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# Comparative Assessment of Phytochemical Contents of Diet Combinations Made From Lima Beans and Cowpea

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**Abstract- Legumes are important sources of nutrients and phytochemicals. Phytochemicals are plant derived chemicals known to possess many properties, including anti-oxidant, anti-microbial and physiological activities. Though phytochemicals are vital to both plants and animals, they are not established as essential nutrients and they can also have adverse effects by functioning as anti-nutrients. Processing affects the nutritional values of plant-based food and such food products may lose part of their functionality as these chemicals are sensitive to the impact of processing methods. Therefore, the objective of this study was to evaluate the phytochemical contents of legume-based lima beans/cowpea diet combinations so as to recommend the best combination to maximize their pharmacological potentials and reduce the anti-nutritional effects. Quantitative analysis of phytochemical constituents of the formulated diet combinations were carried out using standard procedures for oxalate, alkaloids, flavonoids, saponin, cardiac glycosides, tannin, phytate, cyanogenic glycoside while spectrophotometer method was used for the determination of steroids and phenols. Among whole legume-based diet combinations, 75:25 ratio lima beans/cowpea diet recorded the lowest alkaloid, flavonoid, cyanogenic glycosides and saponin levels of 5.20 %, 4.0 %, 4.8 % and 3.0 %, respectively. However, among the dehulled legume-based diet, the 50:50 ratio lima beans/cowpea combination had the lowest saponin, steroid, alkaloid, cyanogenic glycoside and flavonoid levels of 1.90 %, 5.38 mg/g, 3.0 %, 5.55 % and 4 %, respectively. Over all, the 50:50 ratio dehulled lima beans/cowpea diet combination, compared to other diet combinations, had the lowest contents of saponin, steroid, alkaloid and flavonoid out of the nine phytochemicals quantified. Pharmacological properties of phytochemicals are beneficial to human health. However, these phytochemicals could also be detrimental to human health when consumed in excess. Therefore, legume-based lima beans/cowpea diet combination ratios should be done with respect to the pharmacological properties of interest.**

**Index Terms- Legumes, lima beans, cowpea, diet combinations, phytochemicals**

## I. INTRODUCTION

Global food security continues to be a worldwide concern. The existing problems of food security and malnutrition coupled with escalating population, uncertain crop yield and high cost of animal protein supplies have resulted in identification and incorporation of unconventional protein sources to enrich traditional formulations (Awan, 2000). Legumes contribute significantly to world food supplies and food intake.

Legumes (beans and pulses) belong to the family Leguminosae. They occupy an important place in human nutrition, especially among the low-income groups of people in developing countries (Myrtsi, et al., 2024; Tor-Roca, 2020; Siddiq and Uebersax, 2012). Indigenous legumes are an important source of affordable alternative protein to poor resource people in many tropical countries especially in Africa and Asia where they are predominantly consumed. There are large varieties of legumes in tropical Africa which are part of traditional food systems in most communities. Each community evolves different processing methods for food preparations and these processes affect nutritional composition of the legumes.

However, in resource poor communities, it has become clear that malnutrition is attributable not solely to insufficient amounts of food but also to the poor nutritional quality of the available food supply. A number of factors limit legume utilization, including the long soaking and cooking times

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necessary to adequately soften the beans, loss of valuable nutrients during food preparation, presence of anti-nutrients, high level of phytic acid, various flatulence factors, hard shell and hard-to-cook defects that may develop during storage (Alonso et al., 2000; Wang et al., 2010).

Legumes produce primary and secondary metabolites and other phytochemicals (Ganiyu, 2006). Phytochemicals are plant derived chemicals which are beneficial to human health and disease prevention (Myrtsi, et al., 2023; Anderson, 2004). The term is generally used to refer to those chemicals that may have biological significance, for example antioxidants, but are not established as essential nutrients which when in excess could be detrimental. In as much as phytochemicals help to strengthen the body defence mechanism, serving mostly as antioxidants, moderate consumption is highly recommended so that they will not serve as anti-nutrient to the body (Madrera, et al., 2021; Ifemeje et al., 2014).

Processing techniques affect the nutritional values of plant-based food. Literature abounds on the effect of processing on the nutritive value of food processed from single legumes, and also from combination of legume and cereal (Luo and Xie, 2014; Pelgrom et al., 2015; Kaur et al., 2015; Indrani et al., 2015; Torres et al., 2016; Oghbaei et al., 2016; Kumari and Sangeetha, 2017). However, surveys of available literature indicate scanty report on the nutritive value of food prepared from a combination of legumes. Therefore, the aim of the study is to evaluate the phytochemical contents of diet combinations made from lima beans and cowpea so as to recommend the best combination for maximizing their pharmacological potentials and reducing the anti-nutritional effects.

## II. MATERIALS AND METHODS

Dried Lima beans and Cowpea samples were bought from an open market in South-East Nigeria. The legumes were screened, labelled and then stored at room temperature after being identified as lima beans and cowpea by a taxonomist.

**1. Sample Preparations for Diet Combinations**

Sample preparations for diet combinations with dehulled grains 5 kg of each sample of whole lima beans and whole cowpea were respectively cracked using a sheller. The cracked samples were soaked separately in room temperature water for 30 minutes.

At the end of the soaking period, the samples were washed to remove the shell. 4 kg of each dehulled samples were then dried in an oven at 40 oC to constant weight and then ground to powder (355/180 mesh) using a mechanical grinder. The powdered samples were labeled and kept in screw capped air tight containers and stored in glass desiccators until needed for diet combinations.

Sample preparation for diet combinations with whole grains

5 kg of each whole lima beans and whole cowpea samples were dried in an oven at 40 oC to constant weight and then ground to powder (355/180 mesh) using a mechanical grinder. The powdered samples were labelled and kept in screw capped air tight containers and stored in glass desiccators until needed for diet combinations.

**Formulation of diet Combinations**

3 kg of each ground samples (whole and dehulled lima beans and cowpea samples) were set apart for the formulation of 10 different diet combinations, each weighing 500 g. The diet combinations were prepared using different ratios: four 100 % samples (500 g each of whole and dehulled lima beans and 500 g each of whole and dehulled cowpea); two 50:50 ratios of samples {250 g whole lima beans mixed with 250 g whole cowpea; and 250 g dehulled lima beans mixed with 250 g dehulled cowpea}, two 75:25 {375 g whole lima beans mixed with 125 g whole cowpea; 375 g whole cowpea mixed with 125 g whole lima beans} and two 25:75 {125 g dehulled lima beans mixed with 375 dehulled cowpea; 375 g dehulled lima beans mixed with 125 g dehulled cowpea). The samples were labelled A – J.

After measuring and mixing the samples in their required proportions, 250 cl of water was added to each 500 g of measured sample, mixed and poured into labelled pudding plates and cooked for 1 hour. At the end of the cooking process, the samples were allowed to cool, cut into small pieces and then dried in an oven at 40 oC to a constant weight. The dried samples were ground to powder (355/180 mesh) and 300 g of each sample labelled A-J were stored in air tight container for phytochemical analysis.

**2. Quantitative Determination of Phytochemical Constituents**

Formulated diet combinations were analysed for phytochemical constituents. Oxalate determination was done using the titration method (Institute of Chemistry, 2007) while the quantitative determination of alkaloids was according to the methodology of Harborne (1998).

Quantitative determination of flavonoids and saponin were done using the methods of Boham and Kocipai (1994) and Obadoni and Ochuko (2002), respectively. The method of Wang et al., (2008) was used to determine cardiac glycosides while the Follins Dennis titrating method (Pearson, 1976) was used for the determination of tannin.

Phytate contents were determined using the method of Young and Greaves (1940) as adopted by Lucas and Markakes (1975). Acid Titration Method (AOAC, 1990) was used to determine cyanogenic glycoside while the steroid and phenols contents were determined using spectrophotometer method.

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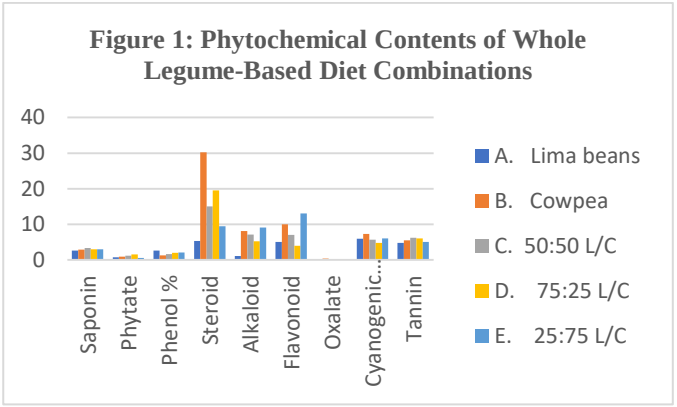
## III. RESULT AND DISCUSSION

Phytochemical contents of 10 legume-based diet combinations (A-J) are shown in Table 1.

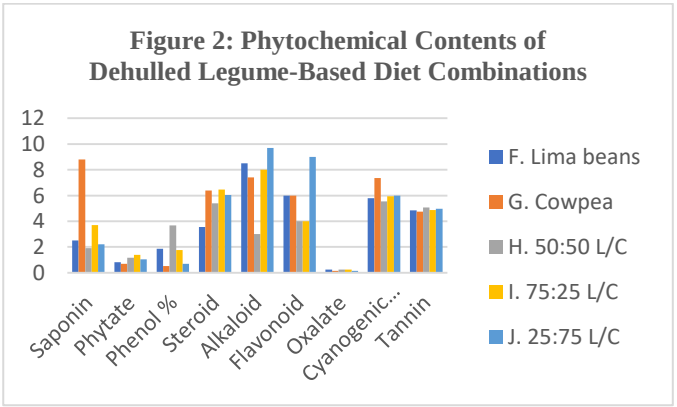
Table 1: Phytochemical Contents of Legume-Based Diet Combinations

| Samples | Saponin % | Phytate mg/g | Phenol % | Steroid mg/g | Alkaloid % | Flavonoid % | Oxalate mg/g | Cyanogenic Glycoside | Tannin % |
|---|---|---|---|---|---|---|---|---|---|
| A. Whole Lima beans (L) | 2.60 | 0.70 | 2.65 | 5.32 | 1.10 | 5.00 | 0.21 | 5.95 | 4.75 |
| B. Whole Cowpea (C) | 2.90 | 0.93 | 1.28 | 30.19 | 8.10 | 10.00 | 0.40 | 7.30 | 5.49 |
| C. 50:50 L/C (whole) | 3.30 | 1.16 | 1.61 | 15.03 | 7.10 | 7.00 | 0.16 | 5.70 | 6.20 |
| D. 75:25 L/C (whole) | 3.00 | 1.57 | 1.94 | 19.49 | 5.20 | 4.00 | 0.18 | 4.80 | 6.05 |
| E. 25:75 L/C (whole) | 3.00 | 0.58 | 2.10 | 9.49 | 9.10 | 13.00 | 0.22 | 6.00 | 5.00 |
| F. Dehulled Lima beans | 2.50 | 0.81 | 1.86 | 3.54 | 8.50 | 6.00 | 0.23 | 5.80 | 4.84 |
| G. Dehulled Cowpea | 8.80 | 0.70 | 0.52 | 6.38 | 7.40 | 6.00 | 0.14 | 7.35 | 4.75 |
| H. 50:50 L/C (dehulled) | 1.90 | 1.16 | 3.68 | 5.38 | 3.00 | 4.00 | 0.23 | 5.55 | 5.06 |
| I. 75:25 L/C (dehulled) | 3.70 | 1.39 | 1.76 | 6.46 | 8.00 | 4.00 | 0.23 | 5.95 | 4.87 |
| J. 25:75 L/C (dehulled) | 2.20 | 1.04 | 0.69 | 6.03 | 9.70 | 9.00 | 0.14 | 6.00 | 4.96 |

Among whole legume-based diet, 50:50 ratio lima beans/cowpea diet combination had the lowest phenol and oxalate contents of 1.61 % and 0.16 mg/g, respectively. The 75:25 ratio lima beans/cowpea diet combination recorded the lowest alkaloid, flavonoid and cyanogenic glycosides of 5.20 %, 4.0 % and 4.8 %, respectively and jointly recorded the lowest saponin level of 3.0 % with 25:75 ratio lima beans/cowpea diet combination. The 25:75 ratio lima beans/cowpea diet combination also recorded the lowest level of 0.58 % and 9.49 mg/g of steroid, respectively (Figure 1).




Among dehulled legume-based diet combinations, 50:50 ratio lima beans/cowpea diet combination had the lowest saponin, steroid, alkaloid and cyanogenic glycoside of 1.90 %, 5.38 mg/g, 3.0 % and 5.55 %, respectively and jointly recorded the lowest flavonoid level of 4 % with the 75:25 ratio lima beans/cowpea diet combination. The 75:25 ratio lima beans/cowpea diet combination also recorded the lowest tannin level of 4.87 % while the 25:75 ratio lima beans/cowpea diet combination had the lowest phytate, phenol and oxalate levels of 1.04 %, 0.69 % and 0.1 mg/g, respectively (Figure 2).




Saponin compositions of all the samples were higher than 0.43 %, 0.25 %, 0.39 % and 0.44 % reported respectively for whole seeds of Vigna subterranean (Bambara groundnut),

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Arachis hypogea (Groundnut), Glycine max (Soya beans) and Vigna unguiculata (Cowpea) found in Eastern Nigeria (Mbagwu et al., 2011). Research sources disclosed that saponins exert various biological benefits, such as anti-inflammatory, anti-diabetic, anti-HIV, anti-atherosclerotic and serve as protective functions like gastro-protective, hepatoprotective and hypolipidemic (Banno et al., 2004). Saponins have cholesterol binding properties and helps in hemolytic activities (Okwu, 2004).

The phytate contents of all the samples in the study were higher than 1.00, 0.19 and 0.18 mg/100g reported by Ikpeme-Emmanuel et al. (2012) in Calabar, Nigeria for soybean and tiger nut combinations weaning food. The phytate compositions of the samples were comparable with the ranges of 0.18 - 1.54 mg/g and 0.13 - 1.54 mg/g reported for boiled and roasted asparagus bean (Vigna sesquipedalis) flour obtained from Anambra State, Nigeria (Nzewi and Egbuonu, 2011). Phytic acid from dietary sources is believed to act as potential antioxidant (Makkar, Siddhuraju and Becker, 2007).

The phenol compositions of all the samples were lower than the value of 7.09 % reported in Kenya for dehusked mucana bean (Mugendi et al., 2010). The phenol compositions of 1.28 and 0.52 % for whole and dehusked cowpea respectively were lower than 3.82 % reported in India for four cultivars of brown cowpea (Vigna unguiculata. L. Walp) (Preet and Punia, 2009). The presence of phenol indicates that these legumes have ability to block specific enzymes that cause inflammation. They also modify the prostaglandin pathways thereby protecting platelets from clumping.

The flavonoid values of all the samples in the study were higher than 0.29 %, 0.18 %, 0.25 % and 0.33 % reported respectively for whole seeds of Vigna subterranean (Bambara groundnut), Arachis hypogea (Groundnut), Glycine max (Soya beans) and Vigna unguiculata (Cowpea) found in eastern Nigeria (Mbagwu et al., 2011). Flavonoids are the most common group of polyphenolic compounds in the human diet and are found ubiquitously in plants (Spencer, 2008; Spencer, 2010).

In this study, the oxalate compositions of all the samples were lower than 0.45 % and 0.43 % respectively reported in Calabar, Nigeria for soybean and tiger nut based weaning food (Tiger nut 75 %/soyabean 15 % and Tiger nut 65 %/soybean 25 %) (Ikpeme-Emmanuel et al., 2012). However, whole cowpea with an oxalate value of 1.00% was higher than 0.37 % reported for -Tiger nut 55 %/soybean 35 % weaning food (Ikpeme-Emmanuel et al., 2012). High oxalate levels in food may reduce the bioavailability of minerals such as calcium, magnesium and zinc thereby interfering with their utilization (Omorayi and Dilworth, 2007; Oluyemi et al., 2006).

The tannin values of all the samples in the study were higher than 0.8, 1.1 and 1.4 % reported respectively for soybean and tiger nut based weaning food (Tiger nut 75 %/soyabean 15 %, Tiger nut 65 %/soybean 25 % and Tiger nut 55 %/soybean 35 %) by Ikpeme-Emmanuel et al. (2012) in Calabar, Nigeria. Also, the phytate compositions of the samples were higher than the ranges of 1.88 to 3.72 % and 1.82 to 3.72 % reported for boiled and roasted asparagus bean (Vigna sesquipedalis) flour procured from Anambra State, Nigeria (Nzewi and Egbuonu, 2011). Tannins have astringent properties for healing of wounds and inflaming mucous membranes (Okwu and Okwu, 2004).

The alkaloid composition of all the samples in this study were higher than 0.40 %, 0.25 %, 0.33 % and 0.37 % reported for whole seeds of Vigna subterranean (Bambara groundnut), Arachis hypogea (Groundnut), Glycine max (Soya beans) and Vigna unguiculata (Cowpea) respectively (Mbagwu et al., 2011). Alkaloids are useful in the prolonging of action of several hormones and acting as stimulants while flavonoids promote peculiar taste in prepared foods. They are potent water soluble, super anti-oxidants and free radical scavengers which prevent oxidative cell damage and have strong anti-cancer activity which adds protection against all stages of carcinogenesis (Okwu, 2004).

## IV. CONCLUSION

Results of the phytochemical analysis of the diet combinations showed that lima beans and cowpea samples used in this study contain phytochemicals such as alkaloids, flavonoids, saponin, tannins, oxalates, phytate, phenols, steroids and cyanogenic glycoside. Comparative assessment of the cooked whole and dehulled legumes and their diet combinations showed that the phytochemical contents vary. Dehulling reduced the saponin, phenol, steroid, oxalate and cyanogenic glycoside contents of lima beans while the reverse is true for phytate, alkaloid, flavonoid and tannin contents.

On the other hand, dehulling reduced the phytate, phenol, steroid, alkaloid, flavonoid, oxalate and tannin contents of cowpea and increased its saponin and cyanogenic glycoside contents. Over all, the 50:50 ratio dehulled lima beans/cowpea diet combination, compared to other diet combinations, had the lowest contents of saponin, steroid, alkaloid and flavonoid out of the nine phytochemicals analysed.

Phytochemicals possess certain pharmacological properties that are beneficial to human health. However, these chemicals are not established as essential nutrients and could be detrimental when consumed in excess. Therefore, diet combination ratios should be done with respect to the pharmacological properties of interest.

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## REFERENCES


1. Alonso, R, Aguire, A, and Marzo, F. (2000). Effects of Extrusion and Traditional Processing Methods on Anti-nutrients and In-vitro Digestibility of Protein and Starch in Faba and Kidney Beans. Journal of Food Chemistry. 68:159-165.
2. Anderson, G.D. (2004). Phytochemicals. Trends in Food Science Technology, 4:168-175.
3. AOAC (1990). Official Methods of Analysis of the Association of Official Analytical Chemists, 15th edition, Arlington, V.A., Methods, 920.39 – 962.09.
4. Awan, J. A. (2000). Elements of Food and Nutrition. 2nd Edition, Uni-tech Communications, Faisalabad, Pakistan. 156 pp
5. Banno, N., Akihisa, T., Tokuda H., Yosukawa K., Hikashihara H., Ukiya M., Watakabe, K., Kimura, Y., Hasegawa J., Nishino H. (2004). Riterpene acids from the leaves of Perilla frutescens and their antiiflammatoty and anti-tumor-promoting effects. Bioscience, Biotechnology and Biochemistry, 68: 85–90.
6. Boham, B. A. and Kocipai, A. R. (1994). Flavonoids and condensed Tannins from Leaves of Hawaiian Vaccinium vaticulatum and V. calycinium." Pacific Science, 48: 458–463.
7. Ganiyu, O. (2006). Antioxidant Properties of Some Commonly Consumed and Underutilized Tropical Legumes. European Food Research Technology, 224: 61–65.
8. Harborne, J.B. (1998). Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis, 3rd Ed., Chapman and Hall, London. ISBN – 13:978041257270. p.302
9. Ifemeje, J. C., Egbuna, C., Eziokwudiaso, J. O. and Ezebuo F. C. (2014). Determination of the Anti-nutrient composition of Ocimum gratissimum, Corchorus olitorius, Murraya koenii Spreng and Cucurbita maxima. International Journal of Innovation and Scientific Research, 3: 127- 133.
10. Ikpeme-Emmanuel, C. A., Ekpeyoung, I. O. and Igile, G. O. (2012). Chemical and Protein Quality of Soybean (Glycine max) and Tigernut (Cyperus esculenta) Based Weaning Food. Journal of Food Research. 1 (2): 246-254.
11. Indrani, D., Milind, S. D., Sakhare, S. D. and Inamdar, A. A. (2015). Development of protein and fiber enriched breads by supplementation of roller milled fractions of green gram. Journal of Food Science and Technology, 52: 415–422.
12. Institute of Chemistry (2007). Analytical Chemistry Laboratory Manual. Revised Edition, University of the Philippines, Diliman Quezon City, p.53
13. Kaur, M., Sandhu, K. S., Ahlawat, R. P. and Sharma, S. (2015). In vitro starch digestibility, pasting and textural properties of mung bean: Effect of different processing methods. Journal of Food Science and Technology, 52: 1642–1648.
14. Kumari, P.V. and Sangeetha, N. (2017). Nutritional significance of cereals and legumes-based food mix- A review. International Journal of Agricultural and Life Sciences- IJALS, 3 (1): 115-122.
15. Lucas, G. M. and Markakas, P. (1975). Phytic acid and other phosphorus compounds of bean (Phaseolus vulgaris). Journal of Agriculture and Education Chemistry, 23: 13–15.
16. Luo, Y. and Xie, W. (2014). Effect of soaking and sprouting on iron and zinc availability in green and white faba bean (Vicia faba L.). Journal of Food Science and Technology, 51: 3970–3976.
17. Madrera, R.R., Negrillo, A.C., Valles, B.S., and Fernández, J.J.F. (2021). Phenolic Content and Antioxidant Activity in Seeds of Common Bean (Phaseolus vulgaris L.). Foods, 10, 864.
18. Makkar, H., Siddhuraju, P. and Becker, K. (2007). Plant Secondary Metabolites. Methods in Molecular Biology, 393:1-122.
19. Mbagwu, F. N., Okafor, V. U. and Ekeanyanwu, J. (2011). Phytochemical Screening on Four Edible Legumes (Vigna subterranean, Glycine max, Arachis hypogea and Vigna unguiculata) found in Eastern Nigeria. African Journal of Plant Science, 5(6): 370-372.
20. Mugendi, J. B., Njagi, E. N. M., Kuria, E. N., Mwasaru, M. A., Mureithi, J. G. and Apostolides, Z. (2010). Effects of Processing Technique on the Nutritional Composition and Anti-nutrient Content of Mucuna Bean (Mucuna pruriens L.). African Journal of Food Science, 4(4): 156-166.
21. Myrtsi, E.D., Vlachostergios, D.N., Petsoulas, C., Koulocheri, S.D., Evergetis, E. And Haroutounian, S.A. (2024). Eleven Greek Legume Beans: Assessment of Genotypic Effect on Their Phytochemical Content and Antioxidant Properties. Antioxidants, 13:459. https://doi.org/10.3390/antiox13040459
22. Myrtsi, E.D., Evergetis, E., Koulocheri, S.D. and Haroutounian, S.A. (2023). Bioactivity of Wild and Cultivated Legumes: Phytochemical Content and Antioxidant Properties. Antioxidants (Basel), 12(4):852. doi: 10.3390/antiox12040852. PMID: 37107225; PMCID: PMC10135128.
23. Nzewi, D. C. and Egbuonu, A. C. (2011). Effect of Boiling and Roasting on Some Anti-nutrient Factors of Asparagus Bean (Vigna sesquipedalis) Flour. African Journal of Food Science and Technology, 2 (3): 075-078.
24. Obadoni, B. O. and Ochuko, P. O. (2002). Phytochemical studies and comparative efficacy of the crude extracts of some haemostatic plants in Edo and Delta States of Nigeria." Global Journal of Pure and Applied Sciences, 8 (2): 203–208.


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25. Oghbaei, M., Prakash, J. and Yildiz, F. (2016) Effect of primary processing of cereals and legumes on its nutritional quality: A comprehensive review. Cogent Food & Agriculture, 2 (1): 1-29.
26. Okwu, D. E. (2004). Phytochemicals and Vitamin Content of Indigenous Spices of Southeastern Nigeria. Journal of Sustainable Agriculture and Environment, 6(1): 30-37.
27. Okwu, D. E. and Okwu, M. E. (2004). Chemical Composition of Spondias mombin Linn Plant Parts. Journal of Sustainable Agriculture and Environment, 6(2): 140-147.
28. Oluyemi, E. A., Akilula, A. A., Adenuya, A. A. and Adebayo, A. A. (2006). Mineral Contents of Some Commonly Consumed Nigerian Foods. Science Focus, 11: 153-157.
29. Omorayi, F. O. and Dilworth, L. (2007). Anti-nutritional Factors, Zinc, Iron and Calcium in Some Cariggean Tuber Crops and Effect of Boiling or Roasting. Nutrition and Food Science, 37: 8-15.
30. Pearson, D. (1976). Chemical Analysis of Food. Churchill Livingston, Edinburgh, UK. Pp. 103-110.
31. Pelgrom, P. J. M., Wang, J., Boom, R. M. and Schutyser, M. A. I. (2015). Pre- and post-treatment enhance the protein enrichment from milling and air classification of legumes. Journal of Food Engineering, 155: 53–61.
32. Preet, K. and Punia, D. (2009) Proximate composition, phytic acid, polyphenols and digestibility (in vitro) of four brown cowpea varieties. International Journal of Food Sciences and Nutrition, 51:3: 189-193.
33. Siddiq, M. and Uebersax, M. A. (2012). Dry Beans and Pulses Production & Consumption: An Overview. In: Dry Beans and Pulses: Production, Processing and Nutrition, 1st ed. Siddiq, M. and Uebersax, M. A. (eds), Blackwell Publishing Ltd., Oxford. 398 pp
34. Torres, J., Rutherfurd, S. M., Muñoz, L. S., Peters, M. and Montoya, C. A. (2016). The impact of heating and soaking on the in vitro enzymatic hydrolysis of protein varies in different species of tropical legumes. Food Chemistry, 194: 377–382.
35. Tor-Roca, A., Garcia-Aloy, M., Mattivi, F., Llorach, R., Andres-Lacueva, C. and Urpi-Sarda, M. (2020). Phytochemicals in Legumes: A Qualitative Reviewed Analysis. Journal of Agricultural and Food Chemistry, 68(47):13486 -13496.
36. Wang, N., Hatcher, D. W., Tyler, R. T., Toews, R. and Gawalko, E.J. (2010). Effect of Cooking on the Composition of Beans (Phaseolus vulgaris L.) and Chickpeas (Cicer arietinum L.). Food Research International, 43 (2): 589-594.
37. Wang S. Y., Chen C. T., Sciarappa W., Wang C. Y. and Camp M. J. (2008). Fruit Quality, Antioxidant Capacity, and Flavonoid Content of Organically and Conventionally Grown Blueberries. Journal of Agricultural and Food Chemistry, 56(14): 5788–5794.
38. Young, S. M. and Greaves, J. S. (1940). Influence of varieties and treatment of phytin contents of wheat. Food Research, 5: 103-105.

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