Global Journal of Science Frontier Research
Chemistry
Volume 13 Issue 2 Version 1.0 Year 2013
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Food Properties of Hull, Dehulled and Whole Seed Samples of Bambara Groundnut (*Vigna Subterranea* L. Verdc)

By E.I. Adeyeye, A.A. Olaleye & A.J. Adesina
Ekiti State University

Abstract - The functional properties of the testa, dehulled and whole seed samples of *Vigna subterranea* were examined under different neutral salt concentrations. Parameters examined for were: foaming capacity (FC), foaming stability (FS), water absorption capacity (WAC), emulsion capacity (EC), lowest gelation concentration (LGC) and protein solubility (PS). Results showed that the highest FC was recorded for NaCl at 0.5 % salt concentration, the lowest FC was recorded for Na_2SO_3 at 10 % salt concentration. Most of the present values of FS were lower than those reported for some legumes in literature. WAC values ranged between 250- 400 % (testa), 140-240 % (dehulled) and 100-240 % (whole seeds) in the various salt solutions; high WAC values could make the samples useful replacement in various food formulations such as baked goods and custards. The EC results showed that EC depended on salts concentrations and the type of salts under consideration. LGC results were in the range of 2.0-8.0 % which were mostly lower or within the range of most literature values for leguminous seeds.

Keywords : functional properties, bambara groundnut seed anatomical parts.

GJSFR-B Classification : FOR Code: 259999p

FOOD PROPERTIES OF HULL, DEHULLED AND WHOLE SEED SAMPLES OF BAMBARA GROUNDNUT VIGNA SUBTERRANEA L. VERDC

Strictly as per the compliance and regulations of :

Food Properties of Hull, Dehulled and Whole Seed Samples of Bambara Groundnut (*Vigna Subterranea* L. Verdc)

E.I. Adeyeye [α], A.A. Olaleye [σ] & A.J. Adesina [ρ]

Abstract - The functional properties of the testa, dehulled and whole seed samples of *Vigna subterranea* were examined under different neutral salt concentrations. Parameters examined for were: foaming capacity (FC), foaming stability (FS), water absorption capacity (WAC), emulsion capacity (EC), lowest gelation concentration (LGC) and protein solubility (PS). Results showed that the highest FC was recorded for NaCl at 0.5 % salt concentration, the lowest FC was recorded for Na_2SO_3 at 10 % salt concentration. Most of the present values of FS were lower than those reported for some legumes in literature. WAC values ranged between 250-400 % (testa), 140-240 % (dehulled) and 100-240 % (whole seeds) in the various salt solutions; high WAC values could make the samples useful replacement in various food formulations such as baked goods and custards. The EC results showed that EC depended on salts concentrations and the type of salts under consideration. LGC results were in the range of 2.0-8.0 % which were mostly lower or within the range of most literature values for leguminous seeds. For the five salts used in the analysis (NaCl, Na_2CO_3, Na_2SO_3, $NaNO_3$ and CH_3COONa), the proteins in the samples were more soluble in the basic region of pH. The PS figures mostly showed two distinct peaks meaning that the bambara groundnut samples might be having two major proteins.

Keywords : functional properties, bambara groundnut seed anatomical parts.

I. Introduction

Bambara groundnut (*Vigna subterranea* L. Verdc) is a seed crop of African origin. It is cultivated principally by farmers as a famine culture crop because of its agronomic values and the ability to produce in soils considered insufficiently fertile for cultivation of other more favoured species such as common beans and groundnuts *(Arachis hypogaea*) (Anchirinah*et al.,* 2001). It is very adaptable to hot temperatures but it is also tolerant to rainfall (Wrigley, 1981). Bambara seeds may be consumed in various forms for food. Fresh seeds may be consumed raw, boiled, grilled or dry seeds made into a powdery form to make cakes (Adebowale and Lawal, 2002).

The nutritional potentials of bambara groundnut were documented. The seed is regarded as a balanced food because when compared to most food legumes, it is rich in iron and the protein contains high lysine and methionine (Adu-Dapaah and Sangwan, 2004). In addition, it is known to contain 63% carbohydrates, 18% oil and the fatty acid content is predominmatly linoleic, palmitic and linolenic acids (Minka and Bruneteau, 2000). It was reported also that it is richer than groundnut in essential amino acids such as leucine, isoleucine, lysine, methionine, phenylalanine, threonine and valine (Ihekoronye and Ngoddy, 1985).

Soils of medium or low fertility, with a pH of 5.0 – 6.5 will produce satisfactory crops. Yields of bambara groundnut on low – fertility soils are generally higher than those of groundnut grown on similar soils. Bambara groundnut will often yield well in environments that may be too hostile for more favoured legumes (Collinson*et al.,* 1996).

Recently, Pasquet*et al.* (1999), using isozyme analysis, found high genetic identities between wild and domesticated bambara groundnut accessions and concluded that the wild bambara is the progenitor of the domesticated form, both being characterized by low total genetic diversity.

An evenly distributed rainfall in the range 600-1000mm encourages optimum growth but satisfactory yield can be obtained in areas with pronounced dry season since the crop is relatively drought resistant. It is tolerant to periods of heavy rainfall except during the flowering period.

It has been scientifically declared that bambara bean is high in protein quotient, particularly in methionine which makes its protein more complete than any other bean. The proximate composition of the bambara groundnut was reported to be 9.7% moisture, 16.6% protein, 5.9 % fat, 2.9% ash, 4.9% crude fibre and 64.9% carbohydrate (Enwere and Hung, 1996).

The high concentration of soluble fibre than any other bean also makes it one step ahead of other beans. This further enhances its quality as nutritious food which reduces the incidence of heart disease and certain types of cancer. Also, bambara beans being nitrogen fixers themselves and along with providing the soil with essential nutrients do not require any artificial fertilizer. The use of artificial flavours or preservatives during the food processing is greatly discarded.

Author α σ ρ : Department of Chemistry, Ekiti State University, PMB 5363, Ado-Ekiti, Nigeria. E-mail : eiadeyeye@yahoo.com

Bambara groundnut was reported to have been fairly well supplied with calcium and iron although poor in phosphorus. It contains thiamine, riboflavin, niacin and carotene but very low in ascorbic acid (Oyenuga, 1968).

Several other reports have been made on bambara nut. The swelling capacity increases with increase in temperature (Adebowale*et al*., 2002). Bambara bean is higher in water absorption capacity than that of great Northern bean (Sathe and Salunkhe, 1981).

The water absorption capacity (WAC) of bambara groundnut flour was higher than that of starch (Piyarat, 2008). This result shows that the flour is more hydrophilic due to a higher protein and carbohydrate contents. Also, the higher oil absorption capacity (OAC) in flour could be due to its higher protein and fat contents which can entrap more oil.

The objectives of this research work therefore are to: find out the functional properties of bambara groundnut, reveal the food properties of the samples and hence, their industrial applications in the food industry and provide useful information that can further suggest the consideration of bambara groundnut as an alternative source of nutrients, especially for populations of the developing countries such as Nigeria.

II. Resources and Techniques

a) Sample collection and preparation

The sample (bambara groundnut) was obtained from the Department of Plant Science, Ekiti State University, Ado-Ekiti. The seeds were screened to eliminate the defective ones, washed and rinsed with distilled water. The seeds were divided into two parts. One part was soaked with distilled water overnight while the other part was dried without soaking. The soaked ones were removed after 24 h and were manually dehulled. Both the cotyledon and the testa were dried in an oven at 45 ^{o}C. All the three samples (whole seed, cotyledon and testa) were dry milled separately to fine powder and stored in a dry, cool place prior to use. The three samples were used for various analyses as described below.

b) Preparation of salt solutions

0.5, 1, 2, 5 and 10% (w/v) concentrations of various salts used were prepared by weighing 0.5, 1, 2, 5 and 10g of salts (NaC1, Na_2CO_3, $NaNO_3$ CH_3COONa and Na_2SO_3) which are respectively added to 99.5, 99, 98, 95 and 90 ml of distilled water for each solution to make up to 100g.

Biuret solution was prepared by weighing (30g of NaOH dissolved in 300 ml of distilled water) + (1.5g $CuSO_4.4H_2O$+6.0g potassium sodium tertarate dissolved in 500ml distilled water) and made up to 1dm^3 with distilled water.

c) Determination of foaming capacity and stability

1g of the sample was whipped with 50ml of distilled water for 5 min in a blender at speed set at "max" and was transferred into a 100ml graduated cylinder. Total volume at time interval of 0.0, 0.05, 0.1, 0.2, 0.3 and 1.0 hour was noted to study the foaming stability. Volume increase (%) was calculated according to the equation of Coffman and Garcia (1977) to obtain the foaming capacity.

d) Determination of emulsion activity

2g of the sample, 20ml distilled water, 20ml executive chef vegetable oil was prepared in a calibrated centrifuge tube. The emulsion was centrifuged for 5 minutes. The ratio of the height of the emulsion layer to the total height of the mixture was calculated as the emulsion activity expressed in percentage (Inklaar and Fortuin, 1969).

e) Determination of water and oil absorption capacity

The water and oil absorption capacity of the sample was determined as described by Beuchat (1977). 10cm^3 of water or salt solution was added to 1.0g sample in a centrifuge tube. The suspension was mixed vigorously using vortex mixer. This was then centrifuged for 25 min and the volume of the supernatant left after centrifuging was noted. Water bound was calculated from the difference in volume of the initial volume of the solvent used and the final volume after centrifuging. The same procedure was used for oil absorption capacity (Inklaar and Fortuin, 1969).

f) Determination of least gelation concentration

Appropriate sample suspensions of 2, 4, 6, 8, 10, 12, 14, 16% were prepared in 5ml of distilled water. The test tubes containing these suspensions were heated for 1 hour in boiling water followed by rapid cooling under running tap water. The test tubes were then cooled for 2 hours at 4^{0}C. The least gelation concentration was determined as concentration when the sample from the inverted test tube did not fall down or slip (Coffman and Garcia, 1977).

g) Protein solubility determination

The protein solubilities of the samples at different salts concentration were studied using the Biuret method (Wiechselboven, 1946).

0.5g of the sample was suspended in 10ml of different salt concentrations. The solubility at natural pH was first determined, that is no acid or alkali was added and so solubility in the case was based on the normal pH of the sample in solution. The suspension was centrifuged at room temperature for 30 min at 3,500 rpm. The supernatant obtained was filtered and the protein of filtrate was determined by Biuret method with standard Bovine Serum Albumin (BSA) (Wiechselboven, 1946).

The Biuret method is a convenient assay for large number of samples of relatively soluble proteins. Kjeldahl method is not a rapid and convenient assay although useful for the determination of the amount of protein in crude mixtures.

For the determination of standard protein using Biuret method, 1g of BSA was dissolved in 100ml distilled water in a volumetric flask. Five tubes were set up containing fractions of the BSA solution in the order: 0.0ml, 0.5ml, 1.0ml, 1.5ml, 2.0ml and they were made up to 2ml by adding 2.0ml, 1.5ml, 1.0ml, 0.5ml and 0.0ml of distilled water. The tubes were left to stand for 30 min. The solution from the tube containing 2.0ml distilled water and 8.0ml Biuret solution was used as the blank to standardize the UV spectrophotometer at 450nm. The absorbance of each of the other tubes was also taken. A standard curve was drawn for absorbance against concentration.

The determination of protein of the filtered supernatant in each sample was carried out as follows: 1.0ml of filtrate was pipetted into a test tube and 8ml of Biuret solution was added. The tube was left to stand for 30 min after which the absorbance was taken. The corresponding protein concentration was obtained. The obtained protein concentrations for the various salts were plotted (Oshodi and Ekperigin, 1989).

III. Results and Discussion

a) *Foaming Capacity (FC)*

Tables 1-3 present the foaming capacity (FC) of bambara groundnut: testa, dehulled and whole seeds under various salts and salt concentrations. The Tables revealed that foaming capacity depends on concentration and types of salts used. There was a decrease in the foaming capacity with increase in concentration of salt from 0.5 to 10%. The FC values in Table 1 showed that the FC was 9.0 cm^3 (18.0%) at zero percent concentration (water only). The FC ranged from 2.0cm^3 (4.0%)-7.0cm^3 (14.0%) for NaCl, 2.0cm^3 (4.0%) – 6.50cm^3 (13.0%) for Na_2CO_3, 2.0cm^3 (4.0%) – 4.0cm^3 (8.0%) for $NaNO_3$, 2.0cm^3 (4.0%) – 5.0cm^3 (10.0%) for CH_3COONa and 2.0cm^3 (4.0%) – 5.50cm^3 (11.0%) for Na_2SO_3. Highest foaming capacity was reported for NaCl at 0.5% salt concentration whereas lowest foaming capacity was reported for NaCl at 5% and 10% salt concentrations, Na_2CO_3 at 10%, $NaNO_3$ at 5%, CH_3COONa at 10% and Na_2SO_3 at 5 and 10% salt concentrations in testa. In dehulled (Table 2), highest FC was recorded for Na_2SO_3 at 1.0% salt concentration and NaCl at 0.5% and the lowest for NaCl and Na_2CO_3 at 10% and CH_3COONa at 2% and 10% salt concentrations. In Table3, for whole seeds, most of the FC values were fairly higher than those recorded for testa and dehulled samples. While the highest FC was recorded for NaCl at 0.5% salt concentration, the lowest FC was recorded for Na_2SO_3 at 10% salt concentration. Fairly high variation in foaming capacity existed within the salt concentrations in all the samples as shown by the CV%. The values of foaming capacity in all the three samples were lower than the values earlier reported for hulled seed flours of African yam bean (AYB) (39.9-55.4%) and dehulled AYB seeds (21.3-48.4%) (Adeyeye and Aye, 1998). The low foaming capacities will reduce the functionality of bambara groundnut in its uses for the production of some foods where foaming is an important factor like cakes (Johnson *et al.,* 1979; Lee *et al.,* 1993).

b) *Foaming Stability (FS)*

The foaming stability (FS) values for testa are presented in Tables 4 (NaCl), 5 (Na_2CO_3), 6 ($NaNO_3$), 7 (CH_3COONa) and 8 (Na_2SO_3). The order of increasing foaming stability among the salts were Na_2CO_3 (rate= 0.0-3.75% min^{-1})< Na_2SO_3 (rate = 0.0-10.0%min^{-1}) <NaCl (rate =1.19-10.0% min^{-1}) < $NaN0_3$ (rate = 2.5-10.0 % min^{-1}) < CH_3COONa (rate = 2.67-10.0 % min^{-1}). The best concentration of NaCl was 0.5% (w/v), 1.0% (w/v) in Na_2CO_3, 1.0% (w/v) in $NaNO_3$, 0.5% (w/v) in CH_3COONa and 0.5% (w/v) in Na_2SO_3.

The foaming stability of dehulled bambara groundnut in Tables 9-13 revealed that the best NaCl concentration was 1.0% (w/v), 2.0% (w/v) for Na_2CO_3,1.0% (w/v) for $NaNO_3$, 5.0% for CH_3COONa and 1.0% (w/v) for Na_2SO_3. Also, in whole seeds (Tables 14-18), the best concentration of NaCl, Na_2CO_3, $NaNO_3$ and Na_2SO_3 was 0.5% (w/v) whereas, 1.0% (w/v) was best in CH_3COONa. Most of the present values of FS% were lower than those reported for AYB seeds (Adeyeye and Aye, 1998), pigeon pea (Oshodi and Ekperigin, 1989) and raw cowpea flour (Padmashree*et al.,* 1987). Foaming stability is important since success of a whipping agent depends on its ability to maintain the whip as long as possible.

c) *Water absorption capacity (WAC)*

The water absorption capacity (WAC) values of bambara groundnut samples: testa, dehulled and whole seeds are shown in Tables 19 (testa), 20 (dehulled) and 21 (whole seeds). The WAC in distilled water was 280%. The values ranged between 250-400% in testa, 140-240% in dehulled and 100-240% in whole seeds in the various salt solutions. The WAC values in various salt solutions were close in all the samples as seen in the coefficients of variation percent (CV %). In testa, the best salts for WAC property were NaCl particularly at 1.0% (w/v) and Na_2CO_3 at 2.0% (w/v) salt concentrations. In dehulled, the best salt was CH_3COONa particularly at 5.0% (w/v) whereas in whole seeds, the best salt for WAC property was Na_2SO_3. All the values in the testa and most of the values in dehulled and whole seeds were comparatively higher than the WAC of 138% reported for pigeon pea flour (Oshodi and Ekperigin, 1989), 130% for soy flour, 107% for sunflower and 60.2%

Global Journal of Science Frontier Research (B) Volume XIII Issue II Version I Year 2013

for wheat flour (Lin *et al.,* 1974) but compared favourably with that of cowpea flour (246%) (Olaofe *et al.,*1993). The high values of WAC in bambara groundnut could make it a useful replacement in viscous food formulations such as baked goods and custards.

d) Emulsion Capacity (EC)

Tables 22–24 present the emulsion capacity (EC) of bambara groundnut testa, dehulled and whole seeds. The results showed that emulsion capacity depended on salt concentrations and the types of salts under consideration. A gradual increase in EC was observed with increase in salt concentrations in NaCl solution in all the samples and CH_3COONa in testa. There was a progressive increase up to 2.0% generally in Na_2CO_3 solution; in Na_2SO_3 solution (testa and whole seeds) and CH_3COONa (dehulled) after which it decreased up to 5.0% and later increased up to 10.0%. Low levels of the coefficients of variation showed that the emulsion capacity values in the various salt concentrations were close in the present report. The present report was fairly better than the 18.0% reported for soy flour and 11.0% for wheat flour (Lin *et al.,* 1974).

e) Lowest gelation concentration (LGC)

The variation in lowest gelation concentration with increase in concentration of salts of bambara groundnut samples: testa, dehulled and whole seeds are indicated in Tables 25, 26 and 27 respectively. The salt free values ranged from 2.0-8.0% while the various salt concentration values ranged from 4.0- 8.0% (NaCl), 4.0-8.0% (Na_2CO_3), 4.0-6.0% ($NaNO_3$), 4.0-8.0% (CH_3COONa) and 4.0-8.0% (Na_2SO_3) (for testa); 2.0-4.0% (NaCl), 2.0-4.0% (Na_2CO_3), 2.0-6.0% ($NaNO_3$),2.0-4.0% (CH_3COONa) and 2.0-6.0% (Na_2SO_3) (for dehulled) and 6.0-8.0% (NaCl), 6.0-8.0% (Na_2CO_3), 6.0-8.0% ($NaNO_3$), 6.0-8.0% (CH_3COONa) and 6.0-8.0% (Na_2SO_3) (for whole seeds). Most of these values were lower or within the range of most literature values for leguminous seeds (Oshodi and Ekperigin, 1989; Adeyeye and Aye, 1998). The variation in the gelation concentration of the samples under different salt concentrations and anions might be due to their different effects on the relative ratios of different constituents: proteins, lipids and carbohydrates (Sathe*et al.,* 1982). The low CV% of lowest gelation concentration among the various salts showed that the results were very close.

f) Protein Solubility (PS)

The solubility of proteins is greatly influenced by pH, as might be expected from their amphoteric behaviour; solubility is at a minimum at the isoelectric point and increases with increasing alkalinity or acidity. It is worthy of note that each protein has a definite solubility in a solution of a fixed salt concentration and pH. The effect of salts in increasing the solubility of globulins is called the "salting-in" effect. The solubility is a function of the ionic strength, which is usually calculated from the molar concentrations of the ions and their charge using the expression: $\mu = \frac{1}{2}\, \varepsilon m z^2$ where μ is the ionic strength, m is the molarity and z, the charge of the ion, the ε denotes that mz^2 terms are added for each of the ions (White *et al.,* 1973) (Table 28). Neutral salts are known to exert striking effects on the solubility, the association-dissociation equilibrium, the enzyme activity, the stability of natural and fibrillar structures and the rate of conformational change of proteins, polypeptides and nucleic acids (Oshodi and Ojokan, 1997). The dependence of protein solubility with pH in the presence of salts is presented in Figures 1-.2.5 Figures 1-5 depict the protein solubility (PS) in different salts/pH of testa. The minimum solubility pH (considering just one or two concentrations) was pH 3 (10%) in Na_2SO_4, pH 3 (10%) in Na_2CO_3;pH 10 (2%) in Na_2SO_3, pH 8 (10%) in CH_3COONa, pH 3 or 5 (2%) and pH 4 (5%) in $NaNO_3$ .In dehulled sample (Figures 6 -10), the maximum solubility pH (taking the best two concentrations) was 12 (0.5%) and 11 (2%) in Na_2SO_4, pH 12 (10%) and 9 (2%) in Na_2CO_3, pH 9 (10%) and 7 (2%) in Na_2SO_3, pH 1 (2%) and 1 (1%) in CH_3COONa and pH 12 (2%) and 7 (10%) in $NaNO_3$. In whole seeds (Figures 11-15), the maximum solubility pH was pH 9 (1.0%) in Na_2SO_4, pH 1 or 10 (5.0%) in Na_2CO_3, pH 10 (0.5%) and pH 7 (10.0%) in Na_2SO_3, pH 12 (5.0%) in CH_3COONa and pH 9 (10.0%).

The minimum solubilities (pI) were recorded for various salts at various concentrations, viz: Na_2CO_3, 2.31% ($8.5x10^{-3}$M or 10%); $NaNO_3$, 6.94 ($2.3x10^{-3}$M or 2.0% and 5.6x 10^{-3}M or 5.0%); Na_2SO_3 3.7 (7.1x 10^{-3}M or 10.0%); CH_3COONa, 4.63 ($1.1x10^{-2}$M or 10.0%) [testa], Na_2CO_3, 5.41 ($9.3x10^{-4}$ M or 1.0% and $1.8x10^{-3}$M or 2.0%); Na_2SO_3, 1.27 ($3.8x10^{-3}$ M or 2.0%); $NaNo_3$, 0.64 (5.9 $x10^{-4}$ M or 0.5%); $NaNO_3$, 0.64 ($5.9x10^{-4}$ M or 0.5%); Na_2SO_3, 1.27 (3.8 x 10^{-3} M or 5.0%); CH_3COONa, 1.59(1.1 x 10^{-2} M or 10.0%) [dehulled] and Na_2CO_3, 7.75 (4.7 x 10^{-4} M or 0.5%); $NaNO_3$, 6.81 (5.9 x 10^{-4} M or 0.5%); Na_2SO_3, 9.84 (7.9 $x10^{-4}$ M or 1.0%, $1.6x10^{-3}$ M or 2.0%. and 3.8 x 10^{-3} M or 5.0%); CH_3COONa, 6.05 ($6.1x10^{-4}$ M or 0.5%w/v) [whole seeds]. Maximum solubility values varied similarly viz: Na_2CO_3 16.2 ($4.7x10^{-4}$ M or 0.5%); $NaNO_3$, 12.0 ($1.2x10^{-3}$M or 1.0%); Na_2SO_3 10.7 ($7.9x10^{-4}$ M or 1.0%); CH_3COONa, 11.6 ($2.4x10^{-3}$ M or 2.0% and $5.8x10^{-3}$ M or 5.0% w/v) [testa], Na_2CO_3, 10.8 ($8.5x10^{-3}$ M or 10.0%); $NaNO_3$, 7.64 ($2.3x10^{-3}$ M or 2.0% and $1.1x10^{-2}$ M or 10.0%); Na_2SO_3 6.36 ($7.1x10^{-3}$ M or 10.0%); CH_3COONa, 8.0 ($2.4x10^{-3}$ M or 2.0% w/v) [dehulled] and Na_2CO_3, 12.1 ($4.5x10^{-3}$ M or 5.0%); $NaNO_3$, 13.2 ($1.1x10^{-2}$ M or 10.0%); Na_2SO_3 12.9 ($3.9x10^{-4}$ M or 0.5% and $7.1x10^{-3}$ M or 10.0%); CH_3COONa, 11.4 ($5.8x10^{-3}$ M or 5.0% w/v) [whole seeds]. The lyotropic series is therefore in the order: $CO_3^{2-} > NO_3^- > CH_3COO^- > SO_3^{2-}$ (testa), $CO_3^{2-} > CH_3COO^- > NO_3^- > SO_3^{2-}$ (dehulled) and $NO_3^- > SO_3^{2-} > CO_3^{2-} > CH_3COO^-$ (whole seeds).

It was generally observed that for the five salts used in the analysis, the proteins in the bambara groundnut samples were more soluble in the basic region of pH. The electrostatic interactions (ionization of interior non-polar groups) are more important in hydration of proteins than the surface charge. This might contribute to the improved protein solubility in the alkaline region. Also, most of the figures showed two distinct peaks meaning that the bambara groundnut samples: testa, dehulled and whole seeds might be having two major proteins.

IV. Conclusion

The samples were good in water absorption capacity and emulsion capacity but foaming capacity and stability are not favourable. It could therefore be concluded that bambara groundnut should be dehulled when it is being used as food supplement especially for infants.

References Références Referencias

1. Adebowale, K.O., and Lawal, O.S. (2002). Effect of annealing and heat moisture conditioning on the physiological characteristics of bambara groundnut (*Voandzeia subterranean*) starch. *Nahrung/ Food*, 46, 311-316.
2. Adeyeye, E.I., and Aye, P.A. (1998). The effects of samples preparation on the proximate composition and the functional properties of the African yam bean (*Sphonostylisstenocarpa*Hochst ex A. Rich) flours. Note1. *La RivistaItalianaDelleSostanze Grasse*, LXXV – *Magio*, 253-261.
3. Adu-Dapaah, H.K. and Sangwan, R.S. (2004). Improving bambara groundnut productivity using gamma irradiation and in vitro techniques. *African Journal of Biotechnology*, 3 (5), 260-265.
4. Anchirinah, V.M., Yiridoe, E.K., Benneh-Lartey, S.O. (2001). Enhancing sustainable production and genetic resources conservation of bambara groundnut: A survey of indigenous agricultural knowledge system. *Outlook on Agric.*, 30, 281-288.
5. Beuchat, L.R. (1977). Functional and electrophoretic characteristics of succinylated peanut flour protein. *J. Agric. Food Chem.*, 25, 258-261.
6. Coffman, C.W., and Garcia, V.C. (1977). Functional properties and amino acid content of a protein isolate from mung bean flour. *J. Food Tech.*, 12, 437-484.
7. Collinson, S.T., Azam-Ali,S.N. Chavula, K.M., Hodson, D.A. (1996). Growth, development and yield of bambara groundnut (Vigina subterranea) in response to soil moisture. *J. Agric. Sci.*, 126, 307-318.
8. Enwere, N.J., and Hung, Y.C. (1996). Some chemical and physical properties of bambara groundnut (Voandzeia subterranean Thouars) seed and products. *Int.J. Food Sci. Nutri.*, 47 (6), 469-475.
9. Ihekoronye, A.I. and Ngoddy, P.O. (1985). *Integrated Food Science and Technology for the Tropics topics.* London, *Macmillan Publishers*.
10. Inklaar, P.A., and Fortuin, J. (1969). Determining emulsifying and emulsion stabilizing capacity of protein meat additives. *J. Food Tech.*, 23, 103-105.
11. Johnson, L.A., Haved, E.F., Hoseney, R.S. (1979). Bovine Plasma as a replacement for egg in cakes. *Cereal Chemistry,* 56, 339-343.
12. Lee, C.C., Love J.A., Johnson L.A. (1993). Sensory and physical of cakes with bovine plasma products substituted for egg. *Cereal Chem.*, 70, 18-23.
13. Lin, M.J.Y., Humbert, E.S., Sosulski, E.W. (1974). Certain functional properties of sun flower meal products. *J. FoodSci.,* 39, 368-370.
14. Minka, S.R., and Bruneteau, M. (2000). Partial chemical composition of bambara pea (*Vigna subterranea* (L) Verdc). *Food Chem.,* 68, 273-276.
15. Olaofe, O., Umar, Y.O., Adediran, G.O. (1993). The effect of nematicides on the nutritive value and functional properties of cowpea seeds. *Food Chem.,* 46, 337-342.
16. Oshodi, A.A., and Ekperign, M.M. (1989). Functional properties of pigeon pea (*Cajanuscajan*) flour. *Food Chemistry,* 34, 187-191.
17. Oshodi, A.A., Ojokan, E. (1997). Effects of salts on some of the functional properties of bovine plasma protein concentrate. *Food Chem.*, 59, 333-338.
18. Oyenuga, V.A. (1968). *Nigeria's Foods and Feeding-stuffs. Their Chemistry and Nutritive value. Ibadan University Press.*
19. Padmashree, T.S., Vijayalashmi L. Puttaraj S. (1987). Effect of traditional processing on the functional properties of cowpea (*Vignacatjang)* flour. *J. Food Sci. Tec.*, 24, 221-225.
20. Pasquet, R.S., Schwedes, S., Gepts, P. (1999). Isozyme diversity in bambara groundnut. *Crop Sci.*, 39, 1228-1236.
21. Piyarat, S. (2008). Structure and functional properties of starch and flour from bambara groundnut. *Songklanakarin J. Sci. Technol.*, 30, (Suppl.1), 51-56.
22. Sathe, S.K.,Salunkhe, D.K. (1981). Functional properties of the great northern bean(*Phaseolus vulgaris L.*) proteins,emulsion, foaming, viscosity and gelation properties. J. Food Sci., 46, 71-76.
23. Sathe, S.K., Deshpande, S.S., Salunkhe, D.K. (1982). Functional properties of winged bean proteins. *J. Food Sci.*, 47, 503-509.
24. White, A., Hander, P, Smith, E.I. (1973). *Principles of biochemistry*, 5th ed. Tokyo, McGraw Hill Kogakusha Ltd.
25. Wiechselboven, T.E. (1946). Biuret method of protein determination. *Am. J. Clin. Path.*, 16, 40-44.

26. Wrigley, G. (1981). *Tropical Agriculture*. London, Longman.

Table 1 : Foaming capacity (cm^3) of bambara groundnut testa in var ous salt concentrations

Salt	Sal concentrations (%) 0.0	0.5	1.0	2.0	5.0	10.0	Mean	SD	CV%
NaCl	9.0(18.0)	7.0(14.0)	5.0(10.0)	3.0(60)	2.0(4.0)	2.0(4.0)	4.67	2.88	61.7
Na_2CO_3	9.0(18.0)	6.50(13.0	6.0(12.0)	4.0(8.0)	3.50(7.0)	2.0(4.0)	5.17	2.50	48.4
$NaNO_3$	9.0(18.0)	3.0(6.0)	4.0(8.0)	3.50(7.0)	2.0(4.0)	4.0(8.0)	4.25	2.44	57.4
CH_3COONa	9.0(18.0)	5.0(10.0)	5.0(10.0)	4.0(8.0)	3.0(6.0)	2.0(4.0)	4.42	2.46	55.7
Na_2SO_3	9.0(18.0)	5.50(11.0)	4.0(8.0)	3.0(6.0)	2.0(4.0)	2.0(4.0)	4.25	2.68	63.1

Note: The values inside the brackets represent the corresponding percentage values. Mean, SD and CV% were calculated based on volume.

Table 2 : Foaming capacity (cm^3) of dehulledbambaragroundnut in various salt concentrations

Salt	Salt concentrations (%) 0.0	0.5	1.0	2.0	5.0	10.0	Mean	SD	CV%
NaCl	5.0(10.0)	6.0(12.0)	5.50(11.0)	3.0(6.0)	3.0(6.0)	2.0(4.0)	4.08	1.63	40.0
Na_2CO_3	5.0(10.0)	3.0(6.0)	4.0(8.0)	5.0(10.0)	3.50(7.0)	2.0(4.0)	3.75	1.17	31.2
$NaNO_3$	5.0(10.0)	3.0(6.0)	3.50(7.0)	4.0(8.0)	3.0(6.0)	2.50(5.0)	3.50	0.89	25.4
CH_3COONa	5.0(10.0)	4.0(8.0)	3.0(6.0)	2.0(4.0)	3.0(6.0)	2.0(4.0)	3.17	1.17	36.9
Na_2SO_3	5.0(10.0)	5.0(10.0)	6.0(12.0)	4.0(8.0)	3.0(6.0)	2.50(5.0)	4.25	1.33	31.3

Table 3 : Foaming capacity (cm^3)of bambara groundnut wholeseeds in various salt concentrations

Salt	Salt concentrations (%) 0.0	0.5	1.0	2.0	5.0	10.0	Mean	SD	CV%
NaCl	13.0(26.0)	12.0(24.0)	10.0(20.0)	11.0(22.0)	8.0(16.0)	6.0(12.0)	10.0	2.61	26.1
Na_2CO_3	13.0(26.0)	7.0(14.0)	6.0(12.0)	4.0(8.0)	3.0(6.0)	2.50(5.0)	5.92	3.88	65.5
$NaNO_3$	13.0(26.0)	10.0(20.0)	8.0(16.0)	6.0(12.0)	7.0(14.0)	4.0(8.0)	8.0	3.16	39.5
CH_3COONa_3	13.0(26.0)	6.0(12.0)	5.0(10.0)	3.0(6.0)	3.0(6.0)	2.0(4.0)	5.33	4.03	75.6
Na_2SO_3	13.0(26.0)	5.0(10.0)	3.50(7.0)	4.0(8.0)	2.0(4.0)	1.50(3.0)	4.83	4.20	87.0

Table 4 : Foaming stability (%) of bambara groundnut testa using NaCl

Time (min)	Salt concentrations (%) 0.0	0.5	1.0	2.0	5.0	10.0	Mean	SD	CV%
0	100(9.0)	100(7.0)	100(5.0)	100(3.0)	100(2.0)	100(2.0)	100	0.0	0.0
5	88.9(8.0)	85.7(6.0)	80.0(4.0)	66.7(2.0)	50.0(1.0)	100(2.0)	78.6	17.8	22.6
10	77.8(7.0)	71.4(5.0)	60.0(3.0)	66.7(2.0)	0.0(0.0)	50.0(1.0)	54.3	28.3	52.1
20	66.7(6.0)	4.0(57.1)	40.0(2.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	27.3	31.1	114
30	55.6(5.0)	42.9(3.0)	20.0(1.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	19.8	24.5	125
60	44.5(4.0)	28.6(2.0)	0.0(0.0)	0.0(0.0)	0.0().0)	0.0(0.0)	12.8	19.5	152
90	223(2.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	3.7	9.1	246
Rate	0.86	1.19	2.67	3.33	10.0	5.0	3.84	3.37	87.8

Table 5 : Foaming stability (%) of bambara groundnut testa using Na_2CO_3

	Salt concentrations (%)						Mean	SD	CV%
Time (min)	0.0	0.5	1.0	2.0	5.0	10.0			
0	100(9.0)	100(6.5)	100(6.0)	100(4.0)	100(3.5)	100(2.0)	100	0.0	0.0
5	88.9(8.0)	76.9(5.0)	83.3(5.0)	75.0(3.0)	57.1(2.0)	100(2.0)	80.2	14.5	18.1
10	77.8(7.0)	61.5 (4.0)	83.3(5.0)	50.0(2.0)	28.6(1.0)	0.0(0.0)	50.2	31.5	62.7
20	66.7(6.0)	46.2(3.0)	66.0(4.0)	25.0(1.0)	28.6(1.0)	0.0(0.0)	38.9	26.1	67.1
30	55.6(5.0)	30.8(2.0)	50.0(3.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	22.7	26.2	115
60	44.5(4.0)	30.8(2.0)	33.3(2.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	18.1	20.4	113
90	22.3(2.0)	15.4(1.0)	33.3(2.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	11.8	14.2	120
Rate	0.86	0.94	0.74	3.5	3.57	0.0	1.64	1.60	97.6

Table 6 : Foaming stability (%) of bambara groundnut testa using $NaNO_3$ salt concentrations

	Salt concentrations (%)						Mean	SD	CV%
Time (min)	0.0	0.5	1.0	2.0	5.0	10.0			
0	100(9.0)	100(3.0)	100(4.0)	100(3.50)	100(2.0)	100(4.0)	100	0.0	0.0
5	88.9(8.0)	66.7(2.0)	75.0(3.0)	57.1(2.0)	50.0(1.0)	75.0(3.0)	68.8	14.0	20.3
10	77.8(7.0)	33.3(1.0)	50.0(2.0)	28.6(1.0)	0.0(0.0)	50.0(2.0)	40.0	26.1	65.3
20	66.7(6.0)	0.0(0.0)	50.0(2.0)	0.0(0.0)	0.0(0.0)	25.0(1.0)	23.6	29.1	123
30	55.6(5.0)	0.0(0.0)	25.0(1.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	13.4	23.0	172
60	44.5(4.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	7.42	18.2	245
Rate	0.93	6.67	2.50	7.14	10.0	3.75	5.17	3.36	65.0

Table 7 : Foaming stability (%) of bambara groundnut testa using CH_3COONa

	Salt concentrations (%)						Mean	SD	CV%
Time (min)	0.0	0.5	1.0	2.0	5.0	10.0			
0	100(90)	100(5.0)	100(4.0)	100(3.0)	100(3.5)	100(2.0)	100	0.0	0.0
5	88.9(8.0)	80.0(4.0)	75.0(3.0)	66.7(2.0)	85.7(3.0)	50.0(1.0)	74.4	14.3	19.2
10	77.8(7.0)	60.0(3.0)	50.0(2.0)	33.3(1.0)	57.1(2.0)	0.0(0.0)	46.4	26.9	85.0
20	66.7(6.0)	40.0(2.0)	25.0(1.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	22.0	27.5	125
30	55.6(5. 0)	20.0(1.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	12.6	22.5	179
60	44.5(4.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	7.42	18.2	68.0
Rate	0.93	2.67	3.75	6.67	4.29	10.0	4.72	3.21	68.0

Table 8 : Foaming stability (%) of bambara groundnut testausing Na_2SO_3

	Salt concentrations (%)						Mean	SD	CV%
Time (min)	0.0	0.5	1.0	2.0	5.0	10.0			
0	100(9.0)	100(5.5)	100(4.0)	100(3.0)	100(2.0)	100(2.0)	100	0.0	0.0
5	88.9(8.0)	72.7(4.0)	75.0(3.0)	66.7(2.0)	100(2.0)	50.0(1.0)	75.6	17.4	23.0
10	77.8(7.0)	54.5(3.0)	50.0(2.0)	33.3(1.0)	0.0(0.0)	0.0(0.0)	35.9	31.3	87.2
20	66.7(6.0)	36.4(2.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	17.2	28.3	165
30	55.6(5.0)	18.2(1.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	12.8	22.4	175
60	44.5(4.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	7.42	18.2	245
Rate	0.93	2.73	5.0	6	0 .0	10.0	4.22	3.76	89.1

Global Journal of Science Frontier Research (B) Volume XIII Issue II Version I Year 2013

Table 9 : Foaming stability (%) of dehulledbambara groundnut using NaCl

	Salt concentrations (%)						Mean	SD	CV%
Time (min)	**0.0**	**0.5**	**1.0**	**2.0**	**5.0**	**10.0**			
0	100(5.0)	100(6.0)	100(5.50)	100(3.0)	100(3.0)	100(2.0)	100	0.0	0.0
5	80.0(4.0)	83.3(5.0)	90.9(5.0)	66.7(2.0)	66.7(2.0)	50.0(1.0)	72.9	14.7	20.2
10	60.0(3.0)	66.7(4.0)	90.9(5.0)	33.3(1.0)	66.7(2.0)	0.0(0.0)	52.9	31.8	60.1
20	40.0(2.0)	50.0(3.0)	72.7(4.0)	0.0(0.0)	33.3(1.0)	0.0(0.0)	32.7	28.6	87.5
30	20.0(1.0)	33.3(2.0)	54.5(3.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	18.0	22.5	125
60	0.0(0.0)	0.0(0.0)	36.4(2.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	6.07	14.9	245
Rate	2.67	2.22	1.06	6.67	3.34	10.0	4.33	3.36	77.6

Table 10 : Foaming stability (%) of dehulledbambara groundnut using Na_2CO_3

	Salt concentrations (%)						Mean	SD	CV%
Time (min)	**0.0**	**0.5**	**1.0**	**2.0**	**5.0**	**10.0**			
0	100(5.0)	100(3.0)	100(4.0)	100(5.0)	100(3.5)	100(2.0)	100	0.0	0.0
5	80.0(4.0)	66.7(2.0)	75.0(3.0)	80.0(4.0)	85.7(3.0)	50.0(1.0)	72.9	13.0	17.8
10	60.0(3.0)	33.3(1.0)	50.0(2.0)	60.0(3.0)	57.1(2.0)	50.0(1.0)	51.7	10.1	19.5
20	40.0(2.0)	0.0(0.0)	25.0(1.0)	40.0(2.0)	28.6(1.0)	0.0(0.0)	22.3	18.3	82.1
30	20.0(1.0)	0.0(0.0)	0.0(0.0)	40.0(2.0)	0.0(0.0)	0.0(0.0)	10.0	16.7	167
60	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0	0.0	0.0
Rate	2.67	6.67	3.75	2.0	3.57	5.0	3.94	1.69	42.9

Table 11 : Foaming stability (%) of dehulledbambara groundnut using $NaNO_3$

	Salt concentrations (%)						Mean	SD	CV%
Time (min)	**0.0**	**0.5**	**1.0**	**2.0**	**5.0**	**10.0**			
0	100(5.0)	100(3.0)	100(3.50)	100(4.0)	100(3.0)	100(2.50)	100	0.0	0.0
5	80.0(4.0)	66.7(2.0)	85.7	75.0(3.0)	66.7(2.0)	80.0(2.0)	75.7	7.74	10.2
10	60.0(3.0)	33.3(1.0)	57.1(2.0)	50.0(2.0)	33.3(1.0)	40.0(1.0)	45.6	11.8	25.9
20	40.0(2.0)	0.0(0.0)	28.6(1.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	11.4	18.1	159
30	20.0(1.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	3.33	8.16	245
60	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0	0.0	0.0
Rate	2.67	6.67	3.57	5.0	6.67	6.0	5.10	1.67	32.7

Table 12 : Foaming stability (%) of dehulledbambara groundnut usingCH_3COONa

	Salt concentrations (%)						Mean	SD	CV%
Time (min)	**0.0**	**0.5**	**1.0**	**2.0**	**5.0**	**10.0**			
0	100(5.0)	100(4.0)	100(3.0)	100(2.0)	100(3.0)	100(2.0)	100	0.0	0.0
5	80.0(4.0)	75.0(3.0)	66.7(2.0)	50.0(1.0)	83.3(2.50)	50.0(1.0)	67.5	14.7	21.8
10	60.0(3.0)	50.0(2.0)	0.0(0.0)	0.0(0.0)	66.7(2.0)	50.0(1.0)	37.8	30.0	79.4
20	40.0(2.0)	25.0(1.0)	0.0(0.0)	0.0(0.0)	33.3(1.0)	0.0(0.0)	16.4	18.6	113
30	20.0(1.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	3.33	8.16	245
60	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0	0.0	0.0
Rate	2.67	3.75	6.66	10.0	3.34	5.0	5.24	2.73	52.1

Table 13 : Foaming stability (%) of dehulledbambara groundnut using Na_2SO_3

	Salt concentrations (%)						Mean	SD	CV%
Time (min)	0.0	0.5	1.0	2.0	5.0	10.0			
0	100(5.0)	100(5.0)	100(6.0)	100(4.0)	100(3.0)	100(2.50)	100	0.0	0.0
5	80.0(4.0)	80.0(4.0)	83.3(5.0)	75.0(3.0)	66.7(2.0)	80.0(2.0)	77.5	5.92	7.6
10	60.0(3.0)	60.0(3.0)	66.7(4.0)	50.0(2.0)	66.7(2.0)	40.0(1.0)	57.2	10.4	18.2
20	40.0(2.0)	40.0(2.0)	50.0(3.0)	25.0(2.0)	33.3(1.0)	0.0(0.0)	31.4	17.5	55.7
30	20.0(1.0)	20.0(1.0)	33.3(2.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	12.2	14.2	116
60	0.0(0.0)	0.0(0.0)	33.3(2.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	5.55	13.6	245
Rate	2.67	2.67	1.11	3.57	3.34	6.0	3.26	1.62	49.7

Table 14 : Foaming stability (%) of bambara groundnut whole seed using NaCl

	Salt concentrations (%)						Mean	SD	CV%
Time (min)	0.0	0.5	1.0	2.0	5.0	10.0			
0	100(13.0)	100(12.0)	100(10.0)	100(11.0)	100(8.0)	100(6.0)	100	0.0	0.0
5	92.3(12.0)	91.7(11.0)	90.0(9.0)	72.7(8.0)	87.5(7.0)	83.3(5.0)	86.3	7.41	8.6
10	84.0(11.0)	83.3(10.0)	80.0(8.0)	63.6(7.0)	75.0(6.0)	66.7(4.0)	75.5	8.75	11.6
20	76.9(10.0)	66.7(8.0)	70.0(7.0)	54.5(6.0)	62.5(5.0)	50.0(3.0)	63.4	9.96	15.7
30	69.2(9.0)	58.3(6.0)	60.0(6.0)	45.5(5.0)	50.0(4.0)	33.3(2.0)	52.7	12.6	23.9
60	61.5(7.0)	41.7(5.0)	40.0(4.0)	27.3(3.0)	25.0(2.0)	16.7(1.0)	36.8	16.9	45.9
90	53.8(7.0)	41.7(6.0)	30.0(3.0)	18.2(2.0)	12.5(1.0)	0.0(0.0)	26.0	19.8	76.2
Rate	0.51	0.65	0.78	0.91	0. 97	1.39	0.87	0.31	35.6

Table 15 : Foaming stability (%) of bambara groundnut whole seed using Na_2CO_3

	Salt concentrations (%)						Mean	SD	CV%
Time (min)	0.0	0.5	1.0	2.0	5.0	10.0			
0	100(13.0)	100(7.0)	100(6.0)	100(4.0)	100(3.0)	100(2.50)	100	0.0	0.0
5	92.3(12.0)	85.7(6.0)	83.3(6.0)	75.0(3.0)	66.7(2.0)	40.0(1.0)	73.8	18.8	25.5
10	84.6(11.0)	71.4(5.0)	66.7(4.0)	50.0(2.0)	33.3(1.0)	0.0(0.0)	51.0	30.7	60.2
20	76.9(10.0)	57.1(4.0)	50.0(3.0)	25.0(1.0)	0.0(0.0)	0.0(0.0)	34.8	31.7	90.1
30	69.2 (9.0)	42.9(3.0)	33.3(2.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	24.2	29.0	120
60	61.5(8.0)	28.6(2.0)	16.7(1.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	17.8	24.4	137
90	53.8(7.0)	14.3(1.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	11.4	21.6	189
Rate	0.51	0.95	1.39	3.75	6.67	12.0	4.21	4.45	106

Table 16 : Foaming stability (%) of bambara groundnut whole seedusing $NaNO_3$

	Salt concentrations (%)						Mean	SD	CV%
Time (min)	0.0	0.5	1.0	2.0	5.0	10.0			
0	100(13.0)	100(10.0)	100(8.0)	100(6.0)	100(7.0)	100(4.0)	100	0.0	0.0
5	92.3(12.0)	90.0(9.0)	87.5(7.0)	83.3(5.0)	85.7(6.0)	75.0(3.0)	85.6	6.09	7.1
10	84.6(11.0)	80.0(8.0)	75.0(6.0)	66.7(6.0)	71.4(5.0)	50.0(2.0)	71.3	12.2	17.1
20	76.9(10.0)	70.0(7.0)	62.5(5.0)	50.0(3.0)	57.1(4.0)	50.0(2.0)	61.1	10.9	17.8
30	69.2(9.0)	60.0(6.0)	50.0(4.0)	33.3(2.0)	42.9(3.0)	25.0(1.0)	46.7	16.5	35.3
60	61.5(8.0)	60.0(6.0)	37.5(3.0)	16.7(1.0)	28.6(2.0)	0.0(0.0)	34.1	24.2	71.0
90	53.8(7.0)	50.0(5.0)	25.0(2.0)	0.0(0.0)	14.3(1.0)	0.0(0.0)	23.9	23.7	99.2
Rate	0.15(0.07)	0.56	0.83	1.39	0.95	2.50	1.12	0.75	67.0

Table 17 : Foaming stability (%) of bambara groundnut whole seedusing CH_3COONa

	Salt concentrations (%)						Mean	SD	CV%
Time (min)	**0.0**	**0.5**	**1.0**	**2.0**	**5.0**	**10.0**			
0	100(13.0)	100(6.0)	100(5.0)	100(3.0)	100(3.0)	100(2.0)	100	0.0	0.0
5	92.3(12.0)	83.3(5.0)	80.0(4.0)	66.7(2.0)	83.3(2.50)	50.0(1.0)	75.9	15.2	20.0
10	84.6(11.0)	66.7(4.0)	60.0(3.0)	33.3(1.0)	66.7(2.0)	0.0(0.0)	51.9	30.4	58.6
20	76.9(10.0)	50.0(3.0)	40.0(2.0)	0.0(0.0)	33.3(1.0)	0.0(0.0)	33.4	29.8	89.2
30	69.2(9.0)	33.3(2.0)	20.0(1.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	20.4	27.6	135
60	61.5(8.0)	16.7(1.0)	20.0(1.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	16.4	24.0	146
90	53.8(1.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	8.97	22.0	245
Rate	0.51	1.39	1.33	6.67	3.34	10.0	3.87	3.73	96.4

Table 18 : Foaming stability (%) of dehulledbambara groundnut using Na_2SO_3

	Salt concentrations (%)						Mean	SD	CV%
Time (min)	**0.0**	**0.5**	**1.0**	**2.0**	**5.0**	**10.0**			
0	100(13.0)	100(5.0)	100(3.50)	100(4.0)	100(2.0)	100(1.50)	100	0.0	0.0
5	92.3(12.0)	80.0(4.0)	85.7(3.0)	87.5(3.5)	100(2.0)	66.7(1.0)	85.4	11.4	13.3
10	84.6(11.0)	60.0(3.0)	57.1(2.0)	75.0(3.0)	50.0(1.0)	0.0(0.0)	54.5	29.5	54.1
20	76.9(10.0)	40.0(2.0)	28.6(1.0)	50.0(2.0)	0.0(0.0)	0.0(0.0)	32.6	30.0	92.0
30	96.2(9.0)	40.0(2.0)	0.0(0.0)	25.0(1.0)	0.0(0.0)	0.0(0.0)	22.4	28.3	126
60	61.5(8.0)	20.0(1.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	13.6	24.8	182
90	53.8(7.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	8.96	22.0	245
Rate	0.51	1.33	3.57	2.50	5.0	6.66	3.26	2.30	70.6

Table 19 : Water absorption capacity (g/100 g) of bambara groundnuttesta

Concentrationof salts (%)	Water absorption capacity					Mean	SD	CV%
	NaCl	**Na_2CO_3**	**$NaNO_3$**	**CH_3OONa**	**Na_2SO_3**			
0.0	280.0	280.0	280.0	280.0	280.0	280.0	280.0	0.0
0.5	300.0	300.0	300.0	260.0	270.0	286	19.5	0.07
1.0	400.0	350.0	290.0	270.0	250.0	312	61.8	0.19
2.0	290.0	400.0	320.0	300.0	280.0	318	48.2	0.15
5.0	280.0	380.0	350.0	320.0	270.0	320	46.4	0.15
10.0	270.0	390.0	330.0	280.0	280.0	310	505	0.16

Table 20 : Water absorption capacity (g/100 g) of dehulled Bambara groundnut

Concentration	Water absorption capacity					Mean	SD	CV%
of salts(%)	**NaCl**	**Na_2CO_3**	**$NaNO_3$**	**CH_3OONa**	**Na_2SO_3**			
0.0	280.0	280.0	280.0	280.0	280.0	280.0	0.0	0.0
0.5	170.0	150.0	170.0	180.0	140.0	162.0	16.4	10.0
1.0	200.0	170.0	160.0	200.0	160.0	178.0	20.5	11.5
2.0	180.0	180.0	180.0	220.0	150.0	182.0	24.9	13.7
5.0	190.0	200.0	200.0	240.0	170.0	200.0	24.5	12.3
10.0	220.0	190.0	170.0	200.0	160.0	188.0	23.9	12.7

Table 21 : Water absorption capacity (g/100 g) of whole seed ofbambara groundnut

Concentration of salts(%)	Water absorption Capacity NaCl	Na_2CO_3	$NaNO_3$	CH_3OONa	Na_2SO_3	Mean	SD	CV%
0.0	280.0	280.0	280.0	280.0	280.0	280.0	0.0	0.0
0.5	100.0	120.0	150.0	160.0	220.0	150.0	45.8	30.5
1.0	110.0	140.0	160.0	180.0	230.0	164.0	45.1	27.5
2.0	150.0	110.0	180.0	220.0	150.0	162.0	40.9	25.2
5.0	120.0	150.0	160.0	160.0	210.0	160.0	32.4	20.3
10.0	140.0	150.0	210.0	170.0	240.0	182.0	42.1	23.1

Table 22 : Emulsion capacity (g/100g) of bambara groundnut testa in various salt concentrations

Concentration of salt (%)	Emulsion capacity of salt					Mean	SD	CV%
	NaCl	Na_2CO_3	$NaNO_3$	CH_3OONa	Na_2SO_3			
0.0	13.0	15.0	15.0	15.3	15.0	14.7	0.94	6.4
0.5	14.3	14.3	23.0	16.0	21.4	17.8	4.12	23.1
1.0	15.0	16.0	22.0	18.4	22.0	18.7	3.27	17.5
2.0	16.3	18.0	24.0	20.0	23.0	20.3	3.25	16.0
5.0	20.0	16.0	25.0	22.2	21.0	20.9	3.18	15.2
10.0	21.0	22.0	24.0	23.0	24.0	22.8	1.30	5.7

Table 23 : Emulsion capacity (g/100g) of dehulledbambara groundnut in various salt concentrations

Concentration of salts (%)	Emulsion capacity of salt					Mean	SD	CV%
	NaCl	Na_2CO_3	$NaNO_3$	CH_3OONa	Na_2SO_3			
0.0	13.0	15.0	15.0	15.3	15.0	14.7	0.94	6.4
0.5	15.0	19.0	23.0	20.4	20.4	19.6	2.93	14.9
1.0	16.2	20.0	22.0	22.2	30.9	22.3	5.40	24.2
2.0	20.0	21.4	25.5	23.0	27.0	23.4	2.88	12.3
5.0	21.0	18.8	26.3	21.0	28.0	23.0	3.92	17.0
10.0	23.5	22.0	25.3	24.7	29.3	25.0	2.73	10.9

Table 24 : Emulsion capacity (g/100 g) of bambara groundnut whole seed in various salt

Concentration Of salt (%)	Emulsion capacity of salts					Mean	SD	CV%
	NaCl	Na_2CO_3	$NaNO_3$	CH_3OONa	Na_2SO_3			
0.0	13.0	15.0	15.0	15.3	15.0	14.7	0.94	6.4
0.5	22.0	25.0	24.0	24.0	32.0	25.4	3.85	15.2
1.0	23.0	26.0	26.5	23.5	33.0	26.4	3.99	15.1
2.0	22.5	28.3	25.0	25.0	29.0	26.0	2.67	10.3
5.0	24.0	27.0	28.0	26.5	35.0	28.1	4.13	14.7
10.0	25.3	28.6	29.6	28.0	34.3	29.2	3.29	11.3

Global Journal of Science Frontier Research (B) Volume XIII Issue II Version I Year 2013

Table 25 : Least gelation concentration of bambara groundnut testa in salt concentrations

Concentration of salts in water (%)	Least gelation concentration (%) NaCl	Na_2CO_3	$NaNO_3$	CH_3OONa	Na_2SO_3	Mean	SD	CV%
0.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	0.0
0.5	6.0	6.0	6.0	6.0	8.0	6.4	0.89	0.14
1.0	4.0	6.0	6.0	8.0	6.0	6.0	1.41	0.24
2.0	8.0	8.0	6.0	4.0	6.0	6.4	1.67	0.26
5.0	4.0	6.0	4.0	6.0	4.0	4.8	1.09	0.23
10.0	6.0	4.0	4.0	4.0	6.0	4.8	1.09	0.23

Table 26 : Least gelation concentration of dehulledbambaragroundnut in salt concentrations

Concentration of salts in water (%)	Least gelation concentration(%) NaCl	Na_2CO_3	$NaNO_3$	CH_3OONa	Na_2SO_3	Mean	SD	CV%
0.0	2.0	2.0	2.0	2.0	2.0	2.0	0.0	0.0
0.5	2. 0	2.0	6.0	4.0	6.0	4.0	2.0	0.5
1.0	4.0	4.0	4.0	2.0	2.0	3.2	1.09	0.34
2.0	2.0	2.0	6.0	4.0	4.0	3.6	1.67	0.46
5.0	4.0	4.0	4.0	4.0	2.0	3.6	0.89	0.25
10.0	4.0	2.0	4.0	2.0	2.0	2.8	1.09	0.39

Table 27 : Least gelation concentration of whole bambara groundnut in salt concentrations

Concentration of salts in water (%)	Least gelation concentration (%) NaCl	Na_2CO_3	$NaNO_3$	CH_3OONa	Na_2SO_3	Mean	SD	CV%
0.0	8.0	8.0	8.0	8.0	8.0	8.0	0.0	0.0
0.5	8.0	8.0	6.0	6.0	8.0	6.8	1.09	0.16
1.0	6.0	6.0	8.0	8.0	6.0	6.8	1.09	0.16
2.0	6.0	6.0	8.0	8.0	6.0	6.8	1.09	0.16
5.0	6.0	6.0	6.0	8.0	8.0	6.8	1.09	0.16
10.0	8.0	6.0	8.0	6.0	6.0	6.8	1.09	0.16

Table 28 : Various salts concentrations [percentage, molarity and ionic strength (μ)]

Salt	Percentageconcentration	Molairty	Ionic strength
NaCl	0.5	8.5×10^{-4}	8.5×10^{-4}
NaCl	1.0	1.7×10^{-3}	1.7×10^{-3}
NaCl	2.0	3.4×10^{-3}	3.4×10^{-3}
NaCl	5.0	8.1×10^{-3}	8.1×10^{-3}
NaCl	10.0	1.5×10^{-2}	1.5×10^{-2}
Na_2CO_3	0.5	4.7×10^{-4}	1.4×10^{-3}
Na_2CO_3	1.0	9.3×10^{-4}	2.8×10^{-3}
Na_2CO_3	2.0	1.8×10^{-3}	5.4×10^{-3}
Na_2CO_3	5.0	4.5×10^{-3}	1.35×10^{-2}
Na_2CO_3	10.0	8.5×10^{-3}	2.6×10^{-2}
$NaNO_3$	0.5	5.9×10^{-4}	5.9×10^{-4}
$NaNO_3$	1.0	1.2×10^{-3}	1.2×10^{-3}
$NaNO_3$	2.0	2.3×10^{-3}	2.3×10^{-3}
$NaNO_3$	5.0	5.6×10^{-3}	5.6×10^{-3}
$NaNO_3$	10.0	1.1×10^{-2}	1.1×10^{-2}

CH_3COONa	0.5	6.1×10^{-4}	6.1×10^{-4}
CH_3COONa	1.0	1.2×10^{-3}	1.2×10^{-3}
CH_3COONa	2.0	2.4×10^{-3}	2.4×10^{-3}
CH_3COONa	5.0	5.8×10^{-3}	5.8×10^{-3}
CH_3COONa	10.0	1.1×10^{-2}	1.1×10^{-2}
Na_2SO_3	0.5	3.9×10^{-4}	1.2×10^{-3}
Na_2SO_3	1.0	7.9×10^{-4}	2.4×10^{-3}
Na_2SO_3	2.0	1.6×10^{-3}	4.8×10^{-3}
Na_2SO_3	5.0	3.8×10^{-3}	1.14×10^{-2}
Na_2SO_3	10.0	7.1×10^{-3}	2.14×10^{-2}

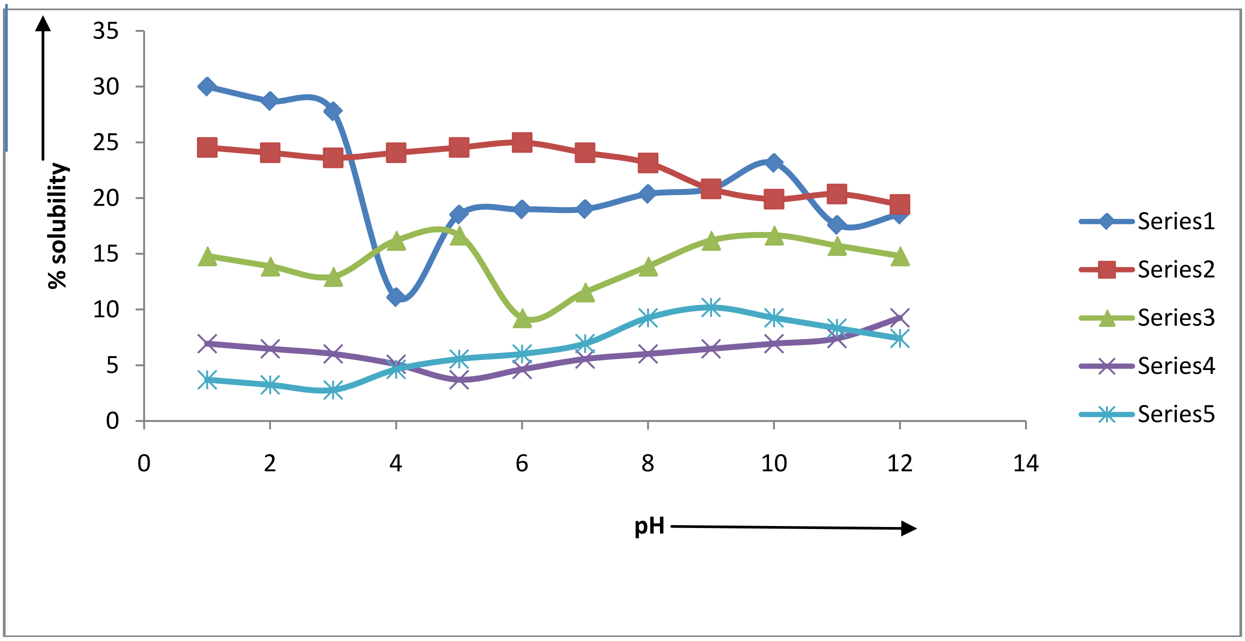

Figure 1 : Protein solubility (%) vs pH at different Na_2SO_4 concentrations in testa

Series 1 - 0.5% salt concentration
Series 2 - 1.0% salt concentration
Series 3 – 2.0% salt concentration
Series 4 – 5.0% salt concentration
Series 5 – 10.0% salt concentration

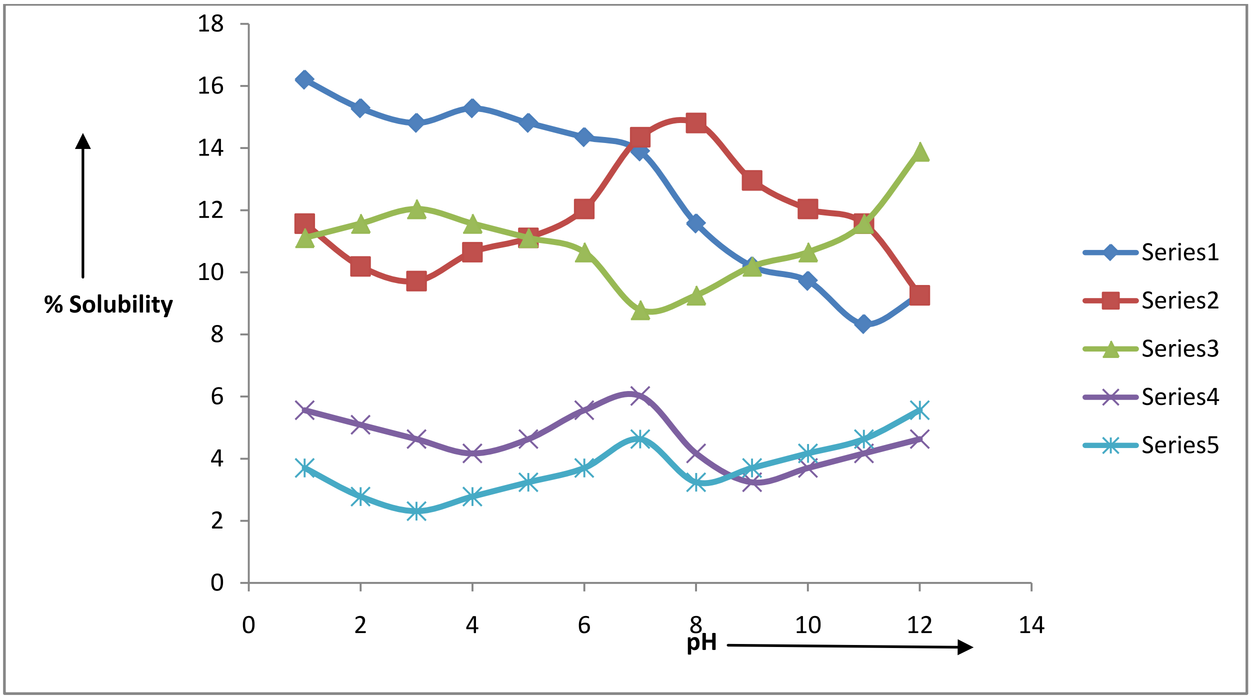

Figure 2 : Protein solubility (%) vs pH at different Na_2CO_3 concentrations in testa

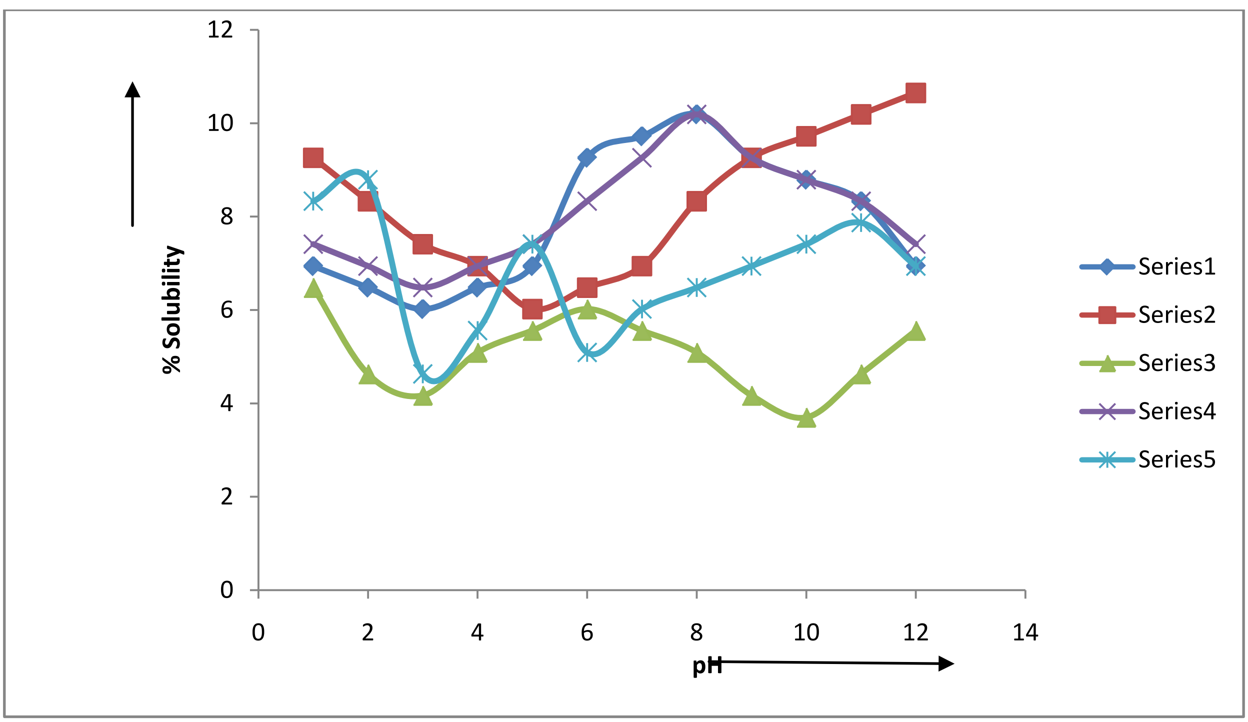

Figure 3 : Protein solubility (%) vs pH at different Na_2SO_3 concentrations in testa

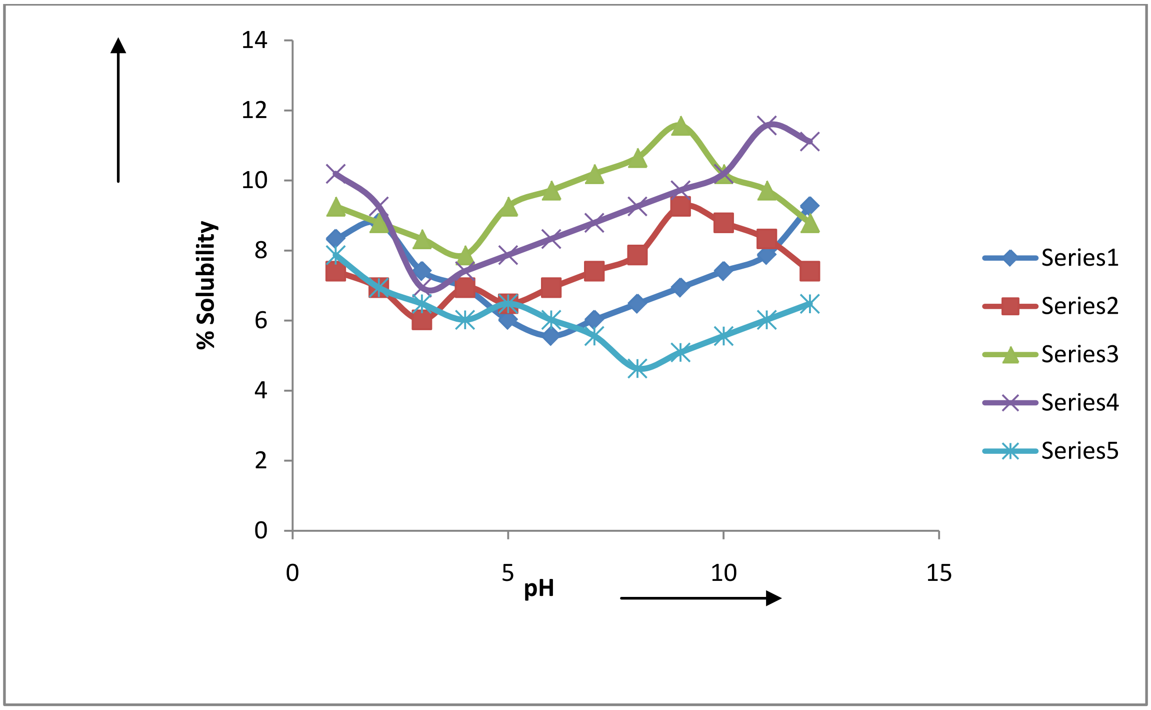

Figure 4 : Protein solibility (%) vs pH at different CH_3COOH concetrations in testa

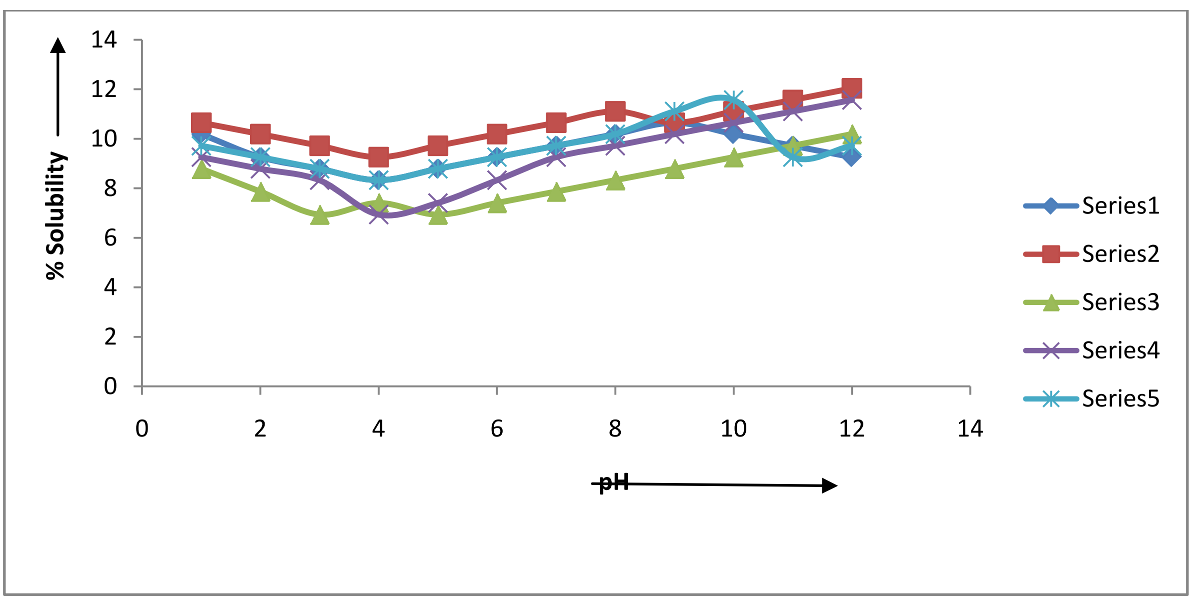

Figure 5 : Protein solubility (%) vs pH at different $NaNO_3$ concentrations in testa

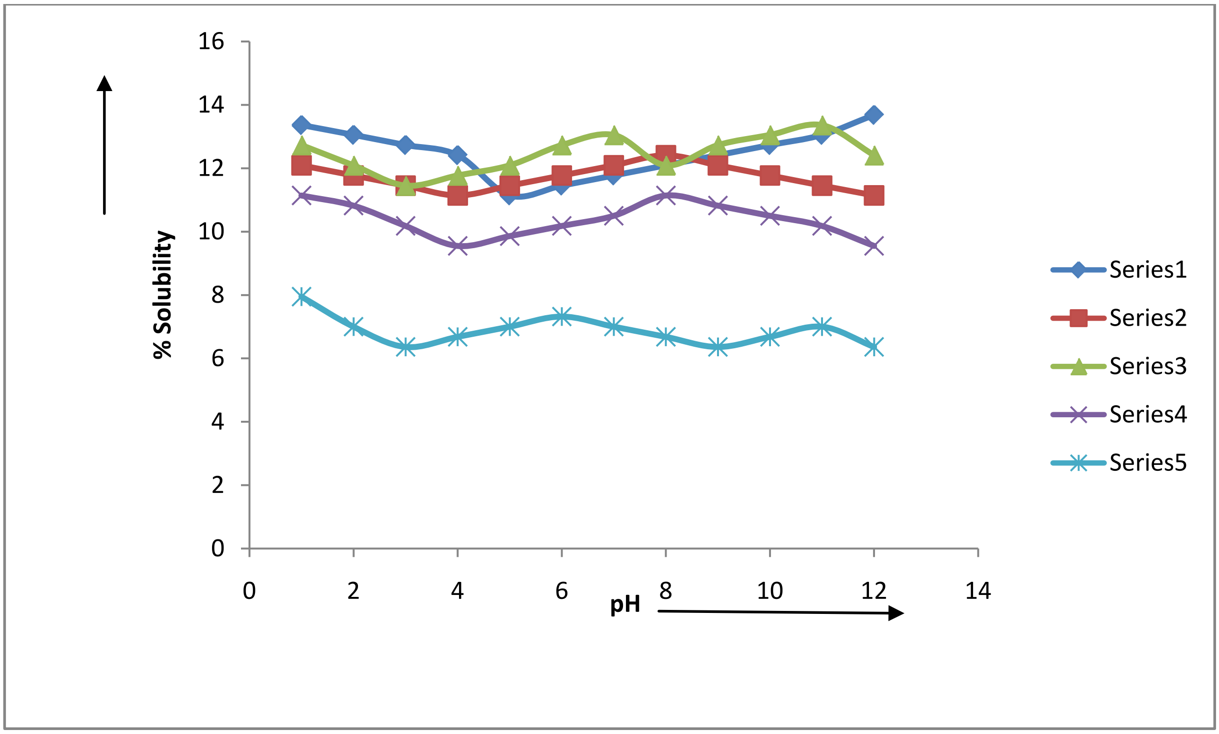

Figure 6 : Protein solubility (%) vs pH at different Na_2SO_4 concentrations in dehulled sample

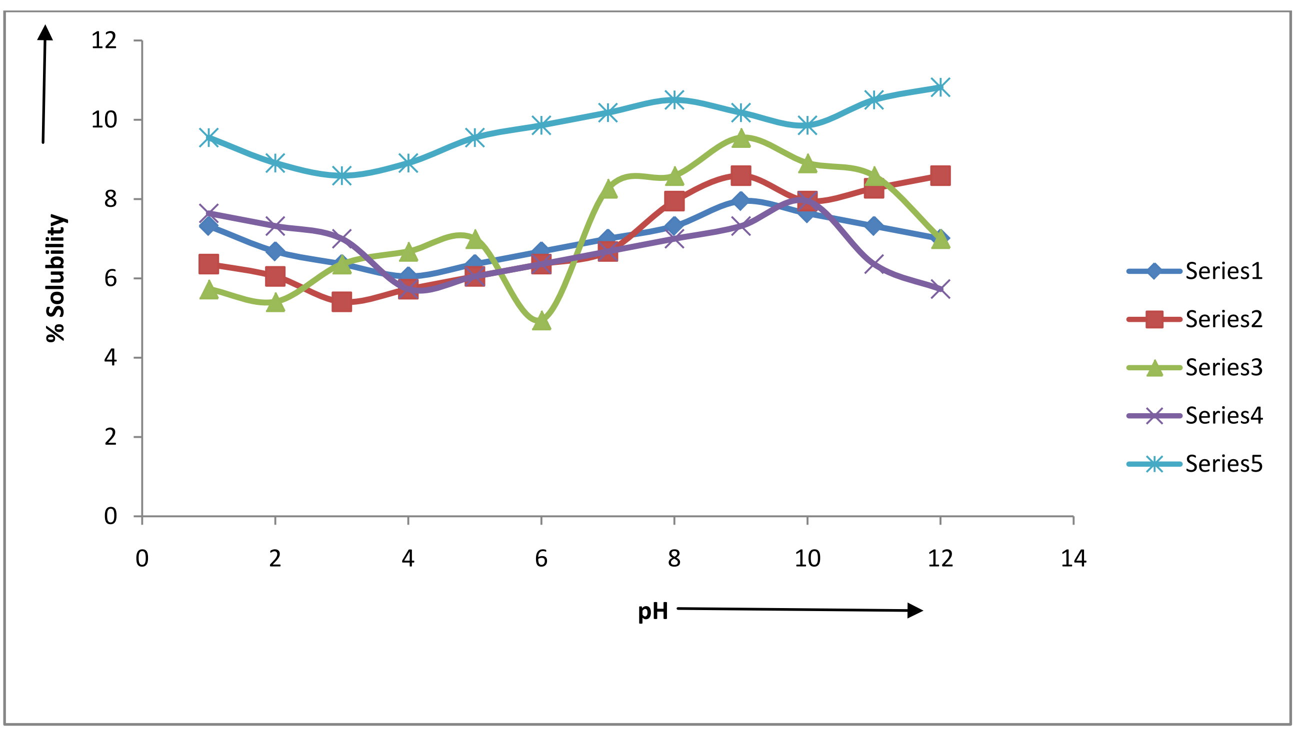

Figure 7 : Protein solubility (%) vs pH at different Na_2CO_3 concentrations in dehulled sample

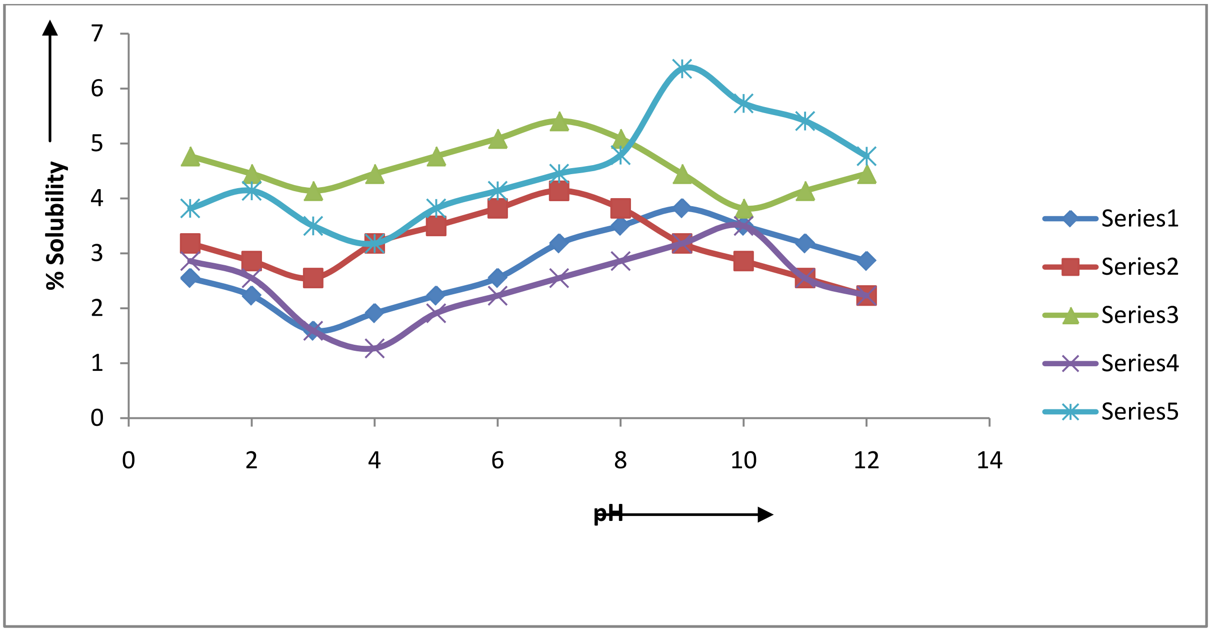

Figure 8 : Protein solubility (%) at different Na_2SO_3 concentrations in dehulled sample

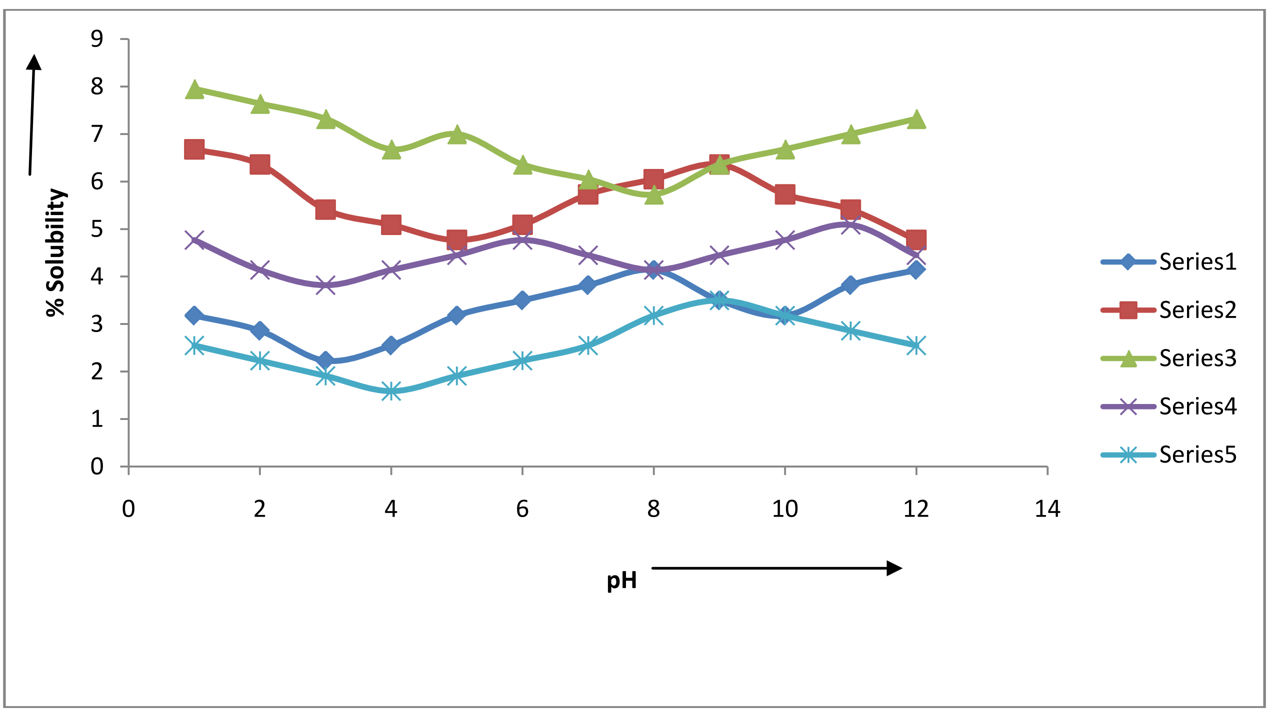

Figure 9 : Protein solubility (%) vs pH at different CH_3COONa concentrations in dehulled sample

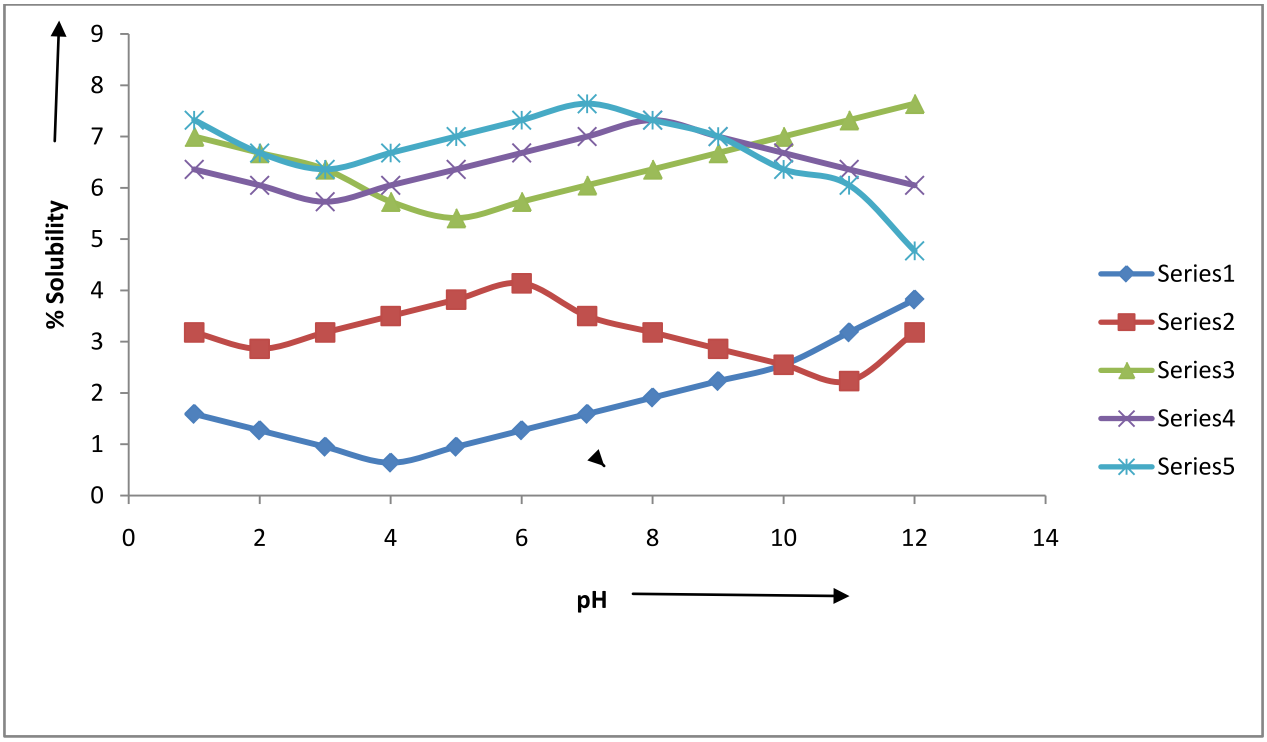

Figure 10 : Protein solubility (%) vs pH at different $NaNO_3$ concentrations in dehulled sample

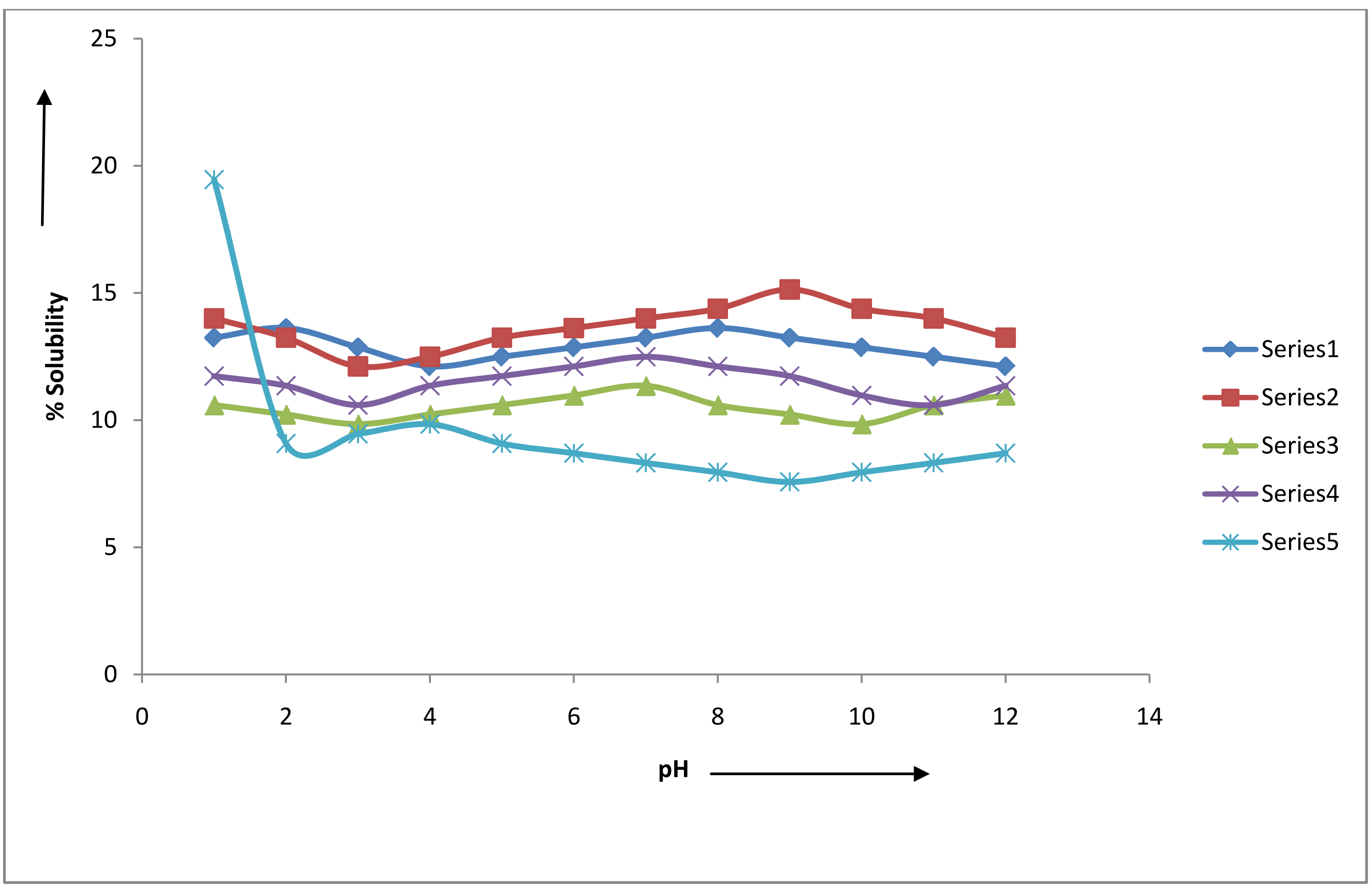

Figure 11 : Protein solubility (%) vs pH at different Na_2SO_4 concentrations in whole seed sample

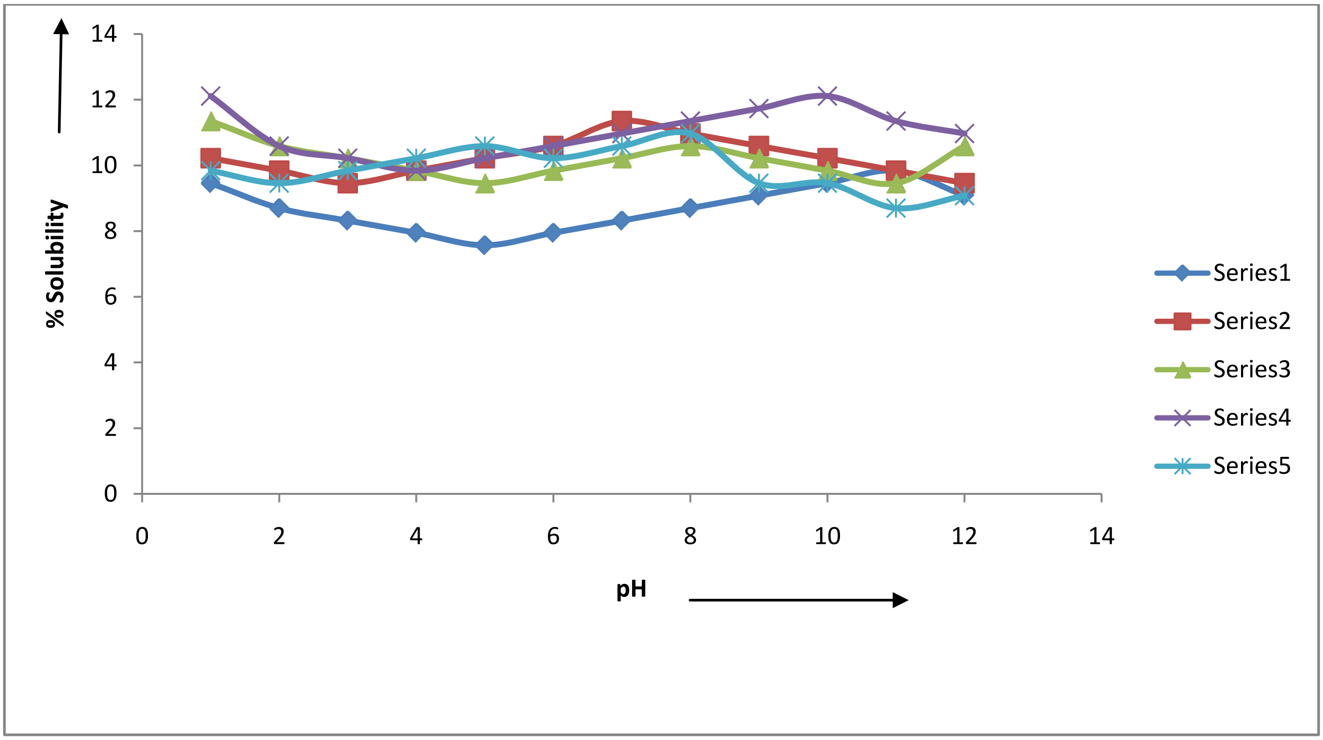

Figure 12 : Protein solubility (%) vs pH at different Na_2CO_3 concentrations in whole seed sample

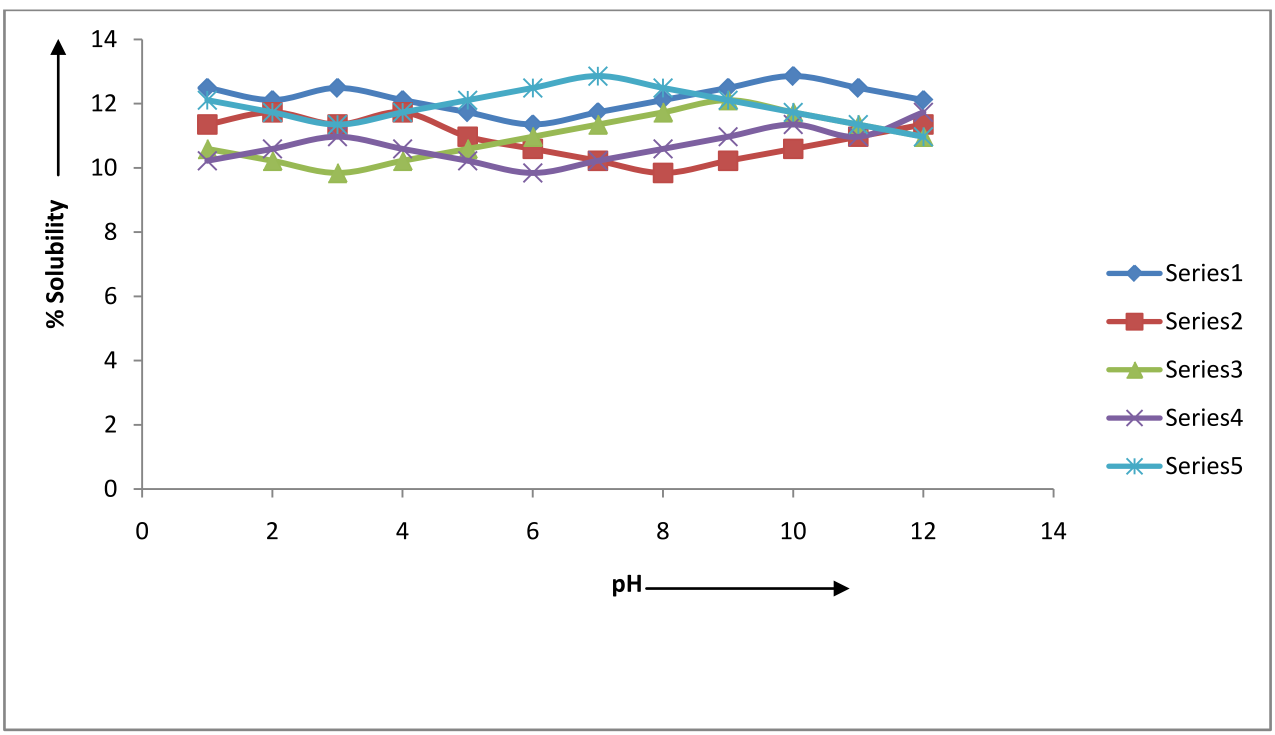

Figure 13 : Protein solubility (%) vs pH at different Na_2SO_3 concentrations in whole seed sample

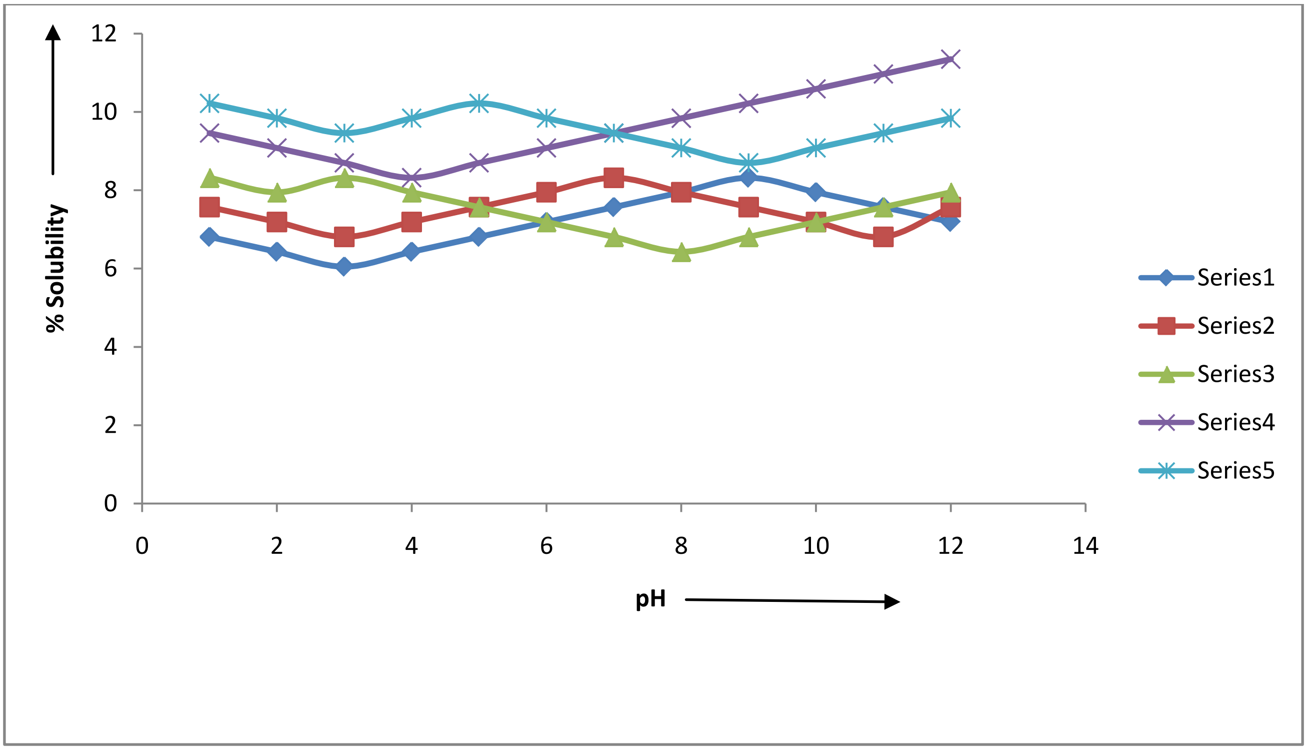

Figure 14 : Protein solubility (%) vs pH at different CH_3COONa concentrations in whole seed sample

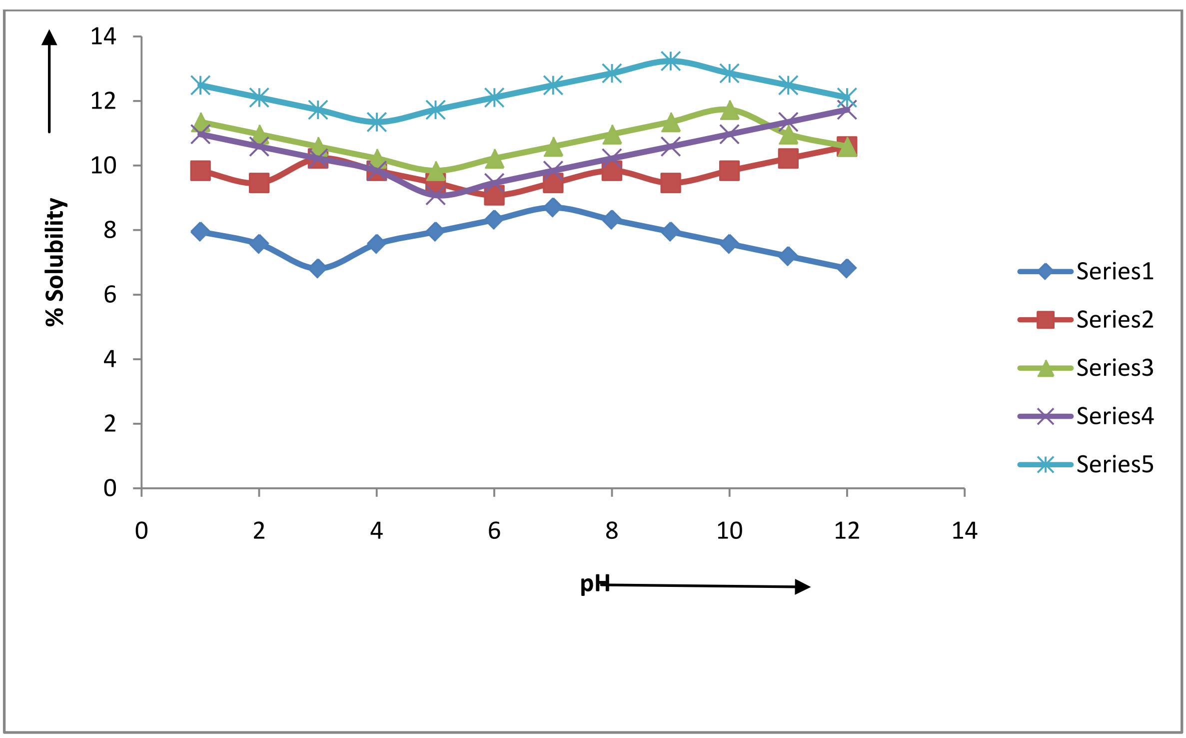

Figure 15 : Protein solubility (%) vs pH at different $NaNO_3$ concentrations in whole seed sample