Sub-Sahara African Academic
Research Publications
March, 2023, Editions

JASOR
Journal of Advanced Science and Optimization Research
Vol. 27, No.9, ISSN 2418-9325

ASSESSMENT OF THE LEVEL OF CONCENTRATION OF SOME SELECTED NUTRITIONAL ELEMENTS IN THE FRESH, DRIED AND CANNED BEANS SAMPLED FROM A POPULAR MARKET IN SAKI WEST LOCAL GOVERNMENT OF OYO STATE.

IMRAN, MUSAH OLALEKAN; LAWAL, ISMAIL AJEROGBA; YEKEEN, UTHMANADEOLA; AND GIWA, AFEEZ AJIBOLA
Department of Science Laboratory Technology, The Oke-Ogun Polytechnic, Saki, Oyo State, Nigeria.

Abstract
The present study evaluated the mean concentrations of minerals in three beans forms (Fresh green beans, Dry beans and canned beans). An analytical methodology was optimized, which involved several steps from sample preparation and instrumental analysis – spectrometer. The present study provides information about the total concentration of trace metals (Na, Mg, Mn, Fe, Ca, K and Zn in those beans samples. The elements that presented a greater mean concentration from all beans involved were K (1.89mg/l in canned beans sample) and Mg (0.7mg/l in canned bean).The canned beans sample showed a higher concentration of K and Mg. In fact, the canned bean was the only sample that contains the entire mineral element investigated. However, among all of the trace metals under studied, Iron (Fe) and Zinc (Zn) is present in all of the beans samples. Manganese (Mn), Magnesium (Mg) and Potassium (K) is not found in both Fresh green and dry beans samples. Sodium (Na) and Calcium (Ca) were not found in the Dry beans sample alone unlike other samples. It could be inferred that, the industrial process that the canned beans underwent is a yardstick towards it nutritional value as show from the result. Also following the canned beans sample in mineral element value is the fresh green beans and this could also be as a result of the nascent nature of the

beans compared with the dry sample that had underwent more dehydration naturally by sun drying, hence, could be reason for the limited metal concentration.

Keywords: Beans, Minerals, Trace metals, Iron, Sodium, Calcium.

INTRODUCTION

Beans were an important source of protein throughout Old and New World history, and still are today. Beans are one of the longest-cultivated plants in history. Broad beans, also called fava beans, are in their wild state the size of a small fingernail, and were first gathered in Afghanistan and the Himalayan foothills.[9] An early cultivated form were grown in Thailand from the early seventh millennium BCE, predating ceramics (Gorman C, 1965). Beans were deposited with the dead in ancient Egypt. Not until the second millennium BCE did cultivated, large-seeded broad beans appear in the Aegean region, Iberia, and transalpine Europe. In the Iliad (8th century BCE), there is a passing mention of beans and chickpeas cast on the threshing floor (Daniel *et al*., 2012).

The oldest-known domesticated beans in the Americas were found in Guitarrero Cave, an archaeological site in Peru, and dated to around the second millennium BCE. However, genetic analyses of the common bean *Phaseolus* show that it originated in Mesoamerica, and subsequently spread southward, along with maize and squash, traditional companion crops (Bitocchi *et al*., 2012).

Most of the kinds of beans commonly eaten today are part of the genus *Phaseolus*, which originated in the Americas. The first European to encounter them was Christopher Columbus, while exploring what may have been the Bahamas, and saw them growing in fields. Five kinds of Phaseolus beans were domesticated by pre-Columbian peoples: common beans (P. vulgaris) grown from Chile to the northern part of what is now the United States; and lima and sieva beans (P. lunatus); as well as the less widely distributed teparies (P. acutifolius), scarlet runner beans (P. coccineus), and polyanthus beans.

One well-documented use of beans by pre-Columbian people as far north as the Atlantic seaboard is the "Three Sisters" method of companion plant cultivation: Many tribes would grow beans together with maize (corn), and squash. The corn would not be planted in rows as is done by European agriculture, but in a checkerboard/hex fashion across a field, in separate patches of one to six stalks each. Beans would be planted around the base of the developing stalks, and would vine their way up as the stalks grew. All American beans at that time were vine plants; "bush beans" were cultivated more recently. The cornstalks would work as a trellis for the bean plants, and the beans would provide much-needed nitrogen for the corn. Squash would be planted in the spaces between the patches of corn in the field. They would be provided slight shelter from the sun by the corn, would shade the soil and reduce evaporation, and would deter many animals from attacking the corn and beans because their coarse, hairy vines and broad, stiff leaves are difficult or uncomfortable for animals such as deer and raccoons to walk through, crows to land on, and are a deterrent to other animals as well. Beans were cultivated across Chile in Pre-Hispanic times, likely as far south as Chiloé Archipelago (Pardo et al., 2014). Dry beans come from both Old World varieties of broad beans (fava beans) and New World varieties (kidney, black, cranberry, pinto, and navy/haricot).

The six elements, H, C, N, O, P and S, are used to build all of the important molecules and biomolecules present in living systems, including proteins, nucleic acids and biomembranes. If we add Ca to this list of elements, about 98% of the elemental mass of the human body is thus accounted for, and the total is brought up to almost 100% by adding another five elements, Na, Mg, S, Cl and K (Sigel *et al.*, 2013). In total, twenty elements appear to be essential for humans: ten of which are metals and ten are non-metals. In addition to sodium (Na), potassium (K), magnesium (Mg) and calcium (Ca), essential metallic elements also include manganese (Mn), iron (Fe), cobalt (Co), copper (Cu), zinc (Zn) and molybdenum (Mo), which are collectively known as trace elements (Zoroddu *et al.*, 2019).

BEANS

A **bean** is the seed of several plants in the family Fabaceae, which are used as vegetables for human or animal food. They can be cooked in many different ways, including boiling, frying, and baking, and are used in many traditional dishes throughout the world (Clark *et al*., 2020).

The word "bean" and its Germanic cognates (e.g. German Bohne) have existed in common use in West Germanic languages since before the 12th century, referring to broad beans, chickpeas, and other pod-borne seeds. This was long before the New World genus Phaseolus was known in Europe. After Columbian-era contact between Europe and the Americas, use of the word was extended to pod-borne seeds of *Phaseolus*, such as the common bean and the runner bean, and the related genus Vigna. The term has long been applied generally to many other seeds of similar form, such as Old World soybeans, peas, other vetches, and lupins, and even to those with slighter resemblances, such as coffee beans, vanilla beans, castor beans, and cocoa beans. Thus the term "bean" in general usage can refer to a host of different species (FAO, 1994).

Seeds called "beans" are often included among the crops called "pulses" (legumes), although the words are not always interchangeable (usage varies by plant variety and by region). Both terms, *beans* and *pulses*, are usually reserved for grain crops and thus exclude those legumes that have tiny seeds and are used exclusively for non-grain purposes (forage, hay, and silage), such as clover and alfalfa. The United Nations Food and Agriculture Organization defines "BEANS, DRY" (item code 176) (FAO, 1994) as applicable only to species of *Phaseolus*. This is one of various examples of how narrower word senses enforced in trade regulations or botany often coexist in natural language with broader senses in culinary use and general use; other common examples are the narrow sense of the word nut and the broader sense of the word nut, and the fact that tomatoes are fruit, botanically speaking, but are often treated as vegetables in culinary and general usage. Relatedly, another detail of usage is that several species of plants that are sometimes called beans, including *Vignaangularis* (azuki bean), *mungo* (black gram), *radiata* (green gram), and *aconitifolia* (moth bean), were once classified as *Phaseolus* but later reclassified—but the taxonomic revision does not entirely stop the use of well-established senses in general usage.

NUTRITIONAL COMPOSITION

Raw green beans are 90% water, 7% carbohydrates, 2% protein, and contain negligible fat (table). In a 100 grams (3.5 oz) reference serving, raw green beans supply 31 calories of food energy, and are a moderate source (10-19% of the Daily Value, DV) of vitamin C (15% DV) and vitamin B6 (11% DV), with no other micronutrients in significant content (Table 1).

Antinutrients

Many types of bean like kidney bean contain significant amounts of antinutrients that inhibit some enzyme processes in the body. Phytic acid and phytates, present in grains, nuts, seeds and beans, interfere with bone growth and interrupt vitamin D metabolism. Pioneering work on the effect of phytic acid was done by Edward Mellanby from 1939 (Harrison *et al*., 1939).

GREEN BEANS

Green beans are young, unripe fruits of various cultivars of the common bean (Phaseolus vulgaris), although immature or young pods of the runner bean (Phaseoluscoccineus), yardlong bean (Vignaunguiculata subsp. sesquipedalis), and hyacinth bean (Lablab purpureus) are used in a similar way. Green beans are known by many common names, including **French beans** (French: ***haricot vert***), **string beans** (although most modern varieties are "stringless"), and **snap beans** or simply "snaps." In the Philippines, they are also known as "Baguio beans" or "*habichuelas*" to distinguish them from yardlong beans (Hatch *et al*., 2012).

They are distinguished from the many other varieties of beans in that green beans are harvested and consumed with their enclosing pods before the bean seeds inside have fully matured. An analogous practice is the harvest and consumption of unripened pea pods, as is done with snow peas or sugar snap peas. Raw green beans are 90% water, 7% carbohydrates, 2% protein, and contain negligible fat. In a 100-gram (3.5 oz) reference amount, raw green beans supply 31 calories and are a moderate source (range 10–19% of the Daily Value) of vitamin C, vitamin K, vitamin B_6, and manganese. Other micronutrients are in low supply. The green bean (*Phaseolus vulgaris*) originated in Central and South America, where there is evidence that it has been cultivated in Mexico and Peru for thousands of years.

Fig. 1; GREEN BEAN Source; https://www.allotment-garden.org

Fig. 2; COOKED GREEN BEANS Source; https://www.allrecipes.com

DRY BEANS

Common bean (Phaseolus vulgaris L.) is the most important legume used for direct human consumption. Nutritionists characterize beans as an exceptional food resource because of its high protein content and its combination of carbohydrates, dietary fiber, and minerals (particularly iron and zinc). While the nutritional composition and human health benefits of dry beans are well recognized (Didinger *et al*., 2022), their positive impact on cropping system is often overlooked. There are numerous aspects of dry beans that dramatically contribute to agricultural sustainability within the context of complex cropping systems. Dry bean is a short-season leguminous crop capable of hosting rhizobia responsible for biological nitrogen fixation (Reinprecht *et al*., 2020) that overall has a smaller carbon footprint when compared to alternative crops (Gan *et al*., 2011). One major advantage that dry beans have for mitigation of greenhouse gasses is that they do not require the energy intensive processes associated with the application of nitrogenous fertilizers. Further, common bean is a nutrient-dense food that is stable during postharvest storage. Total dry bean world production and area harvested in 2020 was 27.5 million metric tons and 34.8 million hectares, respectively. Dry bean production has increased by about 60% since 1990, whereas the area harvested increased 36% in the same period (FAO, 2022). Regionally, Asia leads in dry bean production with about 43% of global production, followed by the Americas—North, Central, and South America (29%), and Africa (26%). Europe and Oceania contribute about 2% of total production. These data demonstrate that the production increases over the last three decades have not been exclusively due to increases in area under cultivation but rather have been achieved through improvements in dry bean breeding (genetics) and improved agronomic practices (crop and seed management, soil fertility, harvest efficiency). Dry bean genetics and selective breeding have produced significant gains in crop yield and quality over the past 60 years.

Vandemark *et al*. (2017) found that on-farm yield across all market classes of dry beans grown in the United States show a yearly average yield increase of 12.9 kg/ha between 1909 and 2012. These gains are largely attributed to selection for plant type and disease and pest resistance. Further, agronomic practices have been adopted to maximize yield and quality. These efforts have enhanced the value and the efficiency of bean production and have enhanced broad aspects of food security. As a directly consumed food crop, beans are associated with minimal processing, prior to reaching the consumer. Beans play an important role in food security and combating malnutrition (Siddiq *et al*., 2022). It is noteworthy that over 300 million people worldwide use beans each year in their daily diets. This review article presents an overview of diverse aspects of common beans that directly contribute to its overall sustainability as a component of food cropping systems. Sustainable innovation through genetic/breeding approaches, optimized agronomic practices, and enhanced nutrition and food security are highlighted.

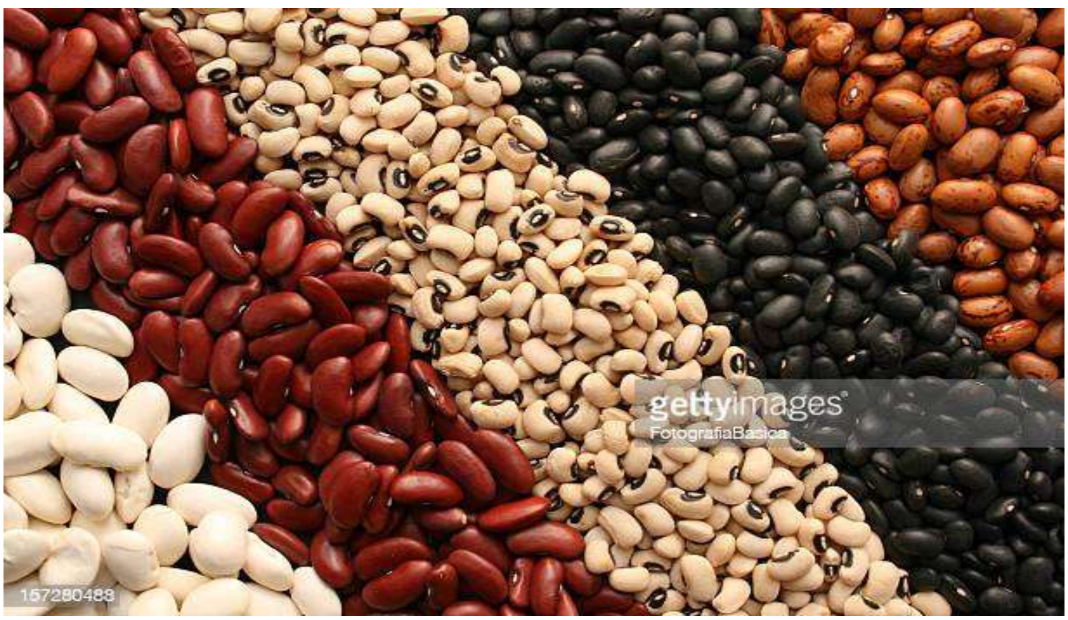

Fig. 3; DRY BEANS Source; https://www.gettyimages.com

CANNED BEANS

Dry legumes are used worldwide, and especially in developing countries, as an inexpensive source of protein and calories. After soy (Glycine Max), the common bean (*Phaseolus vulgaris L.*) is the most important legume, featuring high levels of protein, starch, fibers, vitamins, and minerals.

Beans have nutritional and culinary properties desirable for dry, in natural grain consumers, and processing industries (Osorio-Diaz *et al*., 2002; Rondini *et al*., 2013; Zamindar *et al*., 2013; Lima *et al*., 2014). Owing to the need for more adequate alternatives to fulfill the demands of bean consumers in Brazil and other countries, adding value to the food via industrial processing and offering semi-prepared foods of high nutritional quality, sensory value and reduced cooking times is necessary.

Pan *et al*., (2010) suggested that preprocessing beans may bring benefits such as the increase in product value and greater profitability for farmers and food manufacturers. Different types of beans, such as dehydrated, precooked, canned, microwave oven-ready, flakes, frozen and refrigerated, are in high demand in the food industry, particularly among fast-food restaurants, schools, and domestic consumers (UEBERSAX, 2006). One of the main forms of processed beans reported in the market are cooked and canned beans, a very common form in developed countries throughout Europe and North America. In this type of processing, beans are usually prepared by hydration operations, grain blanching in hot water, canning, brine addition, and addition of other components such as tomato sauce, pork meat or flavor additives, followed by hermetic canning and thermal processing. Canned beans have simple characteristics with wide acceptance in the international market (UEBERSAX, 2006).

FIG 4; CANNED BEANS

TRACE ELELMENT

Trace elements (or trace metals) are minerals present in living tissues in small amounts. Some of them are known to be nutritionally essential, others may be essential (although the evidence is only suggestive or incomplete), and the remainder are considered to be nonessential. Trace elements function primarily as catalysts in enzyme systems; some metallic ions, such as iron and copper, participate in oxidation-reduction reactions in energy metabolism. Iron, as a constituent of hemoglobin and myoglobin, also plays a vital role in the transport of oxygen. All trace elements are toxic if consumed at sufficiently high levels for long enough periods. The difference between toxic intakes and optimal intakes to meet physiological needs for essential trace elements is great for some elements but is much smaller for others.Several other elements have been proposed as essential for humans, of which chromium has become popular as a nutritional supplement for weight loss, even though it has been the subject of extensive debate in regard to the actual roles it may play in biological systems. While Cr (VI) has been classified from a number of studies as a carcinogen, trace amounts of Cr (III) are necessary for the metabolism of lipids and sugars (Valko *et al*., 2005).

Accordingly, the current state of knowledge holds that chromium is a beneficial, rather than an essential element in living organisms. Elements such as boron, silicon, vanadium, nickel and tungsten, have been found to be essential, but only in a restricted number of species. Accepting that metal ions have vital biological roles, not surprisingly, if they are present in excess, they can produce toxic effects. Either a deficiency or an excess of essential metals is connected with many disease states of organisms and studies at the molecular level have been made to elucidate potentially relevant mechanisms for this. Thus the most significant results obtained from such investigations may serve in the design of drugs used to treat metal-related diseases (Palermo *et al*., 2021).

Chemistry of essential metals

The biological functioning of ten essential metal elements is closely connected to their physico-chemical properties, of particular importance being their ligand binding strengths and mobilities (Table 1).

Table 1, Essential metals and their oxidation states, ligand binding properties, mobility, function in biological systems, quantities occurring naturally in the human body, and daily dietary allowances.

Metal ion	Ligand binding properties	Mobility	Biological function	Mass of metals (g)	Daily dietary allowance for adults/infants (mg)
Na^+	Weak	High	Regulatory function: osmotic pressure, membrane potential, enzyme activity Nerve action, osmotic pressure	65–115	1100-3300/260
K^+	Weak	High		155–195	2000-5500/530
Mg^{2+}	Intermediate	Semi-mobile	Energy metabolism ATP → ADP, chlorophyll	30	300-400/60
Ca^{2+}	Intermediate	Semi-mobile	Signalling, enzyme regulation, muscle contraction, skeletal system (Bones, teeth)	1100	800-1200/420
Zn^{2+}	Intermediate/Strong	Intermediate	Lewis acid (Carbonic anhydrase, carboxypeptidase), structural roles – zinc fingers, repair enzymes	2.5	15/5

$Co^{2+,3+}$	Strong	Low	Vitamin B12 coenzyme	0.003	0.2/0.001
$Cu^{+,2+}$	Strong	Low	Electron transfer (copper blue proteins), oxygen storage, transport proteins, ceruloplasmin	0.075	1.5–3.0/1.0
$Fe^{2+,3+}$	Strong	Low	Oxygen storage (Hemoglobin, hemerythrin,. Electron transfer Fe–S proteins, cytochromes)	4.2	10-20/7.0
$Mn^{2+,3+,4+}$	Strong	Low	Enzyme (phosphatase, mitochondrial Mn-SOD, photoredox activity PS II.	0.013	2-5/1.3
$Mo^{2+,3+,4+,5+,-6+}$	Strong	Low	Enzymes (nitrogenase, reductases, hydroxylases)	0.005	0.075–0.250/0.06

Adapted from: *L. Virag, F. Erdodi, P. Gergely*, Bioinorganic chemistry for medical students, University of Debrecen, Hungary, 2016(Virag *et al.*, 2016).

The mobility of metals is inversely correlated with their ligand binding strength (Table 1) (Virag *et al*., 2016). The metal ions, Na^{+}, Mg^{2+}, K^{+}, and Ca^{2+}, have weak to moderate ligand binding strengths and possess high motilities in biological systems. Conversely, Fe, Cu, Zn, Co, Mn and Mo are transition metal elements (containing *d*-electrons), which form discrete metal complexes in which ligands are strongly bound and adopt a wide range of coordination modes.

Aim and Objective

Bean is a staple food in this part of the world and as such more is needed to be done to the nutritive features and packaging of beans to extend it shelves life.

Justification

This comparative study is necessary owning to the scarcity of the canned beans in this part of the world and possible investment in to its production in future. Owning to this and the numerous benefits of canned beans especially in the aspect of packaging and storage of beans for a longer shelve, we embark on this project to make a comparative analysis of their mineral contents. So long the canned beans are always hydrated; hence reason for the employment of fresh green beans which is equally hydrated.

MATERIALS AND METHOD

Sampling

The three samples of beans (Fresh green beans, Dry beans and canned beans) were all purchased at the sanngo market, Saki west local government, Saki. Oyo state. The purchased samples were labeled in small containers and taken to the lab. The whole beans samples were then grinded in to small sizes and sieved in to fine particles using a 0.5mm mesh sieve.

Mineral composition and trace elements

The main minerals found in bean are Na; K; Ca; Mg; Fe; Mn and Zn (Tako *et al.*, 2009).Mineral contents of powder sample are determined by atomic absorption spectrometry/flame photometry according to the methods (AOAC, 2003).

For wet digestion of sample, 1g of the powdered sample is taken in digesting glass tube. 12 ml of HNO_3 is added to the food samples and mixture is kept for overnight at room temperature. Then 4 ml Perchloric acid ($HClO_3$) is added to this mixture and is kept in for the fumes block for digestion. The temperature was increased gradually, starting from 50°C and increasing up to 250-300°C. The digestion completed in about 70-85min as indicated by the appearance of white fumes. The mixture is left to cool down and the contents of the tubes are transferred to 100ml volumetric flasks and the volumes of the contents are made to 100ml with distilled water. The wet digested solution is transferred to plastic bottles labeled accurately. Put the sample in many tube to centrifuge it at 3000rpm to 10min. Use supernatants for mineral determination.

Determination of Iron (Fe), Zinc (Zn), Calcium (Ca), Manganese (Mn) and Magnesium (Mg) by Atomic Absorption Spectrometry

The digested sample was analyzed for mineral contents by Atomic Absorption Spectrophotometer (AAS). Different electrode lamps were used for each mineral. The equipment is run for standard solutions of each mineral before and during determination to check that it is working properly. The dilution factor for all minerals except Mg is 100. For determination of Mg, further dilution of the original solution was done by using 0.5ml original solution and enough distilled water is added to it to make the volume up to 100ml. Also for the determination of Ca, 1.0ml lithium oxide solution is added to the original solution to unmask Ca from Mg. The concentrations of minerals recorded in terms of "ppm" are converted to milligrams (mg) of the minerals by multiplying the ppm with dilution factor and dividing by 1000, as follows:

$$MW \quad \frac{\text{Absorbency x dry wt.xd}}{\text{Wt. Of samplex1000}} \quad (mg/g)$$

RESULTS AND DISCUSSION

RESULTS

Table 2; Levels of concentrations of selected minerals in t**he three samples of beans (Fresh green beans, Dry beans and canned beans) from Owode Market, Saki, South-Western Nigeria.**

Beans SAMPLES	Na (Mg/l)	K (mg/l)	Mg (Mg/l)	Fe (Mg/l)	Mn (Mg/l)	Zn (Mg/l)	Ca (Mg/l)
Fresh	**0.25**	**-**	**-**	**0.22**	**-**	**0.24**	**0.10**
Dry	**-**	**-**	**-**	**0.26**	**-**	**0.10**	**-**
Canned	**0.36**	**1.89**	**0.70**	**0.06**	**0.01**	**0.18**	**0.15**

DISCUSSION

Table 2.0 above shows the result of mineral analysis for essential metals on three different forms of beans; Fresh Green beans, Dry beans and canned beans. The trace metals tested for (Na, K, Mg, Fe, Mn, Zn, and Ca) and their respective concentrations were reported. Among the three forms of beans involved in this research, canned bean was the only one that was subjected to industrial process for full packaging. And as such was used for this study after processing, unlike the remaining two which were still in their somewhat natural forms.

At the same time, among all of the trace metals under study, Iron (Fe) and Zinc (Zn) is present in all of the beans samples. Manganese (Mn), Magnesium (Mg) and Potassium (K) is not found in both Fresh green and dry beans samples. Sodium (Na) and Calcium (Ca) were not found in the Dry beans sample alone unlike other samples. All of the trace metals are present in the canned beans sample and as such, it makes it distinct.

Canned beans

The canned beans sample is the only sample that possesses all of the trace elements tested for in this study, and this could be as a result of the industrial processes that occurs in it production and packaging lines. The most concentrated metal in the beans samples was found only in the canned beans sample (Potassium (K) =1.89mg/l). The average dietary allowance of K=4mg/day, as such a canned beans meal can cater for this. The highest mean concentration of Sodium (Na=0.36mg/l) is also present in canned beans sample among others. Magnesium has the second most concentrated metal value (Mg=0.7mg/l) in this study as a whole and it is only found in the canned beans sample. However, the lowest Fe mean concentration (Fe=0.06mg/l) is found in canned beans among others. Manganese (Mn) is present only in the canned beans sample at a mean concentration (Mn=0.01mg/l) and this is actually the least metal mean concentration observed in this study as a whole. Zinc (Zn) was also found in all of the beans samples with the second most concentrated in the canned beans sample (Zn=0.18mg/l). Calcium is most present in the canned beans among others (Ca=0.15mg/l).

FRESH GREEN BEANS

This result from the table above reveals that, from all the studied metals, the fresh green beans sample only contains Na, Fe, Zn and Ca metals. The absence of other trace metals involved in this study in the sample of a fresh green beans could be as a result of factors like the soil nutrients level and hence the need for bio-fortification of the bean seed and subsequent nutrient addition (Fertilizer application). Sodium (Na) is present in this sample at a mean concentration (Na=0.25mg/l) and this is next to the highest concentration found in the canned beans sample among other. Iron (Fe) is present in the fresh green beans sample at a mean concentration (Fe=0.22mg/l) and this is second to the highest concentration found in the dry beans sample among others. Zinc (Zn) is present in this sample at a highest mean concentration (Zn=0.24mg/l) among others. Calcium (Ca) is present in the fresh green sample at a mean concentration (Ca=0.10mg/ml) and this is second to the highest mean concentration found in the canned beans sample among others.

DRY BEANS

Result from table above reveals that, from all the studied metals, the dry beans sample only contains Fe and Zn trace metals. The absence of other trace metals involved in this study in the sample of a Dry beans could be as a result of factors like the soil nutrients level, the process of sun drying and hence the need for bio-fortification of the bean seed and subsequent nutrient addition (Fertilizer application). Iron (Fe) is present at the highest mean concentration (Fe=0.26mg/l) in the dry beans sample among other samples. The Zinc (Zn) is present at the lowest mean concentration (Zn=0.10mg/l) in the dry bean sample among others.

RECOMMENDATION AND CONCLUSION

RECOMMENDATION

Bean is known as one of the major staple for most populations around the world. Owning to its abundant protein source, it production and consumption is highly encouraged especially among low income earners. As such, with revelations from this study, further studies should be made on how to bio-fortify the local fresh green beans and dry beans in other to meet up with the nutritional demand of trace and essential metals. More awareness should be made on the need to intensify the local production of the canned beans here in Nigeria.

CONCLUSION

Sequel to the discussions given above from the result of the studies on the analysis of the presence of trace metals and their concentration in the three beans types; Fresh green beans, Dry beans and Canned beans, conclusion could therefore be drawn that the canned beans possesses the required trace metals more compared with the remaining two beans types which may be as a result of the processings it has undergone.

REFERENCES

Abu-ghannam, N.; Mckenna, B. Hydration kinetics of red kidney beans (Phaseolus vulgaris L.).Journal of Food Science, v.62, n.3, p.520-523, 1997. Available from: .Accessed: May 12, 2015.doi: 10.1111/j.1365-2621.1997.tb04420.

Almeida, A.J.B.Perfil dos consumidores de feijãonacidade de Cascavel – Paraná. In:congresolatinoamericano y delcaribe de ingenieríaagrícola, 10.; congressbrasileiro de engenhariaagrícolaclia/conbea 41., 2012, Londrina, PR, BrasilAnais...Londrina: CLIA/ CONBEA, 2012. 1-4.

AOAC. *Official methods of analysis of the association of official's analytical chemists*.17th ed. Association of official analytical chemists, Arlington, Virginia; 2003.

Bitocchi, Elena; Nanni, Laura; Bellucci, Elisa; Rossi, Monica; Giardini, Alessandro; Zeuli,PierluigiSpagnoletti; Logozzo, Giuseppina; Stougaard, Jens; McClean, Phillip; Attene, Giovanna; Papa, Roberto (3 April 2012). "Mesoamerican origin of the common bean (Phaseolus vulgaris L.) is revealed by sequence data". *Proceedings of* *the National Academy of Sciences*. **109** (14):E788E796. doi:10.1073/pnas.1108973109. PMC 3325731. PMID 22393017.

Clark, Mellisa. "How to Cook Beans". *New York Times Cooking*.Retrieved 3 January 2020.

Daniel Zohary and Maria Hopf *Domestication of Plants in the Old World* Oxford University Press, 2012, ISBN 0199549060, p. 114.

Didinger, C., Foster, M. T., Bunning, M., & Thompson, H. J. (2022).Nutrition and human health benefits of dry beans and other pulses.In M. Siddiq& M. A. Uebersax (Eds.), Dry Beans and pulses: Production, processing, and Nutrition (pp. 481–504).John Wiley & Sons. https:// doi.org/10.1002/9781119776802.ch19

FAO, United Nations. 1994."Definition And Classification Of Commodities (See Chapter 4)".

FAO.(2022). Crop Production and Trade Data. Retrieved from http:// www.fao.org/faostat/en/#data

Gan, Y., Liang, C., Hamel, C., Cutforth, H., & Wang, H. (2011).Strategies for reducing the carbon footprint of field crops for semiarid areas.A review. Agronomy for Sustainable Development, 31, 643–656. https:// doi.org/10.1007/s13593-011-0011-7

Gorman, CF (1969). "Hoabinhian: A pebble-tool complex with early plant associations in southeast Asia". *Science*. **163** (3868): 6713. Bibcode:1969Sci163..671G. doi:10.1126/science.163.3868.671. PMID 17742735. S2CID 34052655.

Hatch, Peter J. (April 24, 2012). "A Rich Spot of Earth": Thomas Jefferson's Revolutionary Garden at Monticello. pp. 159–161. ISBN 978-0-300-17114-3.

LIMA, R.A. Embalagem a vácuo: efeito no escurecimento e endurecimento do feijão durante o armazenamento. Ciência Rural, v.44, n.9, p.1664-1670, 2014. Available from: . Accessed: May 12, 2015.doi: 10.1590/0103-8478cr20120832.

Osorio-diaz, P. In vitro digestability and resistant starch content of some industrialized commercial beans (Phaseolus vulgaris). Food Chemistry, n.78, p.333-337, 2002. Available from: .Accessed: May 12, 2015.doi: 10.1016/ S0308-8146(02)00117-6.

Palermo G, A. Spinello, A. Saha, A. Magistrato, Frontiers of metal-coordinating drug design, Expert Opin, Drug Discov 16 (2021) 497–511, https://doi.org/10.1080/17460441.2021.1851188

PAN, Z. Development of impact acoustic detection and density separations methods for production of high quality processed beans. Journal of Food Engineering, v.97, n.1, p.292-300, 2010. Available from: .Accessed May 12, 2015.doi: 10.1016/j.jfoodeng.2009.10.016.

Pardo B., Oriana; Pizarro, José Luis (2014). *Chile: PlantasalimentariasPrehispánicas* (in Spanish) (2015 ed.). Arica, Chile: EdicionesParina. p. 162. ISBN 9789569120022.

Reinprecht, Y., Schram, L., Marsolais, F., Smith, T. H., Hill, B.,&Pauls, K. P. (2020). Effects of nitrogen application on nitrogen fixation in common bean production. Frontiers in Plant Science, 11, 1172. https://doi.org/ 10.3389/fpls.2020.01172

Romani A.M.P., Magnesium in health and disease, in: A. Sigel, H. Sigel, R.K. O. Sigel (Eds.), Interrelation between Essential Metal Ions and Human Diseases, Metal Ions in LifeSciences vol. 13, Springer, 2013, pp. 50–79, https://doi.org/ 10.1007/978-94-007-7500-8.

Rondini, E.A. Nutrition and human health benefits of dry beans and pulses. In: Siddiq, M.;Uebersax, M.A. Dry beans and pulses: production, processing and nutrition. Ames:Jonh Wiley & Sons, 2013. p.359-377.

Siddiq, M., Uebersax, M. A., &Siddiq, F. (2022).Global production, trade, processing and nutritional profile of dry beans and other pulses. In M. Siddiq& M. A. Uebersax (Eds.), Dry Beans and Pulses: Production, Processing, and Nutrition (Second ed.) (pp. 1–28). John Wiley & Sons.https://doi.org/10.1002/9781119776802

Sigel A, H. Sigel, R.K.O. Sigel, Interrelation between essential metal ions and human diseases, Metal ions in life sciences 13 (2013) 1–573, https://doi.org/ 10.1007/978-94-007-7500-8. Springer.

Tako E, Glahn RP, Laparra JM. Iron and Zinc: Bioavailabilities to Pigs from Red and White Beans (*Phaseolus vulgaris* L.) are Similar. *J Agric Food Chem.* 2009;57(8):3134 3140.

Uebersax, M.A. Dry edible beans: indigenous staple and healthy cuisine. Forum on Public Policy.Urbana, A Journal of the Oxford round table. 2006. Available from: .Accessed: Feb. 27, 2015.

Valko M, H. Morris, M.T.D. Cronin, Metals, toxicity and oxidative stress, Curr. Med. Chem. 12 (2005) 1161–1209, https://doi.org/10.2174/ 0929867053764635.

Vandemark, G., Brick, M. A., Kelly, J. D., Osorno, J. M., &Urrea, C. A. (2017). Yield Gains in Dry Beans in the U.S. USDA-ARS/UNL Faculty Publication. #1781

Virag L, F. Erdodi, P. Gergely, Bioinorganic Chemistry for Medical Students, Scriptum, University of Debrecen, Hungary, 2016, pp. 1–104.

Zamindar, N. Effect of line, soaking and cooking time on water absorption, texture and splitting of red kidney beans.Journal of Food Science and Technology, v.50, n.1, p.08 114, 2013. Available from: .Accessed: May 12, 2015.doi: 10.1007/ s13197-011-0234 20.182.

Zoroddu M.A, J. Aaseth, G. Crisponi, S. Medici, M. Peana, V.M. Nurchi, The essential metals for humans: a brief overview, J. Inorg. Biochem.195 (2019) 120–129, https://doi.org/10.1016/j.jinorgbio.2019.03.013.