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Effect of pH on Foaming Properties (FC and FS) of Protein Isolates from Two Varieties (DAS & BS) of Nigerian Cultivated Solojo Cowpea (*Vigna Unguiculata* L. Walp)

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Research Article

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Abstract

Effect of pH on the foaming properties (FC and FS) of protein isolates from two Varieties (DAS & BS) of Nigerian cultivated Solojo cowpea (*Vigna Unguiculata* L. Walp) was investigated. Results show that the foaming capacity (FC) followed the solubility trend, with a high foaming capacity at pH 2, which slowly reduced between pH 4 - 6 and gradual increase again with pH as the pH approached 10, where it had another high value. As shown in Figures 1-6 noticeable changes in FC were detected as the pH of the protein solution progressed from pH 2 to 10, with minimum foaming capacity at pH 4 in all cases except for DFDAS flour and BS protein isolate (pH 6). The foaming capacity value for 6 h soaked and 48 hr germinated flours, at pH 4 were observed to be greater than at pH 2 and 6. While the maximum was observed in some cases at pH 8 and some pH 10 but FFDAS Raw, 36 and 48 hr; FFBS, 6 hr; DFBS, Raw and 72 hr; BS, 6 and 24 hr germinated, all had their own max values at pH 2. Defatting was also observed to improve the foaming capacity values of all the treatment. The foaming capacity ranged between 15.19 to 121.16%; 44.76 to 127.36%; 31.23 to 110.93%; 30.84 to 121.16%; 64.97 to 210.00%; 62.67 to 222.00% for FFDAS, DFDAS, FFBS, DFBS, DAS, and BS, respectively. The pattern of FC change followed the pH dependent solubility flow of the test material, showing the importance of solubility on foam formation which confirms that solubility of protein has a great influence on the activities of foam also increasing the pH from 4 to 10 improved the foaming characteristics of flour. This observation proved the authenticity that foaming property depends on protein solubility. The foaming capacity of cowpea protein isolates was pH dependent and high at alkaline pH in comparison to acid region.

Keywords: Solojo Cowpea; Under-utilized legumes; Essential Amino Acids; Nutraceuticals; BS; DA; Gelation Property LGC

Introduction

The Foaming stability (FS) is a very essential characteristic of a whisking agent; is the ability of a foam to be sustained for a period of time [1]. Studies by Ivanova, et al. [2] on Sunflower showed a pH-dependent solubility pattern with the FC. Saavedra, et al. [3] for Lupinus protein isolate reported that foam capacity was high at pH 2, low between pH 4 to pH 6 equivalent to the iso-electric point, continues to increase towards the alkaline pH. Eltayeb, et al. [4] also reported a minimum FC value at pH 6, which also increase with increase and decrease of pH.

Some other researchers likewise observed a reduction in FC at pH 4 when compared with that at other pHs. The pattern of FC change followed the pH dependent solubility flow of the test material, showing the importance of solubility on foam formation. This information supports the findings of Lawal, et al. [5] which says solubility of protein has a great influence on the activities of foam. Raikos, et al. [1] likewise observed an increase in FC of five different flours with increase of pH (4-12). They concluded that increasing the pH from 4 to 10 improved the foaming characteristics of flour especially Buckwheat and Cannabis sativa. Olawuni, et al. [6] also observed an enhancement in the FC of both flours (full fat and defatted) of long-podded cowpea within this same range.

The high foaming capacity (FC) at highly acidic and alkaline pH was probably as a result of the rise in total charge on the protein, bringing about the lowering of the non-polar interactions but increasing protein pliability, making the protein to disperse speedily to the junction between air and water enclosing particles of air thereby encouraging formation of foam [7,8]. This observation proved the authenticity that foaming property depends on protein solubility. Khalid, et al. [9] also reported that foaming capacity of cowpea protein isolates was pH dependent and high at alkaline pH in comparison to acid region. Increased temperature induces the denaturation of native protein leading to the formation of disulphide bonds and the exposure of non-polar residues of the amino acid [10].

Materials and Methods

Location of Study and Raw Material

This research study is a fragment of a PhD research work carried out in the Department of Chemistry, University of Ibadan, Western Nigeria. Two varieties (seeds) of the underutilized cowpea (*V. unguculata*) obtained from Bodija market in Ibadan, the south west region of Nigeria where it is called 'Solojo' were used.

Preparation of Raw Materials for Chemical Analysis

The Samples were screened to get rid of every irrelevant materials and unwholesome seeds. The beans were then portioned into six (6). The Solojo seeds for germination were sterilized by soaking in 0.07 % Sodium hypochlorite for 30 min, then, it was rinsed thoroughly. The Solojo seeds were then immersed for 6 hr in distilled water at ambient temperature (1:10 w/v) (~25°C), then placed in a colander and germinated under subdued light in an open laboratory for, 24, 36, 48 and 72 h.

Preparation of Flours

Raw flour: The grains were segregated to remove the spoilt ones; then dry dehulled with a mechanical dry dehuller (Fabricated in FIIRO), dried at 40°C and later milled dry to powder then sifted using 80 µm mesh. The flour was stored in flexible bags and preserved at 4°C preceding utilization in a refrigerator freezer.

6 h Soaked Flour

The seeds were segregated to remove the unwholesome ones, then immersed for 6 hr in the ratio (1:10 w/v) (seed/water). The grains were then frozen to prevent germination from setting in, then the hull was removed manually, dried for 48 hr at 40°C later milled dry to smooth powder prior to sieving using 80 µm mesh screen. The resulting flour was packaged in plastic pack and preserved in a fridge- freezer at 4°C pending utilization.

Germination of Seed

This was implemented by the method of Mubarak AE [11] with minor adjustment. The seeds for germination were disinfected by soaking in 0.07 % Sodium hypochlorite Rumiyati, et al. [12] for 30 mins, then, it was rinsed painstakingly. The Solojo seeds were then immersed for 6 hours at ambient temperature in water in the ratio (1:10 w/v) (seed/water) (~25°C), then placed in a colander and germinated under subdued light in an open laboratory Rusydi MR, et al. [13] for various hours such as 24, 36, 48 and 72 hr. The process of germination was terminated by freezing, the seeds were manually dehulled, dried in a draught oven (Schutzart DIN EN 60529-IP 20. Memmert, Germany) at 40°C for 48 hr, cooled, milled and packaged in an air tight plastic bag in there frigerator pending analysis.

Figure 1: Brown Solojo Cowpea.

Figure 2: Dark-Ash Solojo Cowpea.

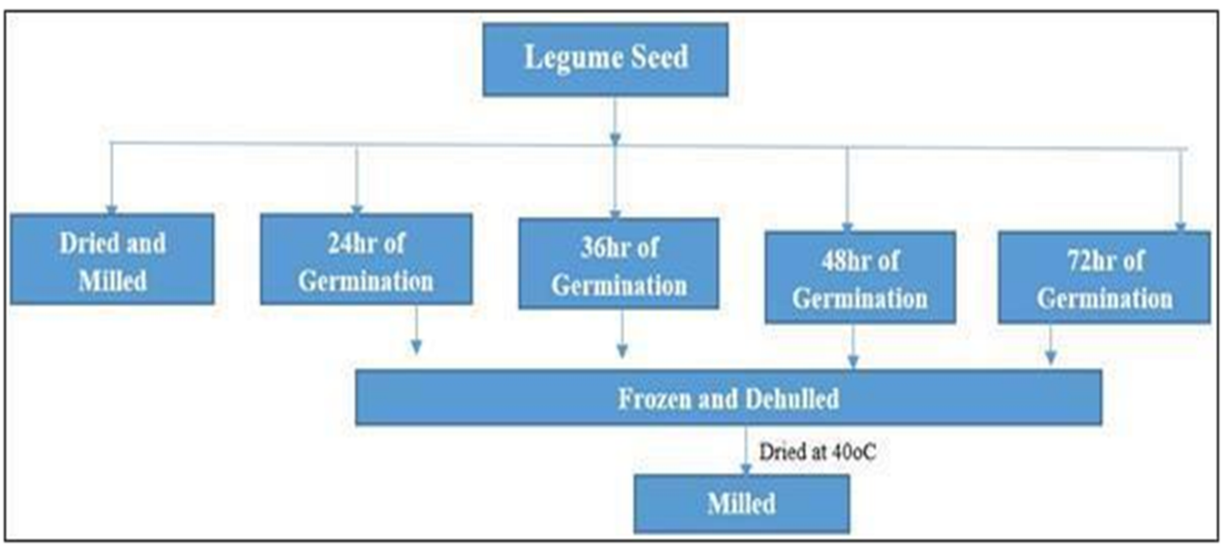

Figure 3: Preparation of Beans Flour/Schematic representation.

Result and Discussion

The foaming capacity (FC) followed the solubility trend, with a high foaming capacity at pH 2 which slowly reduced between pH 4 - 6 and gradual increase again with pH as the pH approached 10, where it had another high value. As shown in Figures 4-9 noticeable changes in FC were detected as the pH of the protein solution progressed from pH 2 to pH 10, with minimum foaming capacity at pH 4 in all cases except for DFDAS flour and BS protein isolate (pH 6).

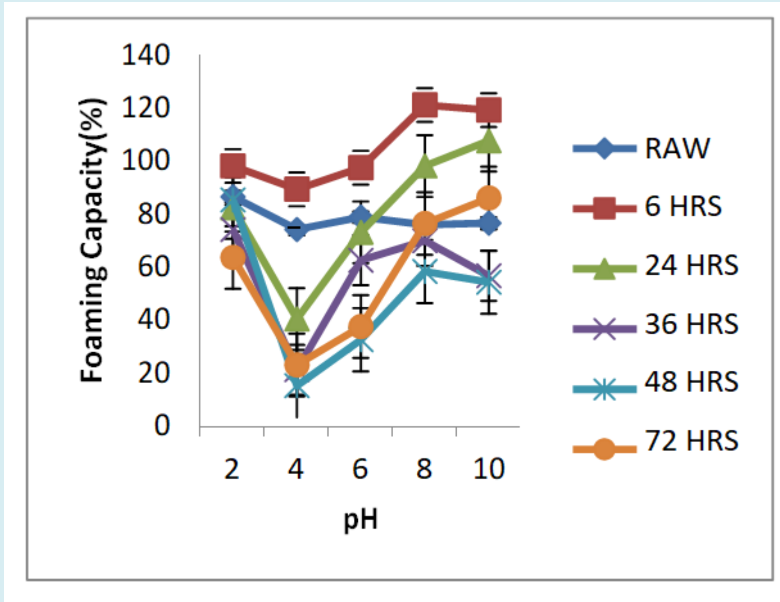

Figure 4: Effect of pH on Foaming Capacity of FFDAS.
FFDAS: Full fat dark-ash Solojo Cowpea.

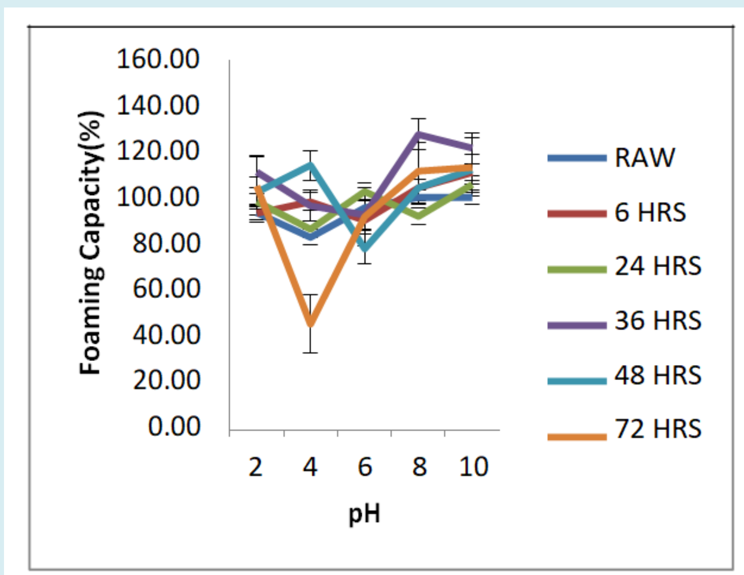

Figure 5: Effect of pH on Foaming Capacity of DFDAS.
DFDAS: Defatted dark ash Solojo Cowpea.

The Foaming capacity value for 6 hr soaked and 48 h germinated flours, at pH 4 were observed to be greater than at pH 2 and pH 6. While the maximum was observed in some cases at pH 8 and some pH 10, but FFDAS Raw, 36 hr and 48 hr; FFBS, 6 hr; DFBS, Raw and 72 hr; BS, 6 hr and 24 hr germinated, all had their own max values at pH 2. Defatting was also observed to improve the foaming capacity values of all the treatment. The foaming capacity ranged between 15.19 to 121.16%; 44.76 to 127.36%; 31.23 to 110.93%; 30.84 to 121.16%; 64.97 to 210.00%; 62.67 to 222.00% for FFDAS, DFDAS, FFBS, DFBS, DAS, and BS respectively.

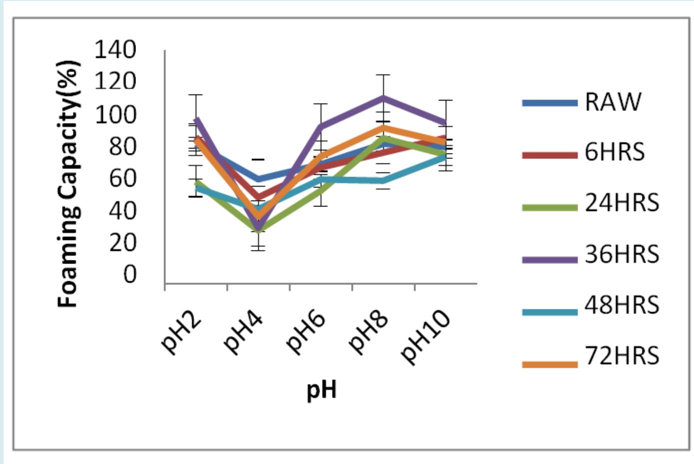

Figure 6: Effect of pH on Foaming Capacity of FFBS.
FFBS: Full fat brown Solojo Cowpea.

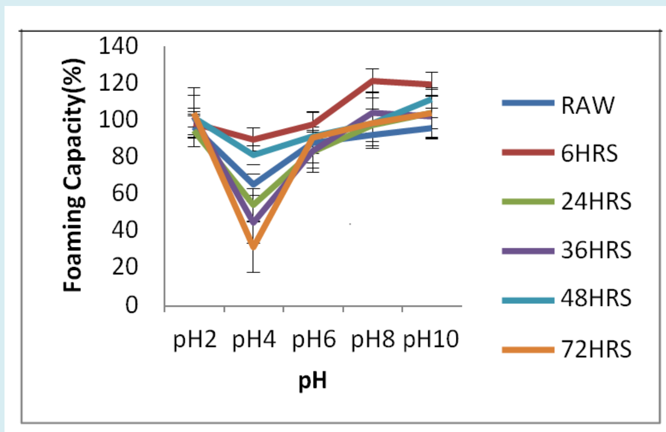

Figure 7: Effect of pH on Foaming Capacity of DFBS.
DFBS: Defatted brown Solojo Cowpea.

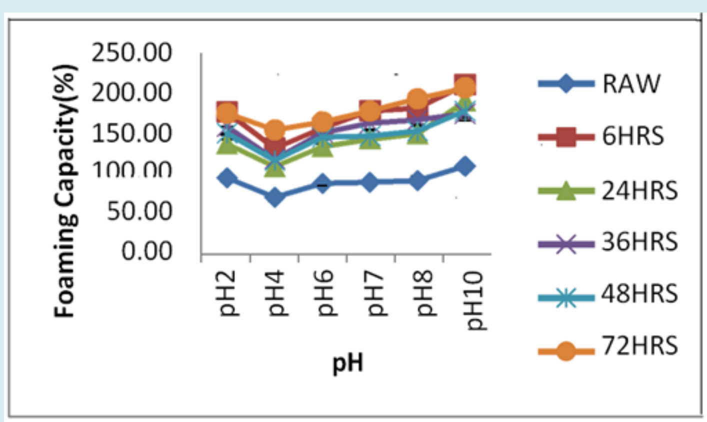

Figure 8: Effect of pH on Foaming Capacity of DAS protein isolate.
DAS: Dark - ash Solojo Cowpea protein isolate.

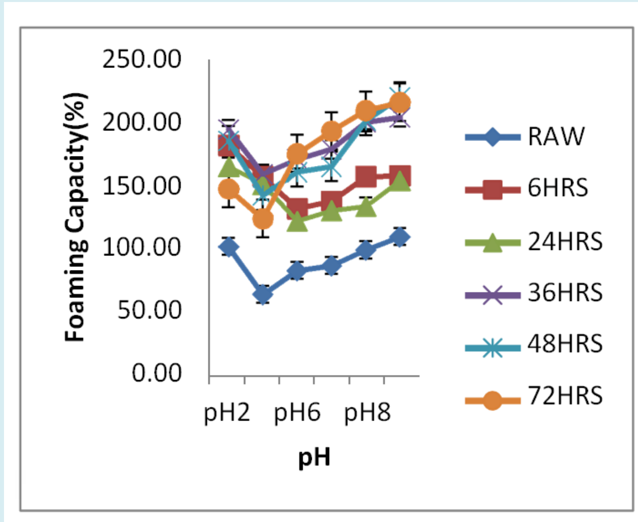

Figure 9: Effect of pH on Foaming Capacity of BS protein isolate.
BS: Brown solojo cowpea protein isolate.

The Foaming stability (FS) was found to increase with increase in pH until the iso-electric point and reduce at the alkaline region for most treatments except for 36, 48 and 72 hr FFDAS germinated samples, which had the FS lowest at the iso- electric point as shown in Figure 7-12.

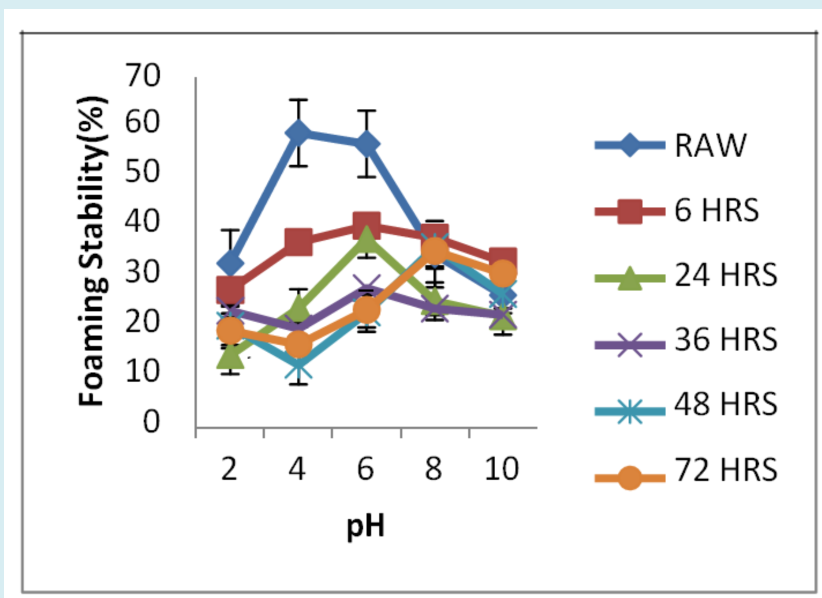

Figure 10: Effect of pH on Foam Stability of FFDAS.
FFDAS: Full fat dark- ash solojo cowpea flour.

This is in accordance with the discoveries of Lawal, et al. [14] for native and chemically modified Pigeon pea protein concentrate which suggest that foam stability is improved at iso-electric precipitation region

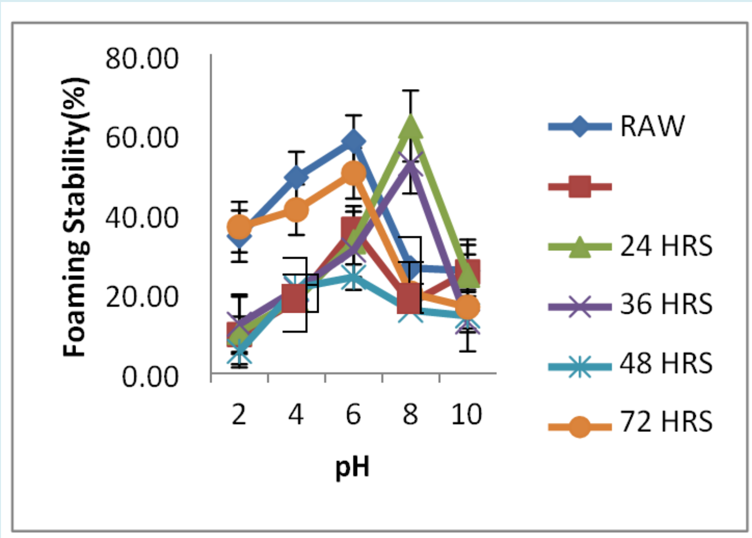

Figure 11: Effect of pH on Foam Stability of DFDAS.
DFDAS: Defatted dark -ash solojo cowpea flour.

This could be due to the formation at this region of stable molecular layer in the air- water interface of the foam. Protein adsorption and viscoelasticity at an air-water interface is maximal or near at the isoelectric pH, which contributes to the formation of stable molecular layers in the air- water interface, this contributes greatly to foam stability A similar result was also found by Lawal, et al. [14] for chemically modified bambarra groundnut. Wani, et al. [15] had a similarly observation for native and hydrolyzed kidney bean (*Phaseolus vulgaris* L.) protein isolates. Barac, et al. [16] also observed improvement in FS of thermally treated adzuki isolate at pH range of pH 3-7

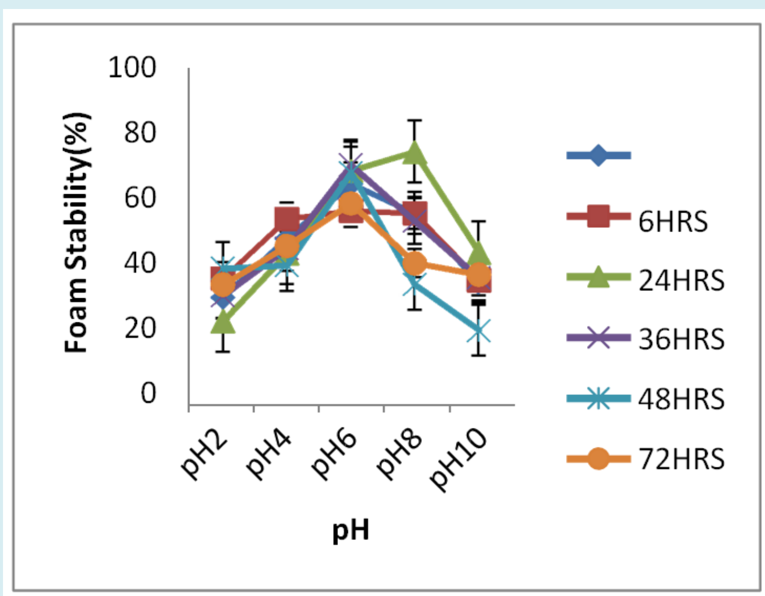

Figure 12: Effect of pH on Foam Stability of FFBS.
FFBS: Full fat brown solojo cowpea flour.

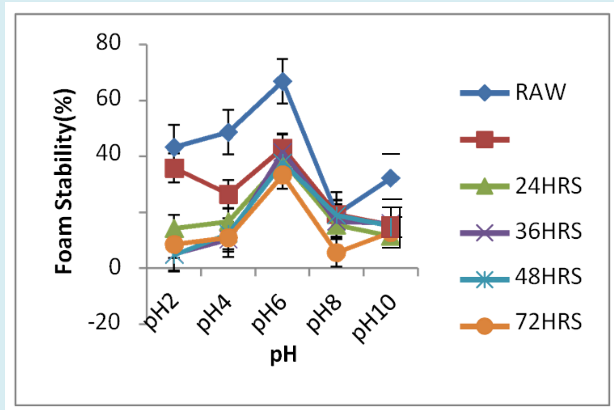

Figure 13: Effect of pH on Foam Stability of DFBS.
DFBS: Defatted brown solojo cowpea flour.

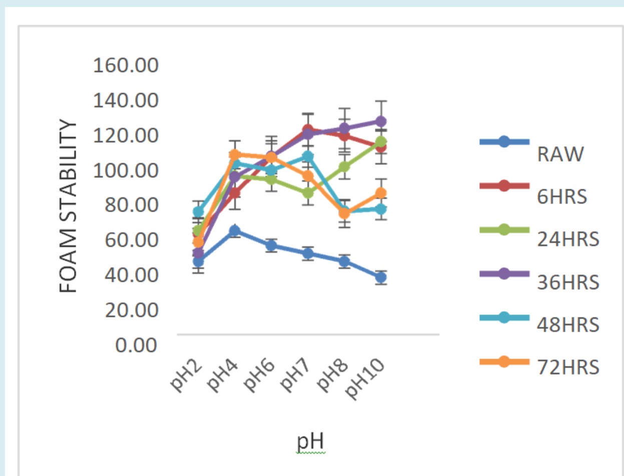

Figure 14: Effect of pH on Foam Stability of DAS.
DAS: Dark – ash solojo cowpea protein isolate.

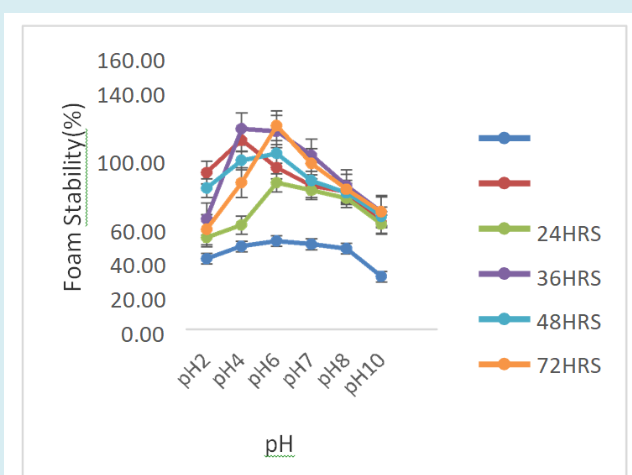

Figure 15: Effect of pH on Foam Stability of BS.
BS: Brown solojo cowpea protein isolate.

Conclusion and Recommendation

This research work shows that germination had a profound and significant ($p<0.05$) effect on the nutritional composition of Solojo beans, revealing great improvement and thus making Solojo a potential substitute to other important legumes. The foam stability ranged between 11.39 and 57.82%; 6.60 and 63.30%; 18.98 and 73.64%; 4.76 and 66.78%; 31.33 and 122.43; 30.00 and 120.00% for FFDAS, DFDAS, FFBS, DFBS, DAS and BS respectively. It was observed that the minimum foam stability was found at pH 4 which corresponded to the iso-electric point.

This research work also shows that biochemical modification (Germination/Malting/ Sprouting) had an enormous impact on the nutritional composition, functional properties, mineral bioavailability, anti-nutrient content and amino assay of Solojo bean, thus, it could be used as protein supplement in infant, young children and geriatric foods. Efforts should be increased to promote the cultivation, encourage the consumption and industrial application of this under-utilized legume by the Government, especially in the south-western region where it can survive the rain fall level. Large scale production of this legume which is gradually going into extinction should be encouraged in order to fight the menace of malnutrition in developing countries where animal protein price is exorbitant; This will ensure food security and also creation of jobs, because people can engage in different aspects of the production process and thereby reducing the rate of unemployment.

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