity). With the aid of retort stand, it was arranged such that a clean test tube was clamped in an inverted position over the water in the beaker. The clamped position was adjusted such that the distance from the mouth of the test tube to the surface of water in the beaker was exactly 10cm. Both the water in the beaker and the clamped position were marked with masking tape. Subsequently, one gram of the sample was weighed into the marked test tube and its mouth covered with a thumb. It was carefully inverted over the water and clamped with the retort stand at the marked spot without removing the thumb. With the stop water set to read, the thumb was removed and the sample allowed to fall into the water surface as the stop watch was put simultaneously. The flour samples were observed and the stop watch stopped as the last few sample got wet. This experiment was repeated three times sample and the mean values taken.

Statistical Analysis

Experimental data were analyzed using Analysis of Variance (ANOVA) and Duncan's multiple range test were used to determine significantly different means.

RESULT AND DISCUSSIONS

Physical Properties

The results of physical properties of the Black bean were presented in Table 1. The seeds were all black in colour and cream eye colour. The black beans seeds in the testa texture had a smooth testa and were firmly attached to the cotyledons. The average seed weight was 0.21 ± 0.01 g and the values correspond to the range of 0.13 to 0.22g reported by Marcone *et al.*, (1990). The length of the seed is 0.8961 ± 0.05 cm, width is 0.5461 ± 0.05 cm and the thickness is 0.3873 ± 0.04 cm. The result was also in agreement with the report of Maria *et al.*, (2000) who reported the length range of 6.7 to 11.2mm and width of 5.3 to 8.2mm for African Yam Bean seeds.

Table 1: Physical properties of Black bean seed

Average seed weight	Seed colour	Testa Characteristics	Testa attachment cotyledon	Eye colour	Average seed size Length x Width x Thickness (cm)
0.21±0.01g	Black	Smooth	Firm	Cream	0.8961x0.5461x0.3873



Plate 1: Undehulled Black Bean



Plate 2: Dehulled Black Bean

Proximate Composition

The proximate composition of the test samples are shown in the Table 2 below. The result revealed a high protein content of $22.70 \pm 0.00\%$ of the seed flour (full fat). This result is in agreement with the value obtained by peer researchers. However, the black protein concentrate and isolate had an average protein content of $47.50 \pm 0.016\%$ and $78.01 \pm 0.008\%$ respectively. This was compared with 81-91% for winged bean and 96.5% for soybean (Okezie and Bello, 1988). The protein isolates exhibit maximum protein content which differs significantly ($P < 0.05$) from that of full fat ($22.70 \pm 0.00\%$) which was high compared with defatted flour sample (24.51 ± 0.02). The high protein content of protein isolate and that of concentrate were as a result of the production process which increases the composition of protein in the finished product. The proteins are polymer and amino acids and their relative proportion represents its quality that is dependent on the genetic makeup of legume. The variation in protein contents are attributed to genetic makeup of legumes along with some environmental factors (Kaur, Singh 2007). Fat content ranged from 0.00 to 9.4%. The full fat flour was noted to be the highest amount due to the processing method used. The crude fibre data shows that defatting

significantly ($P < 0.05$) decreased the crude fibre content from $5.5 \pm 0.408\%$ (for full fat flour) to $4.5763 \pm 0.5\%$ (for defatted flour). There was no crude fibre and fat content for protein concentrate and isolate due to the processing method where other nutrients were removed. Results for ash content demonstrated significantly higher amount ($7.0 \pm 0.016\%$) in the protein concentrate while that of protein isolate, full fat and defatted flour are $4.00 \pm 0.1\%$, $4.50 \pm 1.633\%$ and $4.98 \pm 2.03\%$ respectively are statistically not different at $P = 0.05$ from each other. The values for moisture content in full fat flour ($3.50 \pm 0.408\%$), defatted flour ($4.83 \pm 1.841\%$) and protein isolate ($5.01 \pm 0.025\%$) were statistically equal at $p = 0.05$ level. The carbohydrate content of both flours (full fat, $56.3075 \pm 0.8226\%$) and defatted $61.7175 \pm 2.3046\%$) were statistically different at $P < 0.05$. Production of protein concentrate and isolate significantly ($P < 0.05$) reduced the carbohydrate content to $35.56 \pm 0.0531\%$ and $13.57 \pm 0.4736\%$.

Table 2: Proximate Composition of Black bean flour, defatted flour, protein concentrate and protein isolate

Samples	Protein	Fat	Fibre	Ash	Moisture	Carbohydrate
Full fat	22.70 ^d	9.4 ^a	5.5 ^a	4.5 ^a	3.50 ^b	56.3075 ^b
Flour	± 0.00	± 0.082	± 0.408	± 1.633	± 0.408	± 0.8226
Defatted	24.51 ^c	1.575 ^b	4.5763 ^a	4.98 ^a	4.83 ^b	61.7175 ^a
Flour	± 0.02	± 0.06	± 0.2936	± 2.033	± 1.841	± 2.3046
Protein	47.50 ^b	0.00 ^c	0.00 ^b	7.0 ^a	10.01 ^a	35.565 ^c
Concentrate	± 0.016	± 0.00	± 0.00	± 0.016	± 0.025	± 0.0531
Protein	78.01 ^a	0.00 ^c	0.00 ^b	4.00 ^a	5.01 ^b	13.57 ^d
Isolate	± 0.0082	± 0.00	± 0.00	± 0.016	± 0.025	± 0.4736

All values are expressed as mean \pm SD of the determinations.

Mean values within column with different superscripts are significantly different at $P < 0.05$.

Functional Properties

The functional properties studied for full fat and defatted flour are shown in table 3. The result showed relatively high bulk density. The bulk density of the full fat flour indicated a high volume of per gram of the protein material. The full fat flour was reported to have a bulk density of $0.6635 \pm 0.03\text{g/ml}$ and that of defatted flour was $0.6441 \pm 0.0673\text{g/ml}$. The water absorption capacity was 3.00mls/g for the full fat and 3.20mls/g for the defatted flour samples. The samples were statistically significant different ($P < 0.05$). This may be due to increased proportion of proteins. Water absorption characteristics represent the ability of the product to associate with water under conditions where water is limiting (Dough and Pastes). The oil absorption capacities are $1.5785 \pm 0.149\text{mls/g}$ for full fat and $1.7138 \pm 0.486\text{ml/g}$ for defatted flour. The oil binding capacity of protein material is an important factor which determines how well the material will perform as meat extender or analogue as observed by Circle *et al* (1972b). The foam capacity of the flours ranged from average of 16.667 to 30.208% for full fat flour and defatted respectively and were not significantly different ($P < 0.05$) and they showed a good foam capacity. This property would make the flour useful as an aerating agent in food systems

such as whipped toppings, mixes, „akara and moi-moi“ products which require the production of stapled high volumes when whipped. The emulsion capacity of the full fat and defatted flour which are 9.1967% and 9.872% showed that there was no significant difference at $p < 0.05$. The relatively low emulsion capacity of the flours could be due to the nature and the type of protein (Sathe *et al.*, 1982). The wettability of the flours was found with wettability time of 186.333secs per gram and 113.75secs per gram for defatted and full fat flour respectively. This showed that black bean flours could perform well in textural quality of meat and baked products. The swelling index for the full fat flour and defatted was 2.86 ± 0.345 ml/ml and 2.298 ± 0.403 ml/ml. The lower swelling index of full fat and defatted flour was due to presence of fibre content. Their swelling index will have effect on the texture of food prepared from such flours.

Table 3: Functional Properties of full fat and defatted flour of black beans.

Samples	BD	SWI	WAC	OAC	FC	EC	W	GT
Full fat	0.6636 ^a	2.86 ^a	3.00 ^b	1.5785 ^a	16.6675 ^a	9.1969 ^a	113.15 ^b	75.0 ^a
Flour	± 0.03	± 0.345	± 0.1414	± 0.149	± 5.893	± 1.52	± 0.9354	± 0.00
Defatted	0.6441 ^a	2.298 ^a	3.20 ^a	1.7138 ^a	30.2083 ^a	9.8719 ^a	186.333 ^a	72.0 ^a
Flour	0.067	± 0.403	± 0.0866	± 0.486	± 18.012	± 4.59	± 2.8674	± 0.00

All values are expressed as mean \pm SD of these determinations.

Where BD = Bulk density (g/ml)

SWI = Swelling index (ml/ml)

WAC = Water absorption capacity (ml/g)

OAC = Oil absorption capacity (ml/g)

FC= Foaming capacity (%)

EC = Emulsion capacity (%)

W = Wettability (Sec)

GT = Gelling temperatures ($^{\circ}$ C)

Effect of changes in Temperature and pH Condition

The effects of changes in temperature and pH conditions on the functional properties of Black bean flours are shown below.

Effect of pH

The result shown in figure 5 revealed that the foaming capacity increased with increasing pH. However, full fat flour and defatted had their foaming capacity revealed at optimum pH 12.0 and 6.0 respectively. The ability of protein to form stable foam was reported to depend on many factors some of which include calcium ions, pH, temperature, degree of denaturation, protein type and whipping methods. Figure 6 showed that the swelling index decreases in the pH is in neutral range (from 6-10). The pH is reported to have affected protein solubility (Okezie and Bello, 1988) and protein solubility is known to be a critical functional property which influences other properties like foaming, emulsification and gelation (Kinesella, 1996). The

water absorption capacity of the flour was affected by pH. The full fat and defatted flour had their water absorption capacity at optimum level of pH 4 and declined at pH 6 and 12 respectively. See figure 7 and in figure 8 the wettability result showed that increase in pH increases the wettability which may affect the textural quality of baked products.

Effect of Temperature

The effects of temperature change on the functional properties of black bean flours are shown in figure 9 – 12. The water absorption decreased from 300 to 400C and increased to 600C. The foaming capacity increased with increasing temperature. The wettability result showed that increase in temperature decrease wettability. The swelling index of defatted flour increased with increasing temperature while the full fat was unstable with increasing temperature. The change in functional properties due to temperature change agrees that temperature is one of the factors which affect the functional properties of flours.

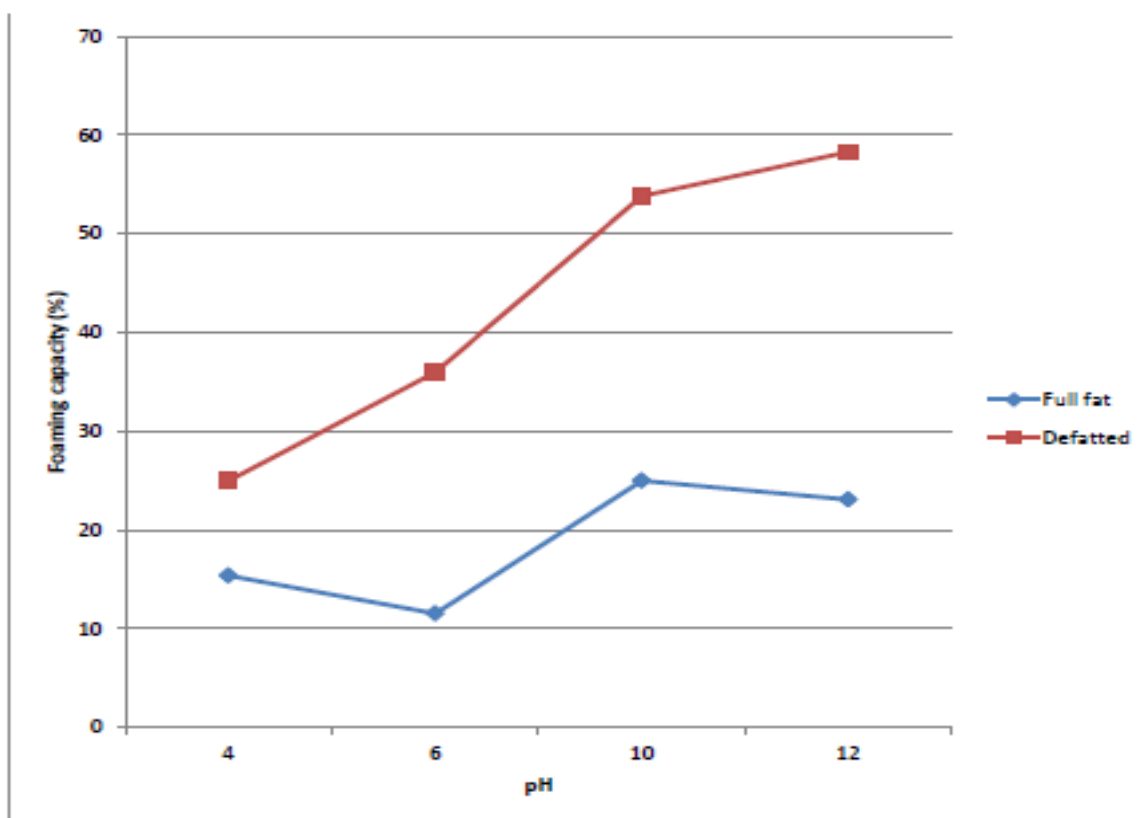


Fig. 5: The effect of pH on foaming capacity of full fat and defatted flour

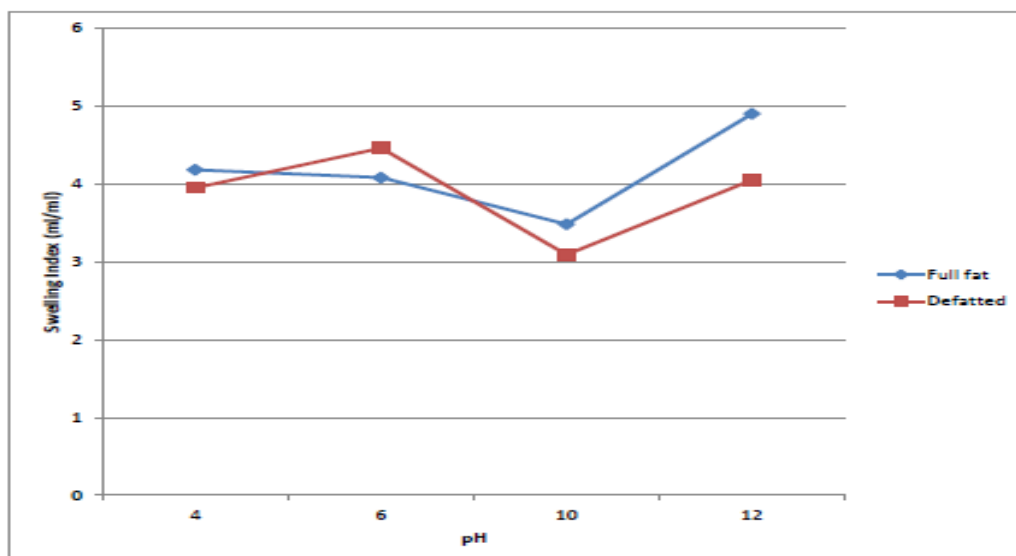


Fig. 6: The effect of pH on Swelling Index of full fat and defatted flour

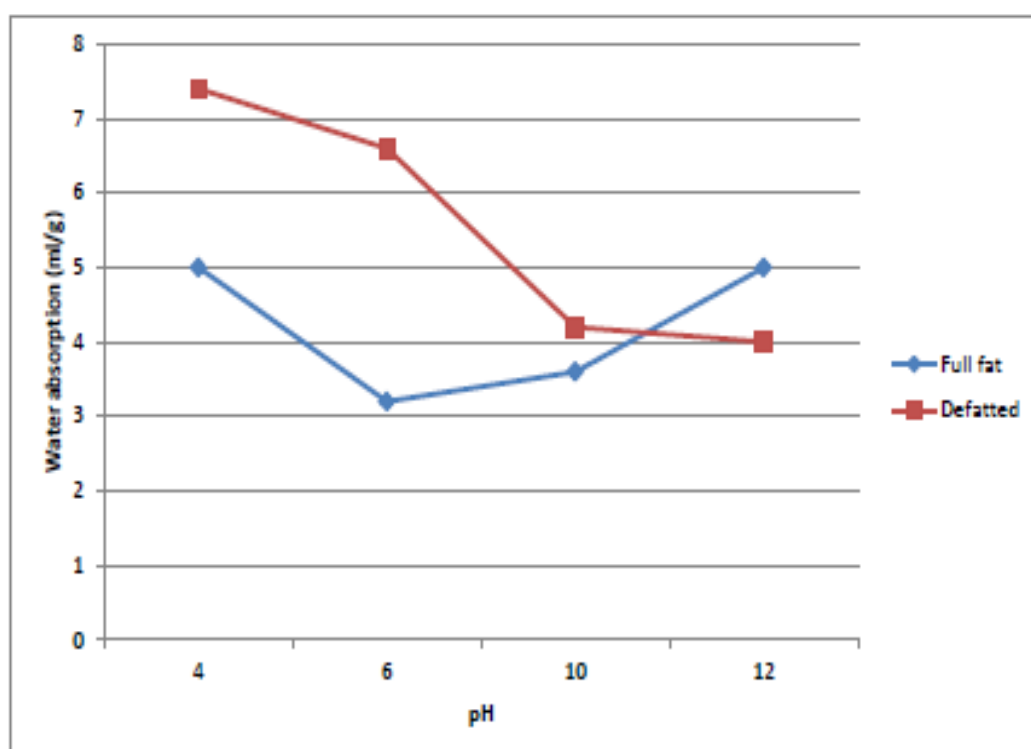


Fig. 7: The effect of pH on water absorption capacity of full fat and defatted flour

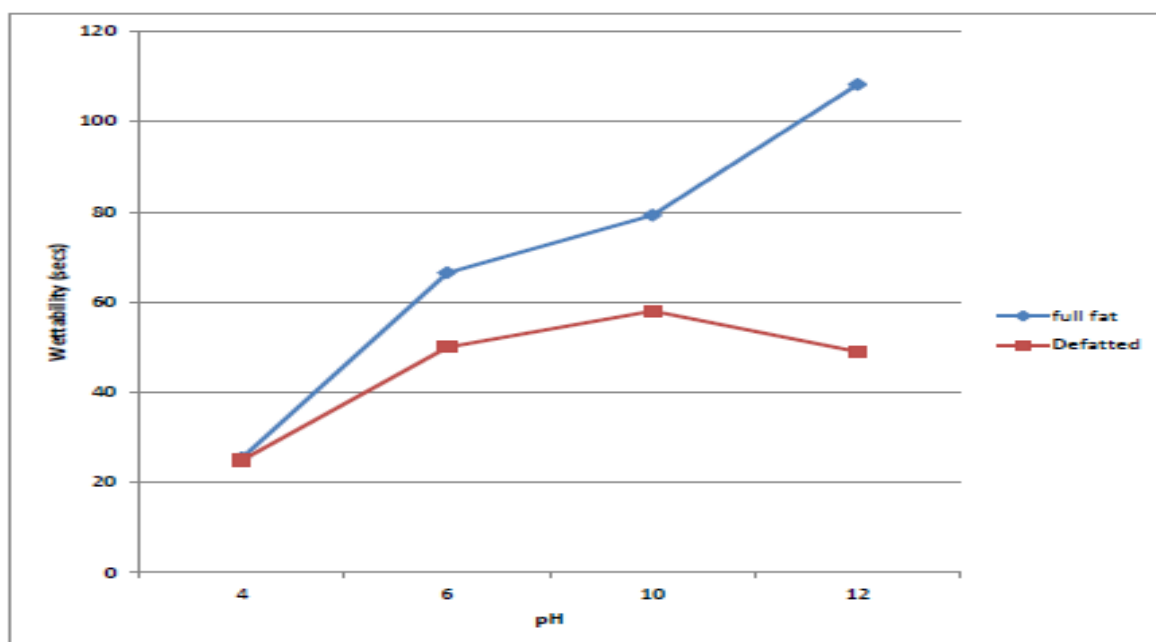


Figure 8: The effect of pH on wettability of full fat and defatted flour

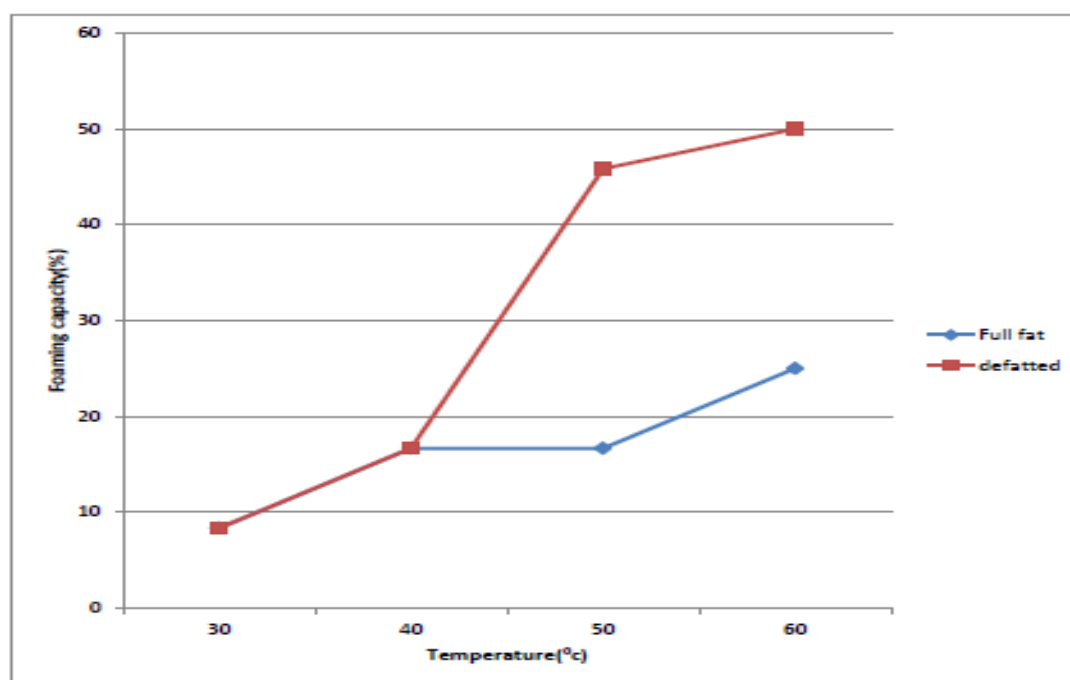


Figure.9: The effect of temperature on foaming capacity of Full fat and defatted flour

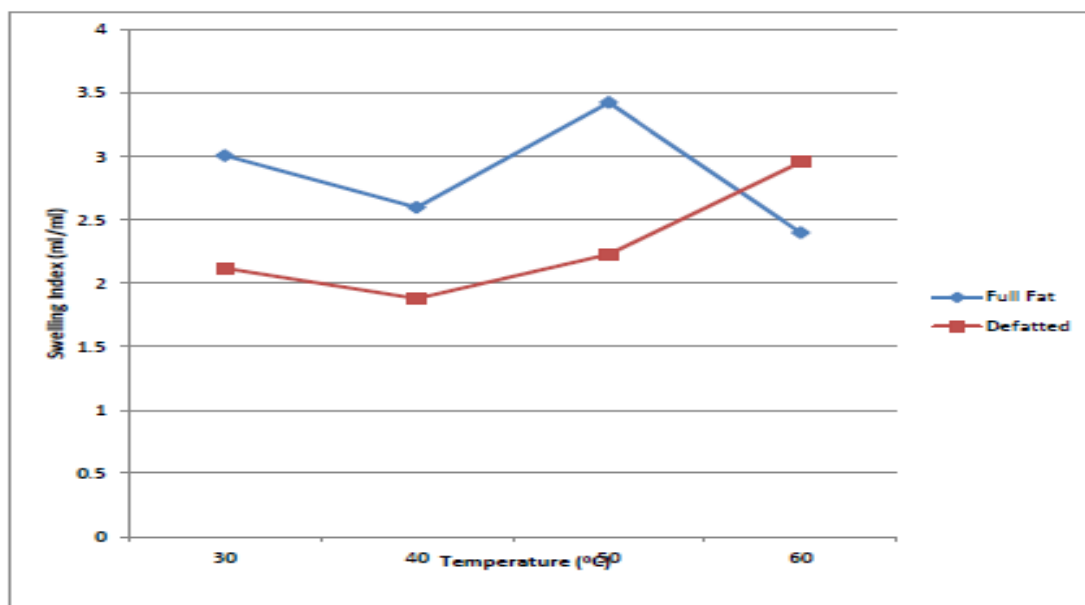


Figure 10: The effect of temperature on Swelling Index of Full fat and defatted flour

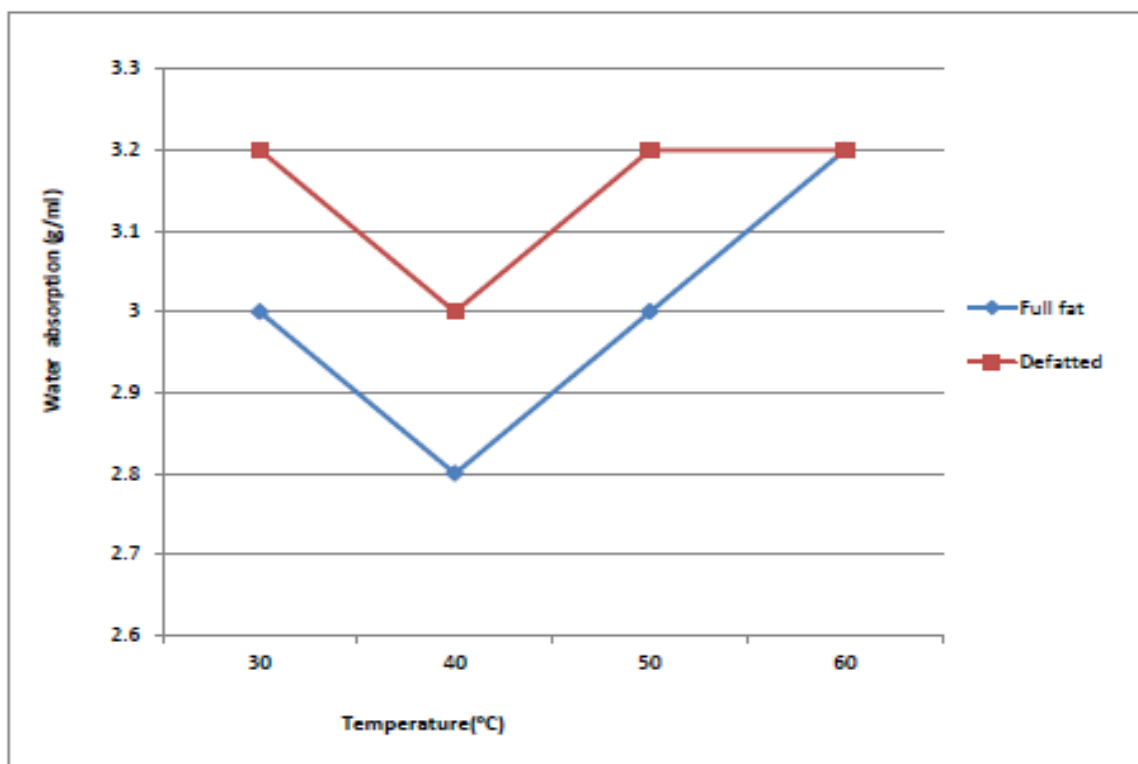


Figure 11 : The effect of temperature on water absorption capacity of Full fat and defatted flour

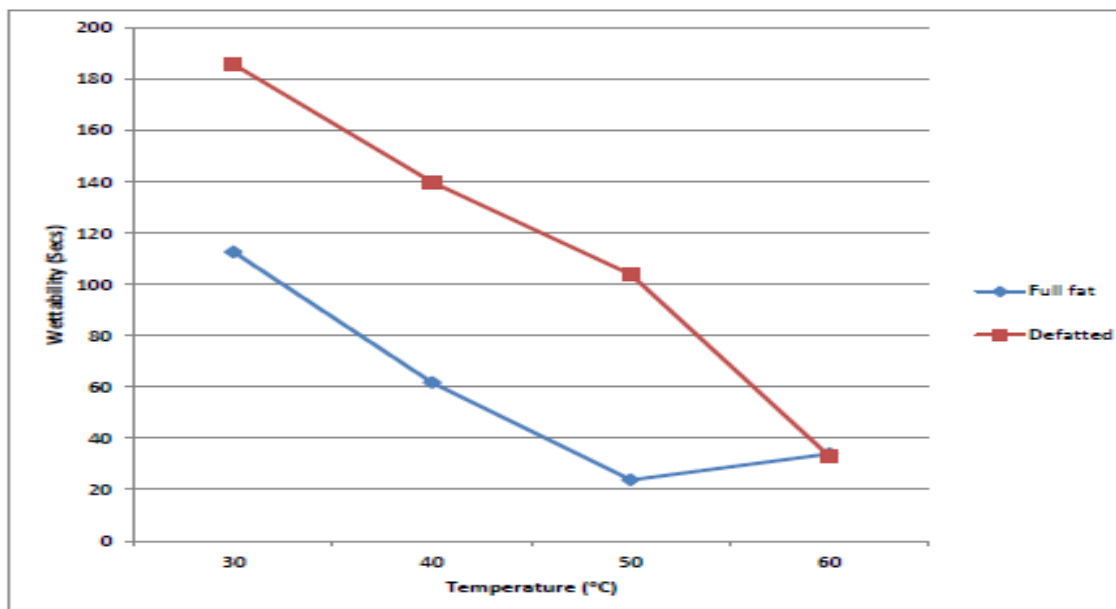


Figure 12: The effect of temperature on wettability of full fat and defatted flour

CONCLUSION AND RECOMMENDATION

CONCLUSION

The work revealed great potentials of Black bean. The protein isolate and concentrate was found to be high thus making it a potential source quality protein material for use in food industry. The proximate composition result of black bean flour showed that the seed is a good source of protein therefore has great potential in combating the protein-energy malnutrition in developing countries. The protein isolate and protein concentrate could be used to fortify food product for nutrient enrichment to meet the consumers' nutritional requirement. It is therefore concluded that black beans represented a source of alternative protein supplement. Also, proteins isolate posses characteristics which shows that it could find its uses in different products as protein enrichment or texturizer. Example is in the production of ice-cream, baked products, "akara, moi-moi", as well as meat analogue.

RECOMMENDATION

As a result of the high protein content and good functionality of the black bean seeds, the seeds would be a good substitute for flour hence their cultivation and consumption of black beans seeds should be encouraged while research effort should continue for increase utility of value of black beans. Again, to be more acceptable and useful in the incorporation of other foods, black beans should be well dehulled and processed into flour as a complement to cereal flour in the preparation of composite flour and infant formulation.

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