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Effect of Germination on the Mineral and Protein Content of Solojo Flour and Isolates from Two Varieties (DAS and BS) of Nigerian Cultivated Solojo Cowpea (*Vigna unguiculata* L. Walp)

Olubamike A Adeyoju[1], Henry O Chibudike[2]*, Kayode O Adebowale[3], Chinedum E Chibudike[4] and Bamidele I OluO-wolabi[5]

[1]Department of Analytical and Laboratory Management, Federal Institute of Industrial Research, Oshodi, Nigeria

[2]Department of Chemical, Fiber and Environmental Technology, Federal Institute of Industrial Research, Oshodi, Nigeria

[3]Department of Chemistry, Industrial Unit, University of Ibadan, Nigeria

[4]Department of Planning, Technology Transfer and Information Management, Federal Institute of Industrial Research, Oshodi, Nigeria

[5]Department of Chemistry, Analytical Unit, University of Ibadan, Nigeria

***Corresponding Author:** Henry O Chibudike, Department of Chemical, Fiber and Environmental Technology, Federal Institute of Industrial Research, Oshodi, Nigeria.

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Abstract

Studies on the Mineral Content of Solojo Flour and Protein Isolates from the two varieties (DAS and BS) of Nigeria cultivated solojo cowpeas were conducted to determine their nutritional value. These inorganic elements or minerals were classified into 3 categories, the ultra-trace minerals, which is the third category; the micro elements, also known as the trace minerals is the second category; while the first category are the macro elements, also known as major minerals. Some of the macro-elements are Ca, P, Na and Cl, the second category, micro-elements include, iron, copper, cobalt, potassium, magnesium, iodine, zinc, manganese, molybdenum, F, Cr, Se and S. Results show that the proportion of Sodium (Na) which is ingested into the body in the form of NaCl through food intake maintenance of body pH and to retain water ranged from 728.97 to 253.37 ppm (72.90 to 25.34 mg/100g); 715.24 to 235.45 ppm; 735.28 to 270.37 ppm; 726.59 to 264.35 ppm, for FFDAS, FFBS, DAS and BS respectively with all values of the germinated samples all bellow the control. While FFDAS iron content ranged from 4.25 to 13.50 mg/100g; FFBS ranged from 3.15 to 12.56 mg/100g; DAS ranged from 3.81 to 12.90 mg/100g; BS ranged from 3.42 to 9.40 mg/100g. The values of the germinated flours were all greater than the ungerminated flour. Iron helps to transport oxygen round the body and also helps in red blood cells building and to convert food into needed energy by the body. While Manganese an element that is needed in micro quantity but necessary to convert food into energy, is also crucial for healthy bone and cartilage creation. Results also show that zinc quantity increased as germination proceeded and the values ranged from 38.80 ppm to 230.00 ppm (3.880 mg/100g to 23.00 mg/100g; 0.003880% to 0.0230%); 40.84 to 250.01 ppm; 32.85 to 93.41 ppm; 37.07 to 115.00 ppm, for FFDAS, FFBS, DAS and BS respectively. The Ca content improved significantly ($p < 0.05$) with sprouting, the value extended from 250.56 ppm to 760.03 ppm (25.056 to 76.00 mg/100g or 0.0251 to 0.0760%); 400.40 to 998.22 ppm; 116.87 to 195.69 ppm; 113.48 to 220.75 ppm, for FFDAS, FFBS, DAS and BS respectively. Zinc element although needed at the micro level in the body, is essential for a strong immune system to keep the body in good health. It is also crucial for the maintenance of a healthy sense of taste and odor, while Calcium is critical for strong bones and teeth, blood coagulation, and muscle tightening and relaxation. Magnesium is needed to build enzyme and antioxidants and also for healthy bones while Potassium is needed to maintain; water balance, muscle movement, and nerve impulses. It functions in conjunction with Na to regulate blood pressure.

Keywords: *Solojo Cowpea; Under-Utilized Legumes; Protein Isolates; BS, DA; Gelation Property, Un-germinated*

Introduction

Akorede., *et al*. state that the world is presently grappling with the monstrous health challenges of malnutrition, and it is unfortunately implicated in the death that takes place in children from 6 to 24 months annually, especially in developing nations, accounting for more than 41% death [1].

Bhat., *et al*. also reported that shortage in animal protein and poverty is the reason why complementary diets in developing countries are predominantly cereal based resulting in nutritional deficiency and malnutrition [2]. Malnutrition has been recognized as a major contributing factor predisposing affected children to reduced immune function, impaired resistance to infectious diseases and increased susceptibility to intestinal parasites causing diarrhea. The most common is Protein-energy malnutrition (PEM). The demand for proteins in the world is rising, therefore additional protein food is imperative from both traditional and unusual source [3].

According to Eromosele., *et al*. the excessive price of protein from animal origin has induced the increasing excitement in utilization of plant protein industrially both in edible and non-food market with special interest in legumes [4].

Proteins are the building blocks of life. There are six major nutrients - water, carbohydrates, protein, fat, vitamins, and minerals. Each plays a unique and important role in how our bodies function. But of these, proteins are the building blocks of life. Every cell in the human body contains protein.

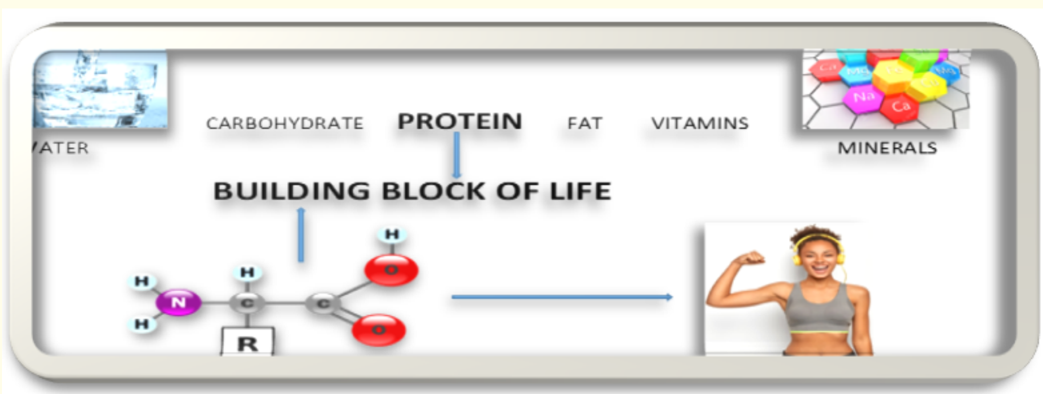

Figure 1: *Schematic diagram showing relevance of protein amongst the six (6) major nutrients.*

Our bodies need protein from the foods we eat to build and maintain bones, muscles and skin. The basic structure of protein is a chain of amino acids. Protein is needed in the diet to help the body repair cells and make new ones. Protein is also important for growth and development in children, teens, and pregnant women. Protein foods are broken down into parts called amino acids during digestion. The human body needs a number of amino acids in large enough amounts to maintain good health. Amino acids are found in animal sources such as meats, milk, fish, and eggs. They are also found in plant sources such as soy, beans, legumes, nut butters, and some grains (such as wheat germ and quinoa).

Deficiency of proteins is responsible for the disease called Kwashiorkor. The World Health Organization (WHO) defines malnutrition as "the cellular imbalance between the supply of nutrients and energy and the body's demand for them to ensure growth, maintenance, and specific functions". The term protein-energy malnutrition (PEM) applies to a group of related disorders that include marasmus, kwashiorkor and intermediate states of marasmus-kwashiorkor. Kwashiorkor is a severe form of protein malnutrition (protein deficiency) characterized by edema and an enlarged liver with fatty infiltrates. It's most common in some developing regions where babies and children do not get enough protein or other essential nutrients in their diet. The main sign of kwashiorkor is too much fluid in the body's tissues, which causes swelling under the skin (oedema). It is thought to be caused by sufficient calorie intake, but with insufficient protein consumption (or lack of good quality protein), which distinguishes it from marasmus. Recent studies have found that a lack of antioxidant micronutrients such as β-carotene, lycopene, other carotenoids, and vitamin C as well as the presence of aflatoxins may play a role in the development of the disease.

Figure 2a and 2b: *Children with kwashiorkor showing nutritional edema and metabolic disturbances, including hypoalbuminemia and hepatic steatosis.*

Marasmus is a state of malnutrition characterized by gradual wasting of somatic fat and muscle stores and preservation of visceral proteins. It is one of the three forms of serious protein-energy malnutrition (PEM). However, the exact cause of kwashiorkor is still unknown. Inadequate food supply is correlated with occurrences of kwashiorkor; occurrences in high income countries are rare. It occurs amongst weaning children to ages of about five years old.

Eltayeb., *et al*. reported that agriculture is intensely pressured with the challenge to feed an envisaged [9] nine billion population projected to be on the planet by 2050, hence the need to identify and integrate unorthodox protein sources to augment the conventional formulation. The increasing demand for protein has become so great due to world population explosion and revolution of the food industry so much that agriculture is intensely pressured with the challenge to feed an envisaged [9] nine billion population projected to be on the planet by 2050 [3]. Research predicts a considerable pressure on the protein sources in the coming decades. Going by FAO (Food and Agriculture Organization of the United Nations) statistics (2021), about 1/6th of the world populace are suffering from starvation and more than 1 billion more people have insufficient in-take of protein therefore additional protein food is imperative from both traditional and unusual source [5].

The existing problems of malnutrition and food in-security coupled with rapid population growth and prohibitive nature of animal-based food have necessitated the need to identify and integrate unorthodox protein sources to augment the conventional formulation.

According to Klupšaitė., *et al*. regular consumption of vegetable protein as opposed to animal protein has been recommended by nutritionists leading to a renewed interest in legumes because of their high level of protein. Two major origin of protein exist, animal and plant. Providing enough proteins from animal source is challenging due to prohibitive cost. Apart from low consumption of mammalian protein due to high cost, large amounts of saturated fat and cholesterol are other problems associated with animal protein sources [6].

Animal protein sources include:

Figure 3, 4, 5, 6

Aletor., *et al*. reported that concerns about high-cholesterol necessitated the recommendation of regular consumption of vegetable protein as opposed to animal protein by nutritionists. This has led to a renewed interest in legume protein because of their high level of protein which ranged between 20 and 60% [7].

Vegetable/plant protein sources include:

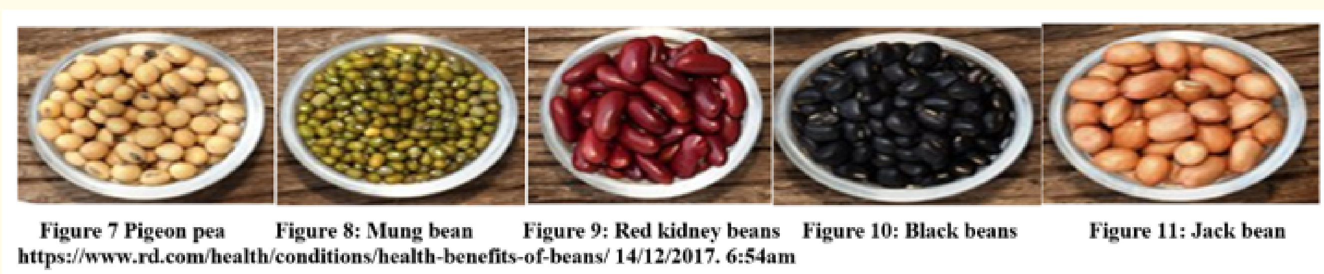

Figure 7-11

As reported in 2018 by Cheng-mei., *et al*. legumes have good protein quality in respect to their digestible and nutritional characters [8]. While Aghajanpour., *et al*. earlier mentioned that the level of fiber in the body also increases with increased consumption of more plant food that helps in reducing the danger of bowel diseases, as well as cancer of the colon and prevalence of osteoporosis [9].

Compared to cereal grains, it was also reported in 2016 by Singhal., *et al*. that legume grains are also very excellent source of weight reduction fibers [10]. However, Sibt-e-Abbas., *et al*. earlier in 2015 stated that according to modern nutrition recommendations, human beings ought to depend majorly on proteins of vegetable and legume origin for their dietary protein needs [11].

According to Oyewale RO., *et al*. Cowpea is an excellent source of nutrition recommended protein. Cowpea is a food legume of the family Fabaceae/Papilionaceae (*Vigna unguiculata*) consumed as a high-quality plant protein source in many parts of the world. High protein and carbohydrate contents with relatively low fat content and complementary amino acid pattern to that of cereal grains make cowpea an important nutritional food in the human diet and has gained more attention recently from consumers and researchers worldwide due to its exerted health beneficial properties including anti-diabetic, anti-cancer, anti-hyperlipidemic, anti-inflammatory and anti-hypertensive properties [12]. And later in 2014, Mudryj., *et al*. also reported that the greatest attribute of legumes is their high plant protein content, brought about by the symbiotic relationship with the nitrogen fixation bacteria. Legumes possess valuable proteins, which not only have superior nutritional and anti-oxidative properties, they have also been successfully used as nutraceutical ingredient. They are also important for providing balanced diet in human nutrition; they also give other nutrients essential to the body, such as, minerals, vitamins, dietary fibre, low glycemic index carbohydrate and variety of phytochemicals. Consumers now have greater diversification in their diet because of legumes which has offered a practical avenue for greater balance between animal and plant food sources [13]. Mune., *et al*. also reported in 2013, that mineral Content of human diet is crucial for the support of some physico-chemical activity that are critical to life. All body tissues and fluids contain inorganic substances known as minerals whose existence is essential for the support of some physico-chemical activity that are critical to life. They are chemical compounds utilized by man for various processes. Even though no energy is given by them, their activities in the body is very crucial [14].

Soetan., *et al*. also mentioned that these inorganic elements or minerals are needed by every living matter only in minute quantity for the sustenance of life. Their classification can be into 3 categories, the ultra- trace minerals, which is the third category; the micro elements, also known as the trace minerals is the second category; while the first category are the macro elements, also known as major minerals. Some of the macro-elements are Ca, P, Na and Cl, the second category, micro-elements include, iron, copper, cobalt, potassium, magnesium, iodine, zinc, manganese, molybdenum, F, Cr, Se and S [15].

Sodium (Na) is ingested into the body in the form of NaCl through food intake sodium helps in the maintenance of body pH and to retain water. Yellavila *et al.* (2015) reported a value range of 19.99 to 21.33 mg/100 g for lima beans flour [16]. Insel., *et al*. also reported that Iron helps to transport oxygen round the body and it helps in red blood cells building and to convert food into needed energy by the body [17].

Devi., *et al*. (2015) reported an improvement in value of iron with germination for the three cultivars of cowpea (PL-1-3) they worked on even after 24h. The values ranged from 4.86 - 6.78 mg/100g [18]. While, Al-Numair., *et al.* (2009) recorded values ranging between 5.97 to 7.08 mg/100g for one faba bean cultivar and 6.47 to 7.47 mg/100g for another cultivar. They also reported a value range of 10.67 to 14.53 mg/100g for one cultivar of white beans and 8.60 to 10.20 mg/100g for another cultivar. They also observed an increase in iron quantity with germination time and cultivar variation was also noticed as was for our solojo varieties [19]. Aremu *et al.* (2006) also reported a value of 5.5 mg/100g and 6.7 mg/100g for moderate brown and small white beans, this also shows varietal difference [20] Ghavidel and Prakash (2007) reported a value of 6.5 mg/100g for raw cowpea, and 5.87 mg/100g after germination, even though the value for the raw was higher than that after germination, the bioavailable iron in the germinated cowpea was 19.7% while that of the raw was 11.2% [21].

Manganese is an element that is needed in micro quantity but necessary to convert food into energy. It is also crucial for healthy bone and cartilage creation. Singh., *et al.* reported for soy protein isolate 0.002% (2 mg/100g), soy concentrates 0.005% (5 mg/100g) and the flour 0.003 to 0.004% (3-4 mg/100g) [22]. Al-Numair., *et al.* (2009) observed a rise in value with germination of the two cultivars of faba beans 2.69 to 4.72 mg/100g (0.269 to 0.472%) and 2.01 to 3.06 mg/100g (0.00201 to 0.00306%). Likewise, the cultivars of white beans also gave the same pattern of increase with germination [19]. Aremu., *et al*. reported values of 1.2 mg/100g (0.12%) for the two cowpea varieties. although these values were found to be lower than that reported for Soy beans and faba beans, it was within the spread of that observed by Aremu., *et al.* for two varieties of cowpea they worked upon. The low result could also have been due to draining into water at the time of soaking, germination and rinsing. On the contrary, Seena *et al*. recorded a value of 1.36 mg/100g for raw *Canavalia cathartica* which reduced in value to 0.79 mg/100g with roasting and cooking [23].

Insel., *et al*. reported that Zinc is an element that is although needed at the micro level in the body but very essential for a strong immune system to keep the body in good health. It is also crucial for the maintenance of a healthy sense of taste and odour [17]. Al-Numair., *et al*. noted a similar increase in zinc quantity of the legumes worked upon with increase in germination. They reported a value range of 2.22 to 2.73 mg/100g (0.00222 to 0.00273%) for faba bean accession and 2.46 to 2.82 mg/100g (0.00246 to 0.00282%) [19], while Aremu., *et al*. had a value of 5.7 and 6.0 mg/100g (0.0057 and 0.0060%) for the two cowpea varieties [20] and Singh., *et al.* recorded a value of 0.004 to 0.009% (4.0 mg/100g to 9.0 mg/100g) for soy protein isolates [22]. These values were found to fall within the values obtained for the Solojo samples in the present work. The increase in value of Zinc with germination could be due to the reduction in the anti-nutrients content in the legume due to germination.

Insel., *et al*. reported that Calcium is a critical element for strong bones and teeth, blood coagulation, and muscle tightening and relaxation and that Magnesium is needed to build enzyme and antioxidants and also for healthy bones They also reported that Potassium is needed to maintain; water balance, muscle movement, and nerve impulses in addition to functioning in conjunction with Na to regulate blood pressure [17].

Onibon., *et al*. reported that Potassium, apart from being important in cellular water balance, it is also very important for protein and carbohydrate metabolism [24].

Generally, the values obtained for each mineral was lower than reported by other researchers, this may be as a result of leakage of the mineral into the water, and this was similarly detected by Desalegn, in 2015 for soaked and germinated chickpea flour [25].

Materials and Methods

Two varieties of the underutilized cowpea (*V. unguiculata*) found in South west region of Nigeria where it is called 'solojo' were used (Figure 12 and 13).

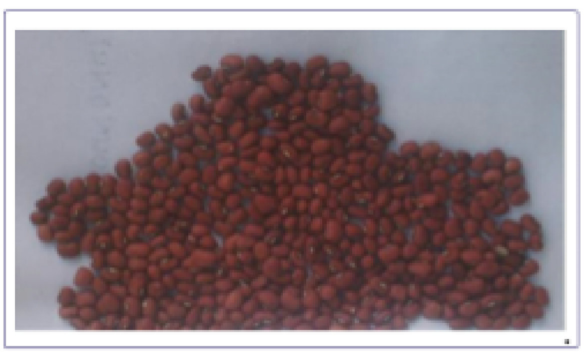

Figure 12: Brown Solojo Cowpea.

Figure 12-13

Seeds obtained from Bodija market in Ibadan, Western Nigeria, 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 6h 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, 24h, 36h, 48h and 72h (Figure 14).

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.

6h Soaked flour: The seeds were segregated to remove the unwholesome ones, then immersed for 6h 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 48h 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 with minor adjustment. The seeds for germination were disinfected by soaking in 0.07% sodium hypochlorite for30 minutes, 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 for various hours such as 24h, 36h, 48h and 72h. The process of germination was terminated by freezing; the seeds were manually dehulled, dried in a draught oven at 40°C for 48h, cooled, milled and packaged in an air tight plastic bag in the refrigerator pending analysis.

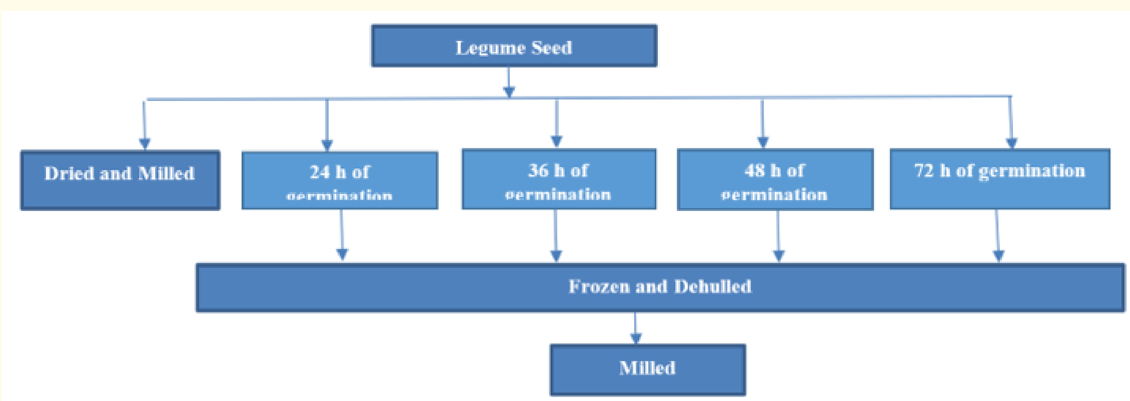

Figure 14: *Preparation of beans flour/schematic representation.*

Results and Discussion

Table 1 to 4 represents the results of mineral analysis for the flours and protein isolates of Solojo cowpea samples.

The values of Sodium (Na) ranged from 728.97 to 253.37 ppm (72.90 to 25.34 mg/100 g); 715.24 to 216.05 ppm; 735.28 to 270.37 ppm; 726.59 to 264.35 ppm, for FFDAS, FFBS, DAS and BS as shown in tables 1-4 respectively with all values of the germinated samples all bellow the control. The low values for all the germinated samples are very good because, Na even though important should not be too much in the body. Germination reduced the Na concentration in the sample, thereby giving room for the added salt in food.

FFDAS (ppm)	Ca	Na	Zn	Fe	Mg	K	Cu	Mn	Cd	Pb	Cr
Raw	250.56	728.97	38.80	4.25	103.0	206.99	0.42	0.36	0.30	ND	0.21
6h	439.36	721.19	59.90	5.20	116.12	427.13	16.99	7.20	0.24	ND	0.21
24h	614.39	704.66	78.90	6.90	125.98	547.45	23.01	8.52	0.20	ND	0.73
36h	642.38	634.61	95.10	7.12	137.00	628.31	27.05	16.93	0.11	ND	0.89
48h	684.62	560.56	139.900	9.97	146.12	1041.23	32.65	16.99	0.06	ND	0.60
72h	760.03	253.37	230.01	13.59	200.88	1118.57	40.42	18.33	0.04	ND	0.94

Table 1: *Elemental analysis of dark ash solojo flour (ppm).*

DAS: Dark Ash Solojo; ND: Not Detected.

The FFDAS iron (Fe) content ranged from 4.25 to 13.50 mg/100g; FFBS ranged from 3.15 to 12.56 mg/100g; DAS ranged from 3.81 to 12.90 mg/100g; BS ranged from 3.42 to 9.40 mg/100g as shown in tables 1-4. The values of the germinated flours were all greater than the un-germinated flour. This buttresses the fact that germination makes the macronutrient to be more available. This could be due to decrease in the anti- nutrient level which was binding to the iron before germination, which has now released the iron to be bioavailable for utilization. The values obtained in this work fell within the range observed by other researchers.

FFBS	Ca	Na	Zn	Fe	Mg	K	Cu	Mn	Cd	Pb	Cr
Raw	400.40	715.24	40.84	3.15	113.03	398.39	0.39	0.38	0.26	ND	0.42
6h	571.06	653.72	65.47	5.39	123.88	547.45	4.32	10.60	0.24	ND	0.52
24h	836.94	460.41	85.47	6.13	166.81	728.34	4.95	11.74	0.23	ND	1.73
36h	870.75	320.48	105.06	8.28	187.10	948.44	5.30	12.66	0.11	ND	1.85
48h	953.42	235.12	148.12	10.26	197.19	1096.65	8.18	14.10	0.08	ND	1.92
72h	998.22	216.05	250.01	12.56	219.26	1268.98	9.39	15.95	0.10	ND	1.98

Table 2: *Elemental analysis of FFBS.*

FFBS: Full Fat Brown Solojo; ND: Not Detected.

The manganese (Mn) quantity in the flour of DAS spread between 0.36 ppm to18.33 ppm (0.036 mg/100g to 1.833 mg/100g) after germinating for 72h; 0.38 to 15.95 ppm; 1.25 to 4.11 ppm; 0.98 to 3.10 ppm, for FFBS, DAS and BS respectively. This value rose with rise in germination time.

The zinc quantity increased as germination proceeded and the values ranged from 38.80 ppm to 230.00 ppm (3.880 mg/100g to 23.00 mg/100g; 0.003880% to 0.0230%); 40.84 to 250.01 ppm; 32.85 to 93.41 ppm; 37.07 to 115.00 ppm, for FFDAS, FFBS, DAS and BS respectively.

DAS	Ca	Na	Zn	Fe	Mg	K	Cu	Mn
Raw	116.87 ± 0.56	735.28 ± 0.43	32.85 ± 0.36	3.81 ± 0.47	38.37 ± 0.47	123.34 ± 0.32	0.89 ± 0.04	1.25 ± 0.25
6h	126.44 ± 0.70	688.24 ± 0.90	42.96 ± 0.49	5.21 ± 0.34	51.91 ± 0.49	154.92 ± 0.26	1.32 ± 0.03	1.55 ± 0.35
24h	139.10 ± 0.40	620.19 ± 0.75	57.73 ± 0.39	6.35 ± 0.47	74.04 ± 0.53	203.38 ± 0.60	1.45 ± 0.03	1.89 ± 0.21
36h	159.09 ± 0.37	524.40 ± 1.38	61.91 ± 0.39	7.42 ± 0.63	100.42 ± 0.45	258.73 ± 0.43	1.72 ± 0.04	2.73 ± 0.26
48h	175.76 ± 0.47	317.17 ± 1.14	79.11 ± 0.18	9.02 ± 0.60	104.04 ± 0.36	412.05 ± 0.47	1.84 ± 0.04	2.95 ± 0.26
72h	195.69 ± 0.84	270.37 ± 6.08	93.41 ± 0.41	12.90 ± 0.50	114.22 ± 0.56	771.73 ± 0.34	1.87 ± 0.07	4.11 ± 0.30

Table 3: *Elemental analysis of dark ash solojo isolate.*

DAS: Dark Ash Solojo Cowpea Protein Isolate.

The Calcium (Ca) content improved significantly ($p<0.05$) with sprouting, the value extended from 250.56 ppm to 760.03 ppm (25.056 to 76.00 mg/100g or 0.0251 to 0.0760%); 400.40 to 998.22 ppm; 116.87 to 195.69 ppm; 113.48 to 220.75 ppm, for FFDAS, FFBS, DAS and BS respectively.

The results obtained in this project were observed to be less than the values recorded by the researchers; these could be due to leaching into water of the nutrient due to the mode of germination employed. The magnesium (Mg) content increased with germination time. The value ranged from 103.0 to 200.80 ppm (10.3 to 20.08 mg/100g; or 0.0103 to 0.0201%); 113.03 to 219.26 ppm (11.30 to 21.93 mg/100g); 38.37 to 114.22 ppm (3.84 to 11.42 mg/100g); 55.89 to 124.17 ppm (5.59 to 12.42 mg/100g) for FFDAS, FFBS, DAS and BS respectively. The results obtained in this project were close in value to that obtained for horse gram and *Canavalia cathartica*. The increase observed could be as a result of decrease in phytate content with germination.

BS	Ca	Na	Zn	Fe	Mg	K	Cu	Mn
Raw	113.48 ± 0.51	726.59 ± 1.99	37.07 ± 0.39	3.42 ± 0.47	55.89 ± 0.71	137.02 ± 0.62	0.82 ± 0.04	0.98 ± 0.05
6h	138.17 ± 0.62	696.95 ± 3.12	62.66 ± 0.45	4.22 ± 0.62	69.91 ± 0.50	248.11 ± 0.48	1.09 ± 0.03	1.24 ± 0.09
24h	156.54 ± 0.60	547.96 ± 2.58	84.43 ± 0.28	5.46 ± 0.56	71.85 ± 0.38	497.58 ± 0.86	1.27 ± 0.03	1.28 ± 0.17
36h	169.43 ± 0.97	417.81 ± 0.80	108.27 ± 0.28	7.37 ± 0.63	82.54 ± 0.41	580.66 ± 0.13	1.38 ± 0.06	1.39 ± 0.06
48h	175.08 ± 0.26	387.68 ± 1.48	115.00 ± 0.38	8.47 ± 0.62	100.78 ± 0.53	792.85 ± 0.47	1.50 ± 0.02	2.30 ± 0.06
72h	220.75 ± 1.21	264.35 ± 1.48	120.57 ± 0.48	9.40 ± 0.67	124.17 ± 0.69	925.97 ± 0.83	1.61 ± 0.05	3.10 ± 0.21

Table 4: *Elemental analysis of brown solojo isolate.*

BS: Brown Solojo Cowpea Protein Isolate.

The potassium (K) content was observed to rise with germination with value ranging from 206.99 ppm to 1118.57 ppm (20.70 to 111.86 mg/100g); 398.39 to 1268.98 ppm; 123.34 to 771.73 ppm; 137.02 to 925.97 ppm for FFDAS, FFBS, DAS and BS respectively.

Conclusion and Recommendation

Biochemical modification which involves the activation of the intrinsic enzymes of the Solojo cowpea seed itself by germination was carried out for different hours for the two varieties, i.e. the Dark-Ash and the Brown Solojo beans. Proximate analysis, revealed that biochemical modification improved the nutritional quality of the Solojo beans better, when compared with the obtained result of Chemical modification in the literature. Which means that, biochemically modified flour and protein isolates will do better in food processing than chemically modified isolates. Germination also brought about reduction in indigestible dietary fiber that causes flatulence and discourages people from wanting to consume legumes, because of the increase in α-amylase activity which brings about the breakdown of complex carbohydrate, this is majorly taken care off. All these make consumption of germinated seed to be healthier than the ungerminated seed. Germination also improved the bio-availability of the important minerals, this is as a result of breakdown of phytate and other anti-nutrients which chelates to the divalent metals, most especially Fe, Zn and Ca, making them unavailable. The decrease in value of the phytate and other anti-nutrients and increase in value of the micro-nutrients shows that germination actually brought about this break down. With the breakdown of the anti-nutrients, the minerals are made more available for use both in the food product and when consumed. The amino acid was also found to increase with germination, this is attributed to the breakdown of the higher molecular weight storage protein which are broken down to lower molecular weight proteins, thus making it more available to the body when used in production. Germination has also been found to increase the amount of the limiting Sulphur amino acids which make legume protein to be termed as incomplete. 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 such as soya beans.

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