

**Full Length Research Paper**

Effect of *ph* and Temperature on Functional Physico-chemical Properties of Asparagus bean (*Vigna sesquipedalis*) Flours

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Abstract

Asparagus bean (Vigna sesquipedalis) seeds of black colour specie was steeped in water, dehulled, dried and processed into full fat flour, defatted flour, protein concentrate and isolate. The physico-chemical and functional properties of the flour samples were investigated. The effect of pH and temperature on some of the functional properties were also investigated. The result showed that the average seed weight was 0.09±0.01g. The protein content of the concentrate and isolate had a higher value of 66.85±0.350% and 89.02±0.202% respectively compared with that of full fat flour (24.03±0.202%) and defatted flour (25.32±0.202%). The protein concentrate and isolate had no fat and crude fibre content as well as low carbohydrate content of 24.27±0.396% and 2.04±0.217% respectively. The results from the functional properties revealed that the protein isolate had more functionality apart from emulsion and foaming capacity of which the protein concentrate was higher. The effect of pH on foaming, emulsion and water absorption showed increased functionality while effect of temperature had an increased emulsion capacity on the full fat flour sample.

Keywords: *Steeping, defatted, protein isolate, functionality*

Introduction

Food legumes particularly vegetable cowpea is one of the most important sources of protein, carbohydrate and vitamins in the diet of many populations especially in developing countries (Phillips and Mc Walters, 1991). These plants are herbs of warm and tropical countries, most are annuals but there are also some perennials. They are deep rooted, vigorous, herbaceous and winding. They are useful crop because they do not mature in a definite period, but continually produce new leaves if cut back regularly from an early stage (Nepal Agricultural Research Council, 2000). Legumes used as food are divided into two groups: the oil seeds and the pulses. The oilseeds are used primarily for their oil content, but the cakes are used to a large extent in feeding livestock e.g. soybean. However, the pulses are planted and harvested primarily for their mature or immature seeds, a significant source of dietary protein and carbohydrates but not primarily oil. Examples of pulses are Bambara groundnut, Mung bean, Chicken pea, Pigeon pea, Asparagus bean e.t.c.

Asparagus bean (*Vigna Sesquipedalis*) is a vareity of vegetable cowpea which is a nutritious component of both human diet and livestock. The crop has large pendant pods which are inflated when green and shrivel when ripe, with elongated, kidney-shaped seeds. Locally, Asparagus bean is grown mostly in the eastern part of Nigeria e.g Abia state, Ebonyi state and Enugu state, thus , it is commonly referred to as 'akidi oji' due to its black colour at maturity (Enwere, 1998). The chemical composition of Asparagus bean is similar to that of most edible legumes. It contains about 23% protein, 62% carbohydrate and minute amount of other nutrients (Nnanyelugo *et al.*, 1995); they are good sources of vitamin A and C, folate, magnesium, manganese, riboflavin, phosphorus, and potassium. Thus, the major nutrient is protein and carbohydrate of which its variability in protein is influenced by genotype as however, they also contain several undesirable components and attributes.

As a result of economic recession, the majority of Nigerians now derive protein mainly from bean species, because the country is faced with acute shortage of animal protein, which is often beyond the reach of an average Nigerian (Henshaw and Sanni, 1995). The choice of beans by Nigerian women is guided predominantly by the cooking time, swelling capacity, taste and colour (Hussain *et al.*, 1984). The matured seeds of Asparagus bean has been found to have limitations such as long cooking, reduced swelling ability and production of coloured liquid during cooking. Also, dehulling of the dry and soaked seeds is of great difficulty to the traditional man. This has seriously affected its use for food products that requires dehulling e.g moin-moin. Other problems associated with Asparagus bean are flatulence and beany off-flavour. These have affected the consumption rate and acceptability of 'akidi oji' for subsequent processes.

The search for nutritional balanced foods to make available to a substantial proportion of the population has stimulated investigation into unusual sources of protein due to the rising cost of conventional protein foods, particularly animal protein. Protein concentrate and isolate have been extensively studied as food and dietary supplements for composite flour.

Many proteins occur in cell conjugated with carbohydrate, lipid and other molecules. However, 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, but the protein should possess a high degree of functionality which is governed by four major factors ; colour, flavour, texture and nutritive value.

Consequently, it is necessary to determine its major components of such as lipids, moisture, protein etc. with respect to the characteristics that govern their behaviour during processing, storage and preparation as they affect the qualities and acceptability of this bean. Therefore, the main objective of this research work is to investigate the proximate composition and the effect of pH and temperature on some functional properties of different flours obtained from Asparagus bean grown in Nigeria.

Materials and Methods

Source of Materials

Asparagus bean seeds in this project work were procured from a local market in Enugu state.

Laboratory and other facilities used for the analysis were sourced from the central laboratory service unit of the National Root Crops Research Institute (NRCRI), Umudike, Umuahia, Abia State.

Equipment

Equipment and instruments used in this study included the Arthur Thomas Laboratory mill, colab fume cupboard, colab electric centrifuge, cabolite electric stoves, excello kjeldahl apparatus, gallen camp, electric muffle furnace, electric water bath, satorious digital weighing balance, pH meter, thermometer, retort stand, stop watch, general laboratory glass wares, e.t.c.

Chemicals and Reagents

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

Sample Preparation

Prior to the preparation of the flours, Asparagus bean seeds were processed. The method described by Okezie and Bello (1988) was employed. The bean seeds were manually sorted to remove extraneous materials like dirt, residue, shriveled and diseased seeds. The healthy ones were separated for use.

Production of Full Fat Asparagus Bean Flour

In the production of full fat Asparagus bean flour, dry bean seeds were soaked overnight (24 hours) in water at 1:5 (w/v) ratio. The following day, the seeds were manually dehulled to separate the seed coats from the cotyledon. The dehulled seeds were dried in the oven at a temperature of 30⁰C for 4hours after which they were ground with a laboratory mill. The milled samples were sieved through a 0.5mm sieve to obtain flour sample, which were stored in airtight containers at room temperature ready for use in analysis.

Production of Defatted Asparagus from Flour

Some of the full fat flour sample was soaked in the solvent at 1:5 (w/v) ratio and allowed to stand overnight at room temperature. The next day, the mixture was filtered with a filtration apparatus, the defatted flour was air dried for 8 hours and pulverized in a motor. Part of the defatted flour was set aside for analysis while the rest were used for the production of protein concentrate and isolate.

Production of Asparagus Bean Concentrate.

The method of Arntfield *et al.*, (1985) was employed. The method involved defatting of the flour with normal hexane (soaked for 3 hours and dried after sieving). The carbohydrate in the defatted flour (mainly sugars) was removed by extraction with ethanol for 30 minutes. The resulting defatted, carbohydrate-free concentrate was dried in the oven at 45⁰C and used as the protein concentrate.

Production of Asparagus Bean Isolate

The protein isolate was done following the method described by Okezie and Bello (1988). 70g of defatted flour was mixed with 1400ml of water to form a 1:20 (w/v) ratio of slurry. The solution at pH 6.37 was allowed to settle for 3 hours. The spent residue was separated from the dissolved protein extract by decanting, after which decanting took place. The pH of the solution extracted protein was adjusted with HCl to its isoelectric point between 4.0 – 4.5. The precipitate formed was subsequently recovered by centrifugation at room temperature by removing the whey which contains soluble sugar, residue protein, peptide salt, minor constituents. The resultant curd (protein isolate) was then dried in air using a desiccator before grinding followed by sieving.

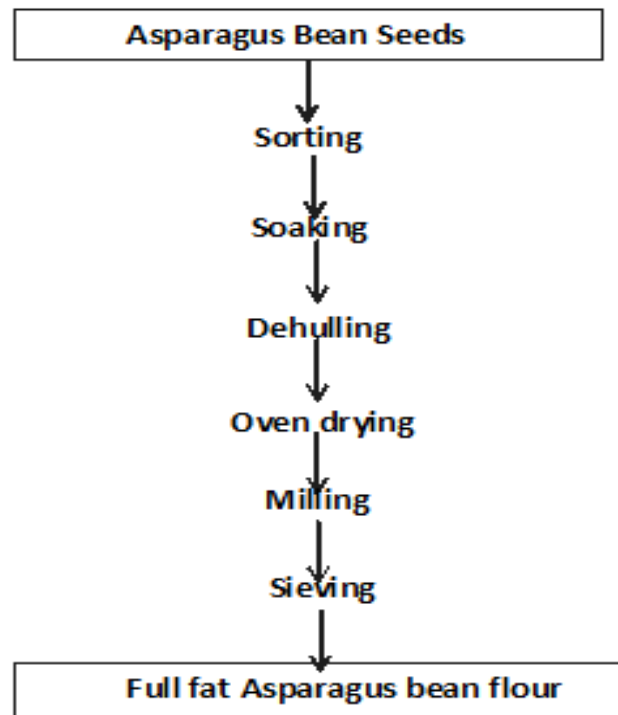


Fig. 1: Flow diagram for the production of dehulled full fat Asparagus bean flour.

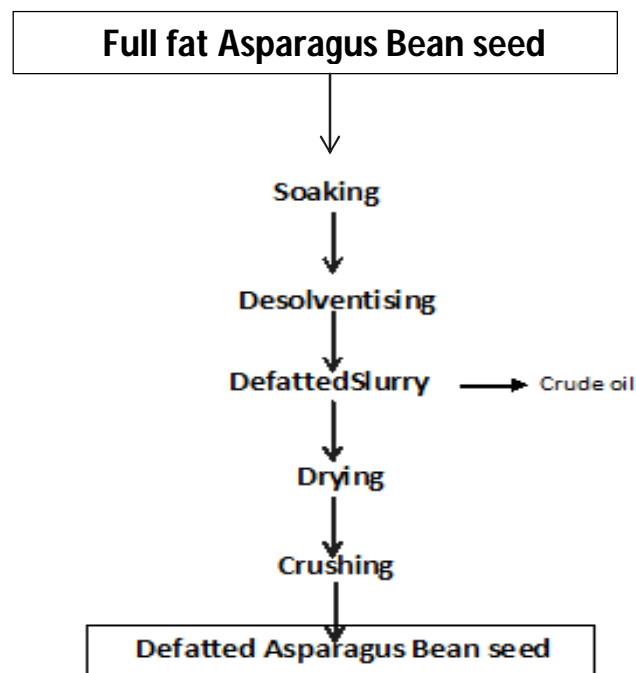


Fig 2: Flow diagram of commercial processing of defatted Asparagus Bean seed.

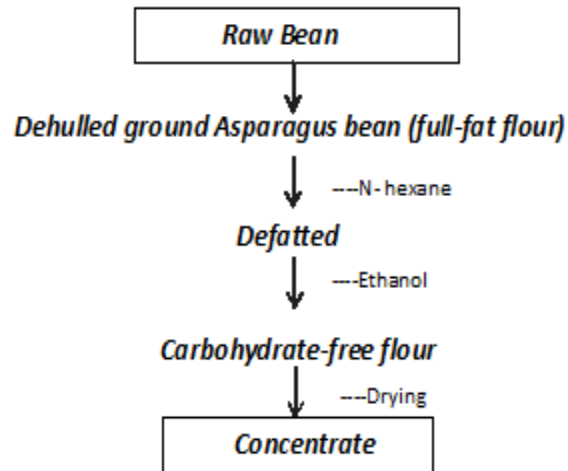


Fig 3: Flow diagrams of the production of protein concentrate from defatted Asparagus bean flour

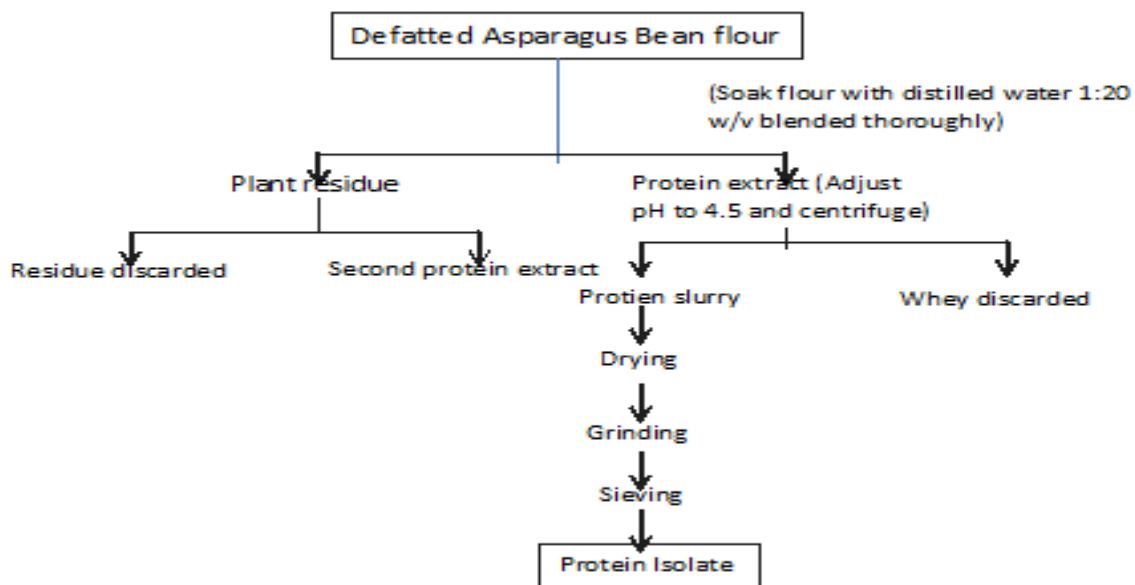


Fig. 4: Flow diagram for the production of isolated protein from defatted Asparagus bean seed.

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 shapes 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.

Proximate Composition

The procedures for the chemical analysis for moisture, crude fibre, crude protein, fat content, ash, carbohydrates were carried out as outlined by the Association of Official Analytical Chemist (AOAC, 1990). The analysis were carried out in both full fat flour, defatted flour, protein concentrate, and protein isolate from Asparagus bean seeds and results obtained in triplicates.

Determination of Moisture Content.

The gravimetric method as described by (AOAC, 1990) was used to measure weight of samples. 2g of each flour samples was weighed into dried moisture can of known mass. They were placed into the oven at 105⁰C for 3 hours, withdrawn into a desiccator to cool and weighed. They were again reheated/dried, cooled reweighed and reheated. This process was repeated until relatively constant mass was realized.

The weight of moisture lost was calculated and expressed as a percentage of the weight of samples analyzed. It was given by the expression below;

$$\% \text{ moisture content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100\%$$

Where W_1 = Weight of moisture can

W_2 = Weight of empty can + sample before drying W_3 = Weight of empty can + sample dried to constant weight

Determination of Ash Content

This was carried out by the furnace incineration gravimetric method (James, 1995; AOAC, 1984). 5g of the processed samples was measured into a previously weighed porcelin crucible. The samples were burnt to ashes in a muffle furnace at 550⁰C for 5 hours. After which they were cooled in a desiccator, weighed and recorded. The weight of ash obtained was calculated by difference and expressed as a percentage of the weight of sample analyzed as shown below,

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

Where W_1 = Weight of empty crucible W_1

W_2 = weight of crucible + ash

Determination of crude fibre

The Weende method (James, 1995) was employed. 2g of the processed sample was boiled in 150mls of 1.25% H₂SO₄ solution for 30 minutes under flux. The boiled samples were washed in several portion of hot water using two fold muslin cloths to trap the particles. It was returned to the flask and boiled again in 150mls of 1.25% NaOH for another 30 minutes under same conditions. After washing in several portions of hot, the samples were allowed to drain dry before being transferred quantitatively to a weighed crucible where it was dried in the oven at 105⁰C to a constant weight. Afterwards, it was taken to a muffle furnace in which it was burnt until only ash was left. 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;

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

Where W_2 = Weight of crucible + sample after boiling, washing and drying

W_3 = Weight of crucible + sample ash

Determination of protein

This was carried out by the Kjeldhal method described by Chang (2003). The total N₂ was determined and multiplied with factor 6.25 to obtain the protein content. 1 gram of sample was mixed with 10mls of concentrated H₂SO₄ in a digested flask. A table of selenium catalyst was added to it before it was heated under a fume cupboard until a clear solution was obtained (i.e. the digest). The digest was digested to 100ml in a volumetric flask and used for analysis. The 10mls of 4% Boric acid containing 3 drops of mixed indicator (bromocresol green / methyl red). A total of 50mls of distillates was collected and titrated against 0.02N EDTA from green to a deep red end point. A reagent blank was calculated using the formula below;

$$\begin{aligned} \% \text{ protein} &= \% \text{ Nitrogen} \times 6.25 \\ \% \text{ N} &= [(100/W \times (N \times 14/1000) \times (Vt/Va)]^{T-b} \\ W &= \text{weight of samples (1g)} \\ N &= \text{Normality of titrant (0.02N . H}_2\text{SO}_4\text{).} \\ Vt &= \text{total digest volume (100mls)} \\ Va &= \text{volume of digest analyzed (10mls)} \\ B &= \text{Blank} \\ T &= \text{Sample titre value} \end{aligned}$$

Fat Determination

This was carried out using the solvent extraction gravimetric method (Kirk and Sanyer, 1980). 1gram of the sample was wrapped in a porous paper (Whitman filter paper) and put in a thimble. The thimble was placed in a sohxlet reflux flask and mounted into a weighed extraction flask containing 200mls of hexane. The upper end of the flask was connected to a water condenser.

The hexane was heated, boiled, vaporized and condensed into the flask. 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 after which the 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. The difference in mass was calculated as crude fat. The expression is given as a percentage below;

$$\% \text{ Fat} = \frac{W_2 - W_1}{\text{Weight of sample}} \times 100$$

Where; W₁ = weight of empty extraction flask
W₂ = weight of flask + oil extract

Determination of Carbohydrate

This component was determined by difference. It was calculated using the formula described by AOAC (1990) and James (1995). This percentage value of moisture, ash, fat, fibre and protein contents were summed up and subtracted from 100% to obtain the value of carbohydrate content in each test flour.

Functional Properties of Flour Samples

The functional properties of Asparagus bean flour (full fat, defatted, concentrate and isolate) was determined using various individual methods.

Bulk Density

Method as described by Onwuka (2005) was adopted. 2 gram of flour sample was measured into an already dry, calibrated measuring cylinder of the known weight. The bottom of the cylinder was tapped repeatedly on a pad placed on a laboratory bench. This continued until no further diminution of the test flour in the cylinder after filling to 10ml mark was observed. The bulk density was determined as the ratio of the weight of the sample to its volume calculated as shown below;

$$\text{Bulk density (g/ml)} = \frac{\text{weight of sample (g)}}{\text{Volume of sample (ml)}}$$

Determination of Foam capacity

The method described by Navasinga and Rao (1982) was adopted. 1 gram of the flour sample was mixed with 10mls of distilled water and blended at 1600rpm for 5 minutes. After the resulting mixture, the height of foam was recorded after 30 seconds. The capacity was expressed as a percentage of foam produced after whipping, using Abbey and Ibeh (1988) formula.

$$\text{Foam capacity} = \frac{(V_a - V_b)}{V_b} \times 100$$

Where; V_a = Volume after whipping
 V_b = Volume before whipping

Swelling index

A portion (1g) of each flour sample was weighed into clean, dry test tubes. The flour samples were gently leveled in the test tubes and the volumes noted. 10mls of distilled water was added to each sample. The smirled cylinder was allowed to stand for 60 minutes, while the change in volume recorded every 15 minutes. The swelling power index of each flour sample was calculated as a multiple of the original volume.

$$\text{Swelling Index} = H_2/H_1$$

Where; H_2 = Final height
 H_1 = Initial height

Water Absorption Capacity

This was determined as the weight of water absorbed and held by 1 gram of the sample (Okaka and Potter, 1997). 1 gram of the sample was weighed and put into a clean, dry test tube. 10mls of distilled water was added to the sample and mixed properly to form a suspension. The mixture was allowed to stand for 30 minutes at room temperature. The mixture was centrifuged at 3500rpm for 30 minutes. After which the supernatant was discarded then, the tube and its content re-weighed and noted. The gain in weight was the water absorption capacity of the test sample.

$$\text{Water absorption Capacity} = V_1 - V_2$$

Where; V_1 = Initial volume of distilled water
 V_2 = Final volume of distilled water

Oil Absorption Capacity

The method as described by Abbey and Ibeh (1998) was adopted. One gram (dmb) of the flour sample was weighed into a dry, clean centrifuge tube and both weight noted. 10mls of refined vegetable oil was poured into the tube and properly mixed with the flour. The suspension was centrifuged at 3500rpm speed for 30 minutes after it was left to stand for 30 minutes. The oil absorption capacity was determined by difference as shown below;

$$\text{Oil absorption capacity} = \text{Initial volume of oil} - \text{Food volume of oil.}$$

Determination of Gelling and Boiling points

The method of Narayana and Rao (1982) was adopted. The flour sample (5 grams) was dispersed in distilled water, in a 250ml beaker and made up to 100ml. A thermometer was clamped on a retort stand with its bulb submerged in the suspension. With a magnetic stirrer, the suspension was continuously stirred and heated. This continued until the suspension began to gel and the corresponding temperature recorded. The temperature as soon as boiling commenced was also noted and recorded.

Determination of Emulsion Capacity

The method as described by Okezie and Bello (1988) was adopted. 1 gram of sample was mixed with 10mls of distilled water in a test tube for 30 seconds. After which 10mls of refined vegetable oil was added with continuous agitation. The test tube was left to stand for 30 minutes. The height of oil separation from the sample was expressed as the amount of oil emulsified and held per gram of the sample as shown below;

$$\text{Emulsion capacity} = \frac{\text{Emulsion height}}{\text{Water height}} \times 100$$

Determination of Wettability

This as described by Onwuka (2005) was adopted. One gram of each flour sample was placed in a clean, dry test tube. Placing a finger over the open end, the test tube was inverted and clamped at a height of 10cm from the surface of a 600ml beaker containing 500ml of distilled water. The flour in the test tube was gradually spread on the surface of the water on moderate speed. The time taken for the sample to be completely wet is noted as wettability.

Results and Discussion

Seed Characteristics

The result of the seed characteristics of Asparagus bean is presented in Table 1. The seeds were black in colour, cream eye colour, loosed attachment to the cotyledon, of a smooth testa when fresh and average seed weight of 0.09 ± 0.01 g.

Proximate Composition of the Flour Samples

Analysis was carried out on the proximate composition of the flour samples as soon as they were ready, in order to prevent loss of value due to deterioration.

The proximate composition of test samples are shown in Table 2 below. The result revealed a high protein content of $24.03\pm 0.20\%$ of the seed full fat flour. This result falls within the same range of other legumes like pigeon pea ($24.46\pm 0.32\%$) and cowpea ($24.13\pm 0.31\%$) as reported by Arawande and Borokini, (2010). However, the Asparagus bean protein concentrate and isolate had an average protein content of 66.85% and 89.02% respectively.

Carbohydrate and dry matter value ranged from 2.04-62.48% and 94.09-94.77% respectively. There was significant difference ($p<0.05$) between the protein concentrate, isolate and Asparagus bean flours. The ash contents of the protein concentrate ($3.61\pm 0.04\%$) and isolate ($3.71\pm 0.04\%$) had a significant difference at $p<0.05$. However, that of protein isolate is higher than the report given by Okezie and Bello, (1988) for winged bean (3.4%) and lower for soy bean (5.5-7.5%).

The full fat flour and the defatted flour contains fibre of $2.02\pm 0.14\%$ and $2.48\pm 0.02\%$ respectively which slows down the release of glucose into the blood stream hence, high legume diet is commended for diabetic patients.

There was little or no traces of fibre and fat found in the protein concentrate and isolate of Asparagus bean. Asparagus bean concentrate and isolate was found to have values which were significantly different at ($p<0.05$) from those of the full fat and defatted flour.

Table 1: Seed Characteristics of Asparagus bean seed

Average seed weight	Seed colour	Testa characteristics	Testa attachment to cotyledon
0.09 ± 0.01 g	Black	Smooth when freshly harvested, wrinkled with storage.	Loose



Plate 1: Undehulled Asparagus Bean Seeds



Plate 2: Dehulled Asparagus Bean Seeds

Table 2: Proximate composition of Asparagus Bean Seed Flour Samples

Samples	Moisture Content	Crude Fibre	Protein	Fat	Ash	Dry Matter	Carbohydrate
Full Fat Flour	5.91 ^a ±0.117	2.02 ^c ±0.140	24.03 ^b ±0.202	5.39 ^d ±0.042	3.49 ^c ±0.042	94.09 ^a ±0.117	59.16 ^b ±0.253
Defatted Flour	5.83 ^c ±0.012	2.48 ^a ±0.020	25.32 ^d ±0.202	0.31 ^b ±0.023	3.58 ^b ±0.040	94.17 ^b ±0.012	62.48 ^c ±0.178
Protein Concentrate	5.27 ^b ±0.058	0.00 ^d ±0.000	66.85 ^a ±0.350	0.00 ^c ±0.000	3.61 ^a ±0.042	94.73 ^d ±0.058	24.27 ^d ±0.396
Protein Isolate	5.23 ^d ±0.058	0.00 ^b ±0.000	89.02 ^c ±0.202	0.00 ^a ±0.000	3.71 ^d ±0.042	94.77 ^c ±0.058	2.04 ^a ±0.217

All values are expressed as mean±SD of four determinations. Mean values within column with different superscript are significantly different at $p < 0.05$.

Functional Properties of the Flour Samples

The functional properties of the flour samples are shown in Table 3 below. The result revealed relatively high bulk density with the concentrate having the highest value of 1.58%. This indicates a high volume per gram of the protein material. Kinsella, (1996) reported that a high bulk density is relevant to packaging. The bulk density of the protein isolate was 0.60g/cm³ which is the same range with the protein isolate of African Yam bean (0.61g/cm³) and lower than that of soy bean isolate (0.43g/cm³).

The protein isolate had the highest oil absorption capacity of 3.50g/ml which is far lower compared to values from other legumes such as 4.08g/ml obtained for African Yam bean isolate by Adebawale *et al.*, (2009). This result shows that Asparagus bean have lower flavour retention than other legumes of higher oil absorption capacity such as soy bean flour. This may be due to low hydrophobic protein in the Asparagus bean flour. Consequently, the low oil absorption capacity shows that it decreases the mouthfeel when used in food preparations such as, meat analogues.

The foaming capacity of Asparagus bean isolate had a significantly lower value of 3.94% than those of the full fat flour (8.45%), defatted (12.46%) and the concentrate (5.33%). This means that the isolate does not have the ability to retain a stable foam when whipped. Therefore, the isolate may not do well as an aerating or foaming agent in formulations like ice cream but could be used to enhance a higher nutritional value.

The emulsion capacity of the protein isolate was found to be 37.58% and comparatively lower than the other flour samples. The relatively low emulsion capacity of the isolate could be due to the nature and type of protein. Sathe and Salunkhe, (1982) reported that emulsion capacity and stability is higher in protein with globular nature. Also, the isolate had wettability of 8.64sec/g. This affinity for

water was also evident on water absorption capacity of 1.73g/ml. The low values of the water absorption capacity of the different flour samples suggest that Asparagus bean flour is less hydrophobic than other legume flours. Therefore, Asparagus bean flours have more useful functional ingredient in viscous foods like baked products, gravies, soup e.t.c to increase viscosity.

The low gelling concentration obtained in this study for the protein concentrate and isolate is due to high protein content of the flour. However, the full fat and defatted flours were found to gel at temperatures 96°C and 94°C respectively. Sathe and Salunkhe, (1982) associated the variation in gelling properties to different constituents – proteins, lipids, and carbohydrate that make up the legume. Protein was attributed to globulin fraction and gelling point is indeed an aggregation of denatured molecules. This suggest that this property would make the full fat and defatted flours suitable in food systems such as pudding, sauces and moin-moin which require thickening and gelling properties.

Table 3: Table showing the functional properties of Full Fat flour, Defatted flour, Protein Concentrate and Protein Isolate of Asparagus Bean Seed.

Samples	BD	SWI	WAC	OAC	FC	EC	W	GT
Full Fat	0.638 ^a ±0.0115	1.253 ^b ±0.0058	1.330 ^c ±0.0578	1.430 ^c ±0.052	8.457 ^b ±0.4792	66.513 ^d ±1.5116	3.360 ^d ±0.6102	96.00 ^a ±1.000
Defatted	0.632 ^a ±0.0115	1.463 ^a ±0.0058	1.770 ^b ±0.0578	2.680 ^d ±0.1375	12.463 ^a ±0.4619	86.207 ^b ±0.5093	2.580 ^a ±0.7299	94.00 ^a ±1.000
Protein Concentrate	1.588 ^c ±0.1374	2.217 ^{ac} ±0.0058	1.330 ^{ac} ±0.1155	3.140 ^b ±0.052	5.330 ^c ±0.5289	45.437 ^a ±0.4272	5.610 ^c ±0.1908	Nil
Protein Isolate	0.602 ^b ±0.0398	2.967 ^c ±0.0058	1.730 ^a ±0.1155	3.503 ^a ±0.0577	3.940 ^d ±0.6149	37.580 ^c ±0.3464	8.640 ^b ±1.0341	Nil
LSD	2.3648	2.3107	2.3805	2.3739	2.7344	2.9950	2.8851	2.8835

All values are expressed as mean ± SD of these determinants.

Where: BD = Bulk Density (g/cm³)

SWI = Swelling Index (g/cm)

WAC = Water absorption capacity (g/ml)

OAC = Oil absorption capacity (g/ml)

FC = Foaming capacity (%)

EC = Emulsion capacity (%)

W = Wettability (sec)

GT = Gelling temperature (°C)

Effect of Changes in Temperature and pH conditions

The effect of changes in temperature and pH conditions on some functional properties of Asparagus bean flours, protein concentrate and isolate are shown in the graphical representation (figs.5-12) below.

Effect of pH on the Flour Samples

The effect of the pH conditions on some functional properties of Asparagus bean flours, concentrate and isolate are shown in figs 9-12. The result in fig. 8 revealed that the foaming capacity increased with increasing pH for full fat and defatted flour. However, there was a considerable decreased foaming capacity with increased pH for protein concentrate and isolate. Stable foam formation as reported by Hussain *et al.*, (2010) depend on factors including pH, degree of denaturation, temperature, protein type and whipping method. The swelling index in fig 7 decreased with increasing pH apart from the defatted flour which is linear. Okezie and Bello, (1988) reported that the pH affects protein solubility which is a critical functional property that influences other properties like foaming, emulsion and gelation capacities (Kinsella, 1996). The water absorption capacity of the flour samples as shown in fig 9 was also affected by pH conditions especially full fat flour which increased to a maximum at pH 6 and declined.

Effect of Temperature on the Flour Samples

The effect of temperature change on some functional properties of Asparagus bean flours, concentrate and isolate are shown in figs5-8. The result in fig 5 showed that the water absorption capacity decreased steadily with increasing temperature from 30°C to 60°C. Similarly, the foaming capacity decreased with increasing temperature. However, the swelling index of the protein concentrate and isolate increased with increased temperature. Therefore, the protein concentrate and isolate from Asparagus bean would perform well in food formulations of high textural demands and baked products. The change in functional properties due to temperature change agrees with earlier report which observed temperature as one of the initial factor that affects the functional properties of flours, concentrate and isolate.

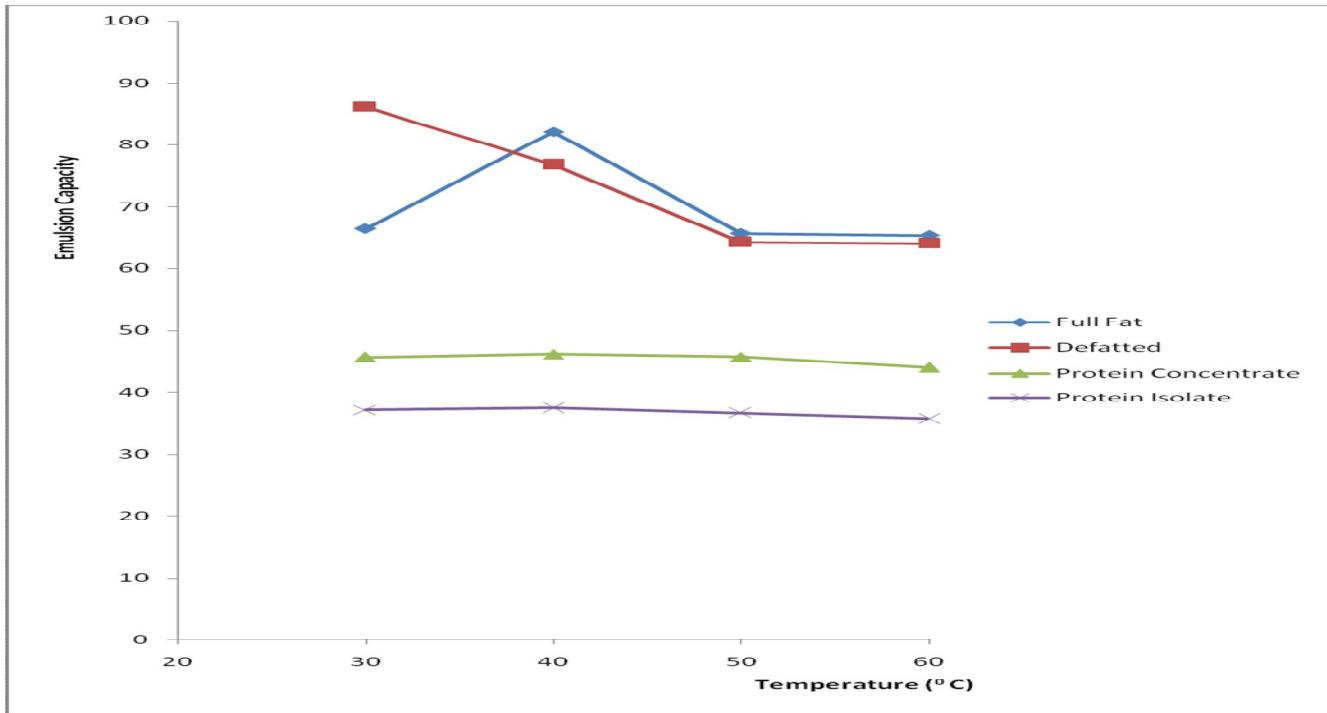


Fig 5: The effect of Temperature on Emulsion Capacity of Full Fat, Defatted Flour, Protein Concentrate and Protein Isolate.

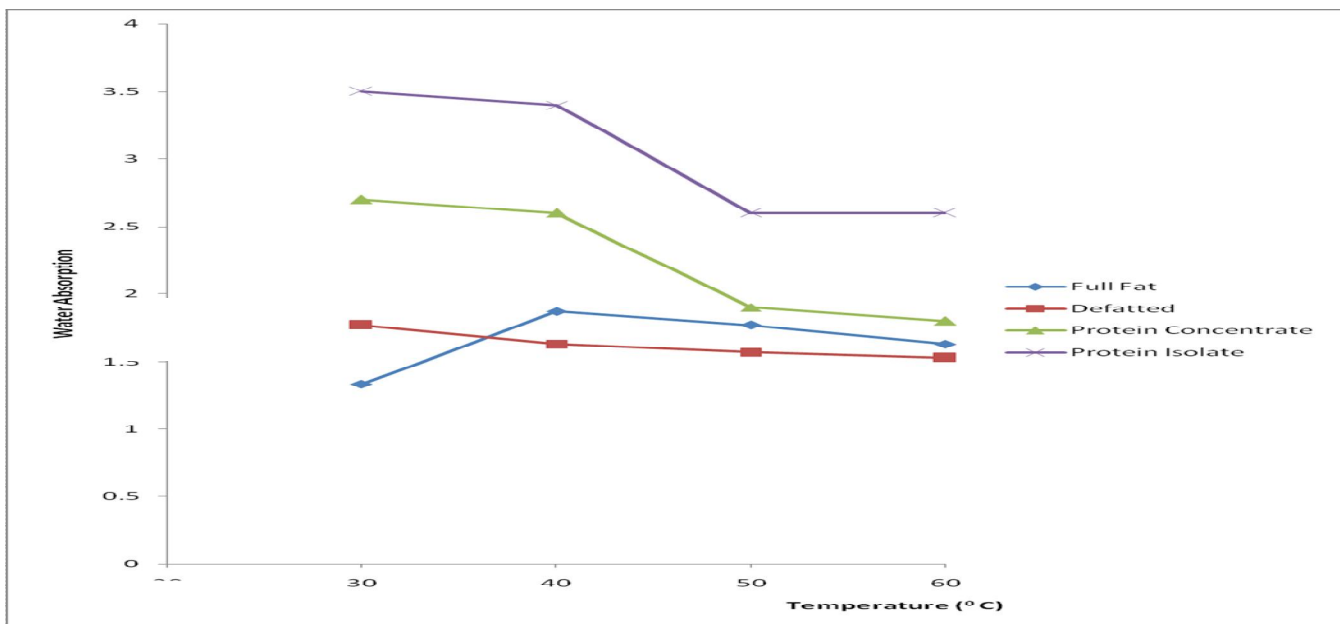


Fig 6: The effect of Temperature on Water Absorption of Full Fat, Defatted Flour, Protein Concentrate and Protein Isolate.

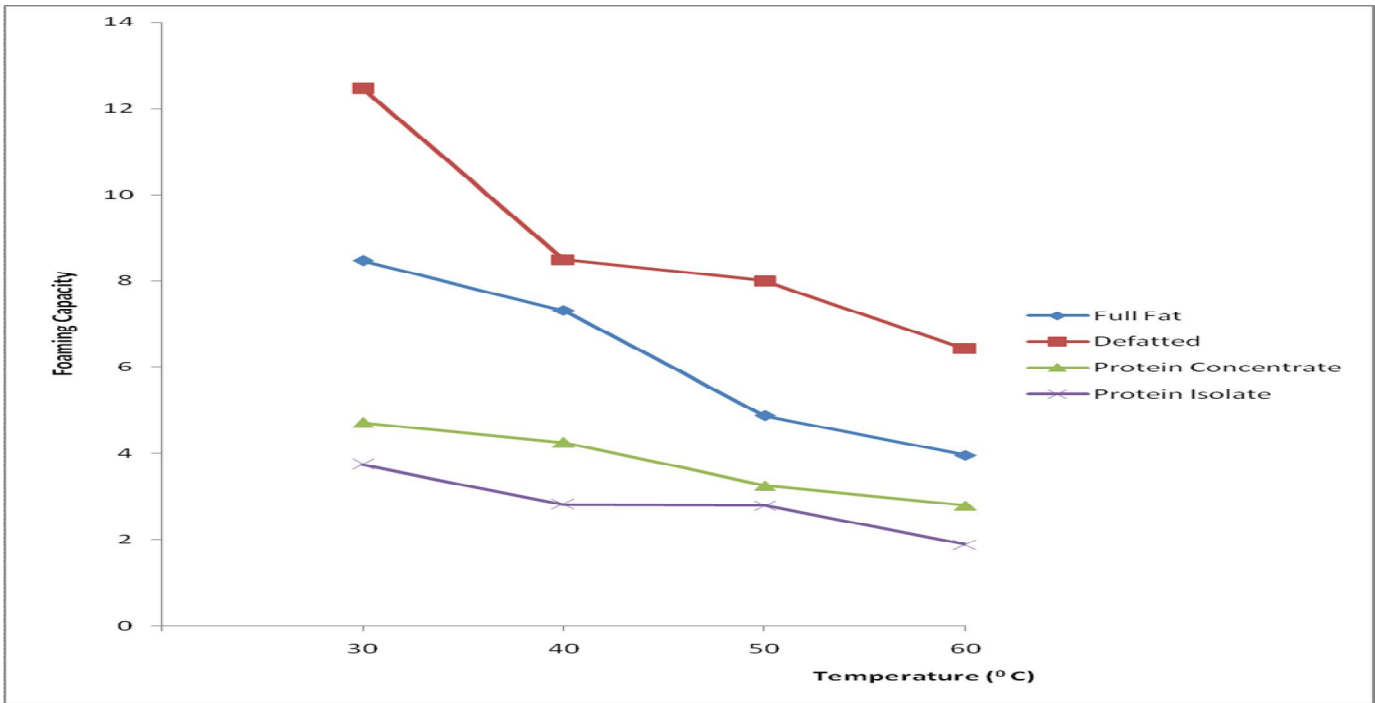


Fig 7: The effect of Temperature on Foaming Capacity of Full Fat, Defatted Flour, Protein Concentrate and Protein Isolate.

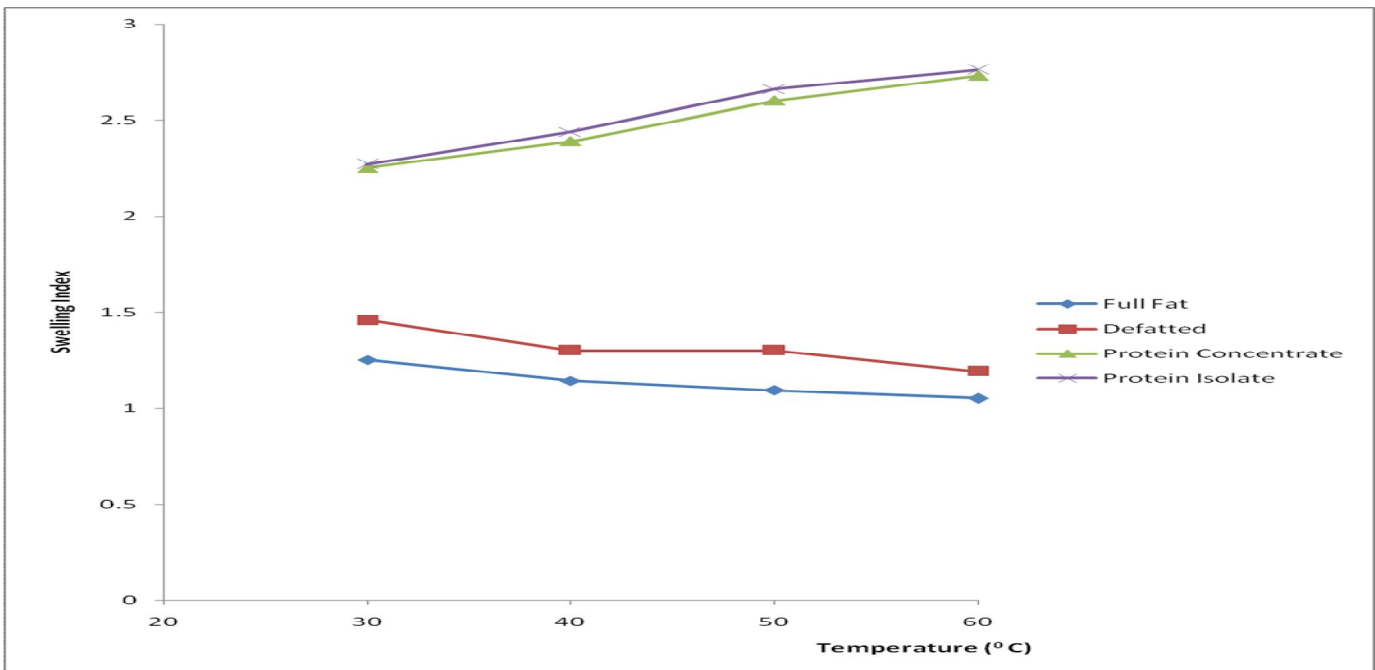


Fig 8: The effect of Temperature on Swelling Index of Full Fat, Defatted Flour, Protein Concentrate and Protein Isolate.

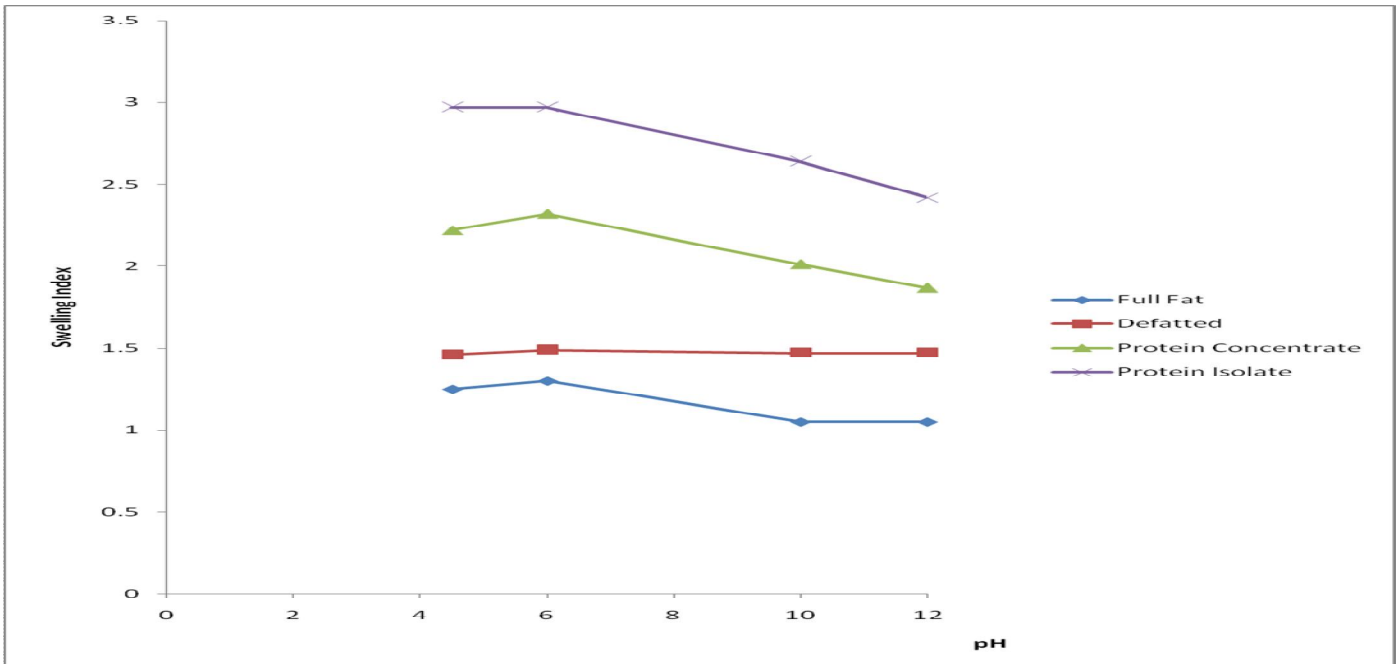


Fig 9: The effect of pH on Swelling Index of Full Fat, Defatted Flour, Protein Concentrate and Protein Isolate.

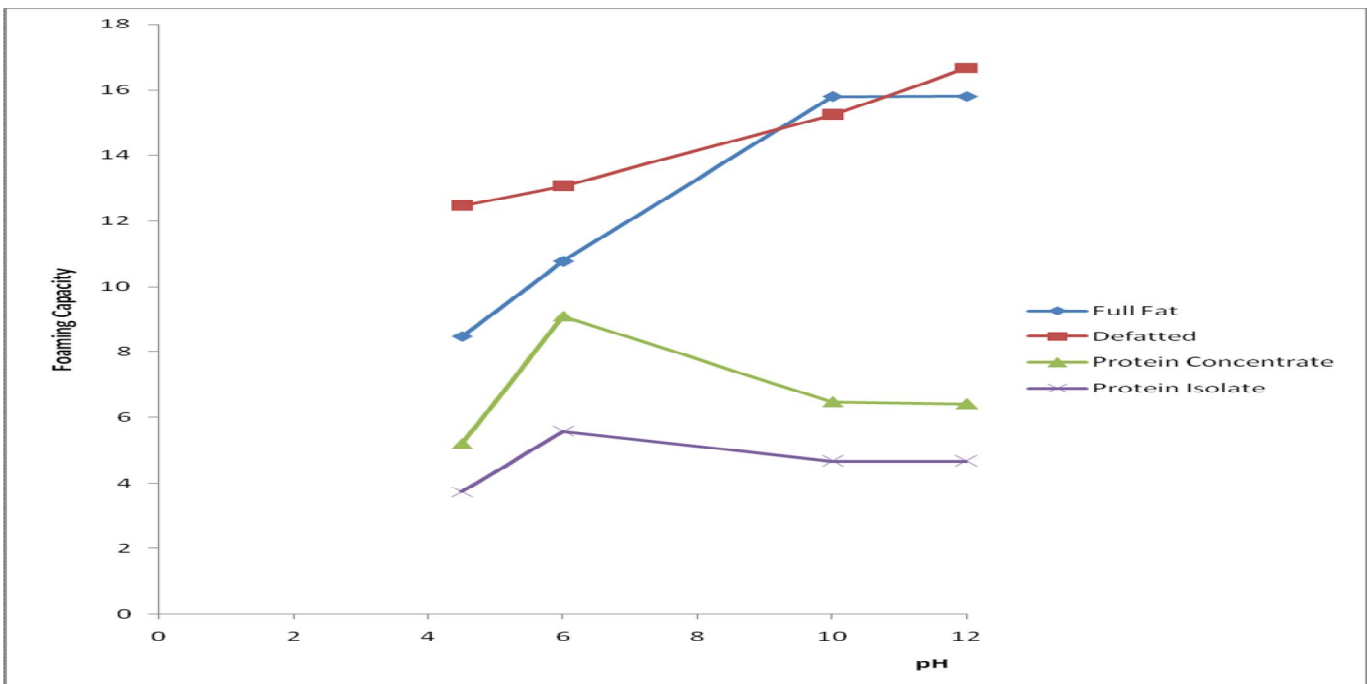


Fig 10: The effect of pH on Foaming Capacity of Full Fat, Defatted Flour, Protein Concentrate and Protein Isolate.

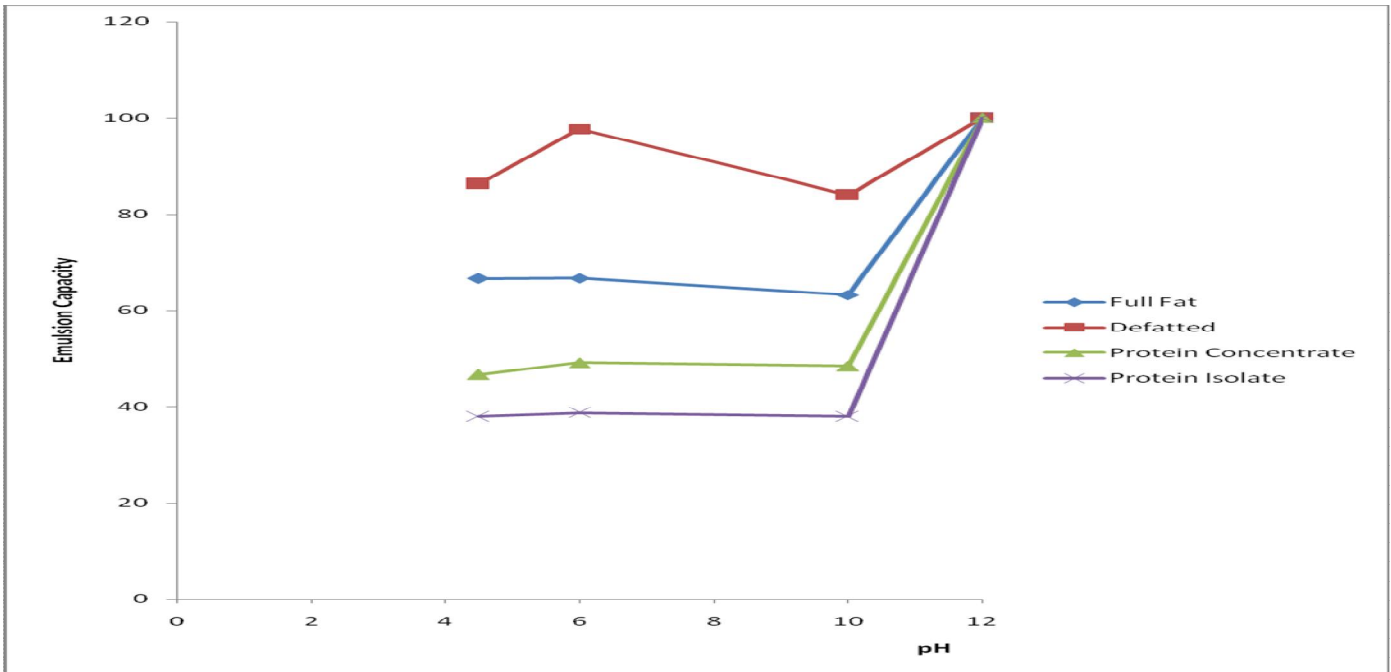


Fig 11: The effect of pH on Emulsion Capacity of Full Fat, Defatted Flour, Protein Concentrate and Protein Isolate.

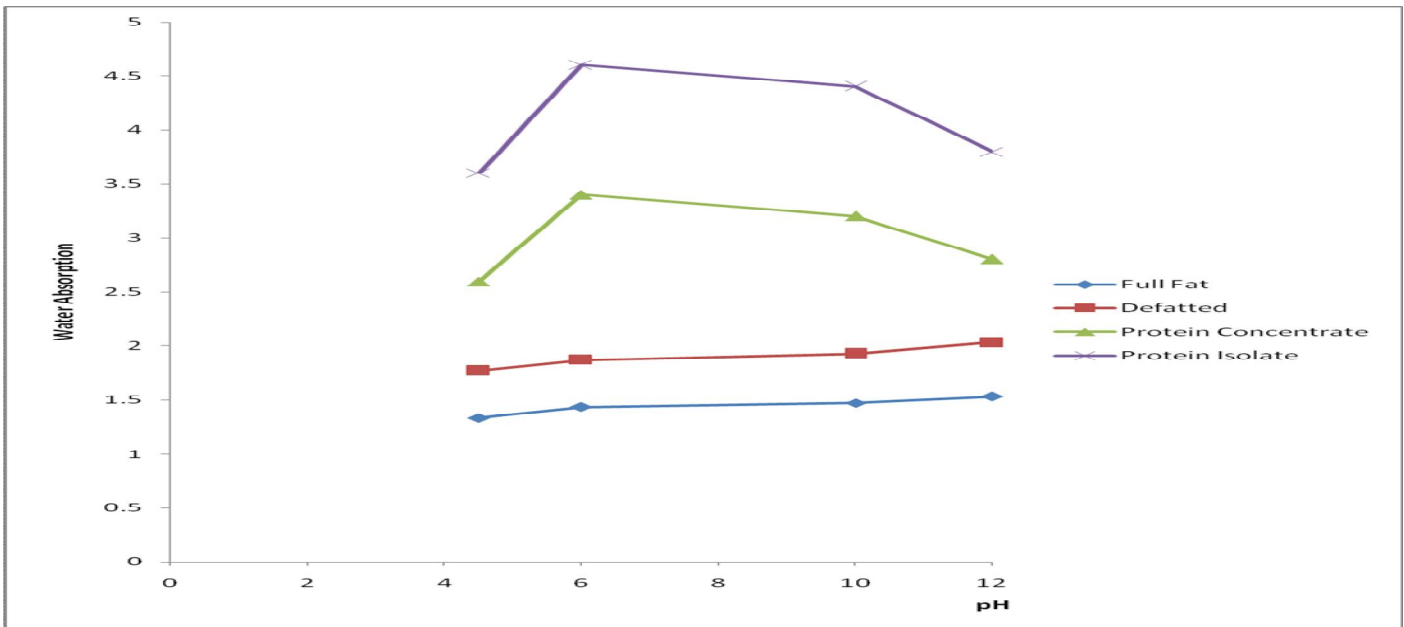


Fig 12: The effect of pH on Water Absorption of Full Fat, Defatted Flour, Protein Concentrate and Protein Isolate.

Conclusion and Recommendations

Conclusion

The result obtained from this study showed that Asparagus bean flour is a good substitute for flour from other legumes such as soy bean, cowpea, in some food formulation. The result from the proximate composition showed that Asparagus bean is highly nutritional especially in protein content. Moreover, the result for the functional properties showed that alkaline pH and increased temperature improved and modified the functional properties of the Asparagus bean flours thus, causing an improvement in the swelling index, emulsion, water absorption and foaming capacity which are important parameters in food formulations and utilization. Hence, data from the functional properties will give a guide to the use of the flours for some food products.

Recommendation

As a result of the potential contribution of Asparagus bean to human nutrition, it is thus recommended to encourage the cultivation and consumption of the bean seeds while research effort should continue to maximize the processing of Asparagus bean. Furthermore, to be more acceptable and useful in food formulations, Asparagus bean should be well dehulled and processed into flour, protein concentrate and isolate.

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