

Comparative Analysis on the Nutritional and Anti-Nutritional Contents of the Sweet and Bitter Cassava Varieties

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Abstract: The main aim of this research was to investigate the nutritional content and anti nutritional factors of the varieties of cassava in order to provide knowledge on the nutritional implication of feeding on cassava diet, which will help to ensure better health condition of people in developing countries. A comparative analysis of the nutritional and anti-nutritional contents of sweet and bitter varieties of cassava (*Manihot esculenta*) was carried out using standard analytical techniques. Results obtained showed the percentage (%) Moisture contents as 0.82 and 0.14, Ash as 2.71 and 1.85, Crude fiber as 4.40 and 4.61, Crude protein as 2.69 and 3.37, Crude lipid as 3.92 and 3.82 and total carbohydrate as 85.46 and 86.21% for sweet and bitter cassava, respectively. The findings also revealed that calcium contents as 33 and 30 mg/100g, phosphorus contents as 52 and 80 mg/100g and iron contents as 30 and 18 mg/100g for sweet and bitter cassava, respectively. The contents of cyanogenic glycosides were 0.46 and 0.65 mg/100g, Trypsin inhibitor were 1.0 and 4.0 mg/100g, oxalates were 22.0 and 44.0 mg/100g, phytate were 216 and 304 mg/100g and tannin were 0.40 and 0.60 mg/100g for sweet and bitter cassava, respectively. A comparative assessment of the results however, showed that sweet cassava has higher values of Moisture, Ash, Lipid, Calcium, and Iron but lower value of Fiber, Protein, carbohydrate, phosphorus, and all the anti-nutrients analyzed as compared to the bitter cassava.

Key words: Anti-nutrient, bitter cassava, *Manihot esculenta*, sweet cassava

INTRODUCTION

Every person and every other living organism needs certain substances called nutrients to build and maintain the body's structure and to supply the energy that powers all vital activities. Food is made up of different nutrients needed for growth and health, which include proteins, carbohydrates, fats, water, minerals and vitamins. All nutrients needed by the body are available through food: many kinds and combination of food can lead to a well balance diet. Each nutrient has specific uses in the body. It is the relationship of food to the health of the body that determines nutritional status. Proper nutrition means that all the nutrients are supplied and utilize in adequate amount to maintain optimal health and well-being (Thomas, 2006). Anti-nutrients are found at some level in almost all foods for a variety of reasons. However, their levels are reduced in modern crops, probably as an outcome of the process of domestication. Nevertheless the large fraction of modern diets that comes from a few crops particularly tubers has raised concerns about the effects of the anti-nutrients in this crop on human health

(Cordian, 1999). Anti-nutrients are natural or synthetic compounds that interfere with the absorption of nutrients. One common example is phytate, which forms insoluble complexes with calcium, zinc, iron and copper. Proteins can also be anti-nutrients, such as the trypsin inhibitors and lectins found in legumes (Gilani *et al.*, 2005). Another particular widespread form of anti-nutrients are flavonoids, which are a group of polyphenolic compounds that include tannins. These compounds chelate metals such as iron and zinc, and reduce the absorption of these nutrients. They also inhibit digestive enzymes and may precipitate proteins (Beecher, 2003).

Tubers are underground plant stems or shoot bearing tiny leaves whose buds are the 'eye' of the tuber. They are valued for their highly nutritious starch content (Welch and Graham, 2004). Cassava is the common name for a starch producing tuber crop *Mani hot esculenta*, Because it is an important source of starch, cassava is of major importance in tropics and is one of the great root crop of the world. It tolerates drought and low fertility and is sometime a nutritionally strategic famine reserve crop in areas of unreliable rainfall, poor soil or unfavorable

climate. The raw roots and leaves of cassava plant can be toxic due to the presence of natural nitrile (-CN) compounds called cyanogenic glycosides or cyanogens, which are in the form of Linamarin (93%) and Lotaustralin (7%). They are B-glycosides of acetone cyanohydrins and ethy-methy cyanohydrin, respectively (Bolhuis, 1954). These precursors upon breakdown release the toxic compound hydrogen cyanide (HCN) which can be harmful to the consumers through an enzyme catalyzed process called cyanogenesis. Cassava has a cyanogenic potential (CNP) which means that though not normally present in plant tissues, cyanide (hydrocyanic acid) can be produced through enzymatic process which occurs when the plant cells are bruised, crushed, grated or bitten and when cyanogens and degradative enzyme come in contact with each other (Cooke and Maduagwu, 1985). The numerous varieties of cassava are grouped into two main categories; *Manihot aipi* and *Manihot palmate* or sweet and bitter cassava. Various varieties are usually differentiated from one another by their morphological characteristics such as colour of stem, petioles, leaves and tubers. Societies which traditionally eat cassava, generally understand that some processing such as peeling, soaking, cooking, drying and fermentation are necessary to eliminate the toxin to avoid getting sick. For some smaller-rooted sweet varieties, cooking is sufficient to eliminate all toxicity. Historically, people economically forced to depend on cassava are in risk to chronic poisoning disease, such as Tropical Ataxic Neuropathy (TAN), or malnutrition diseases as kwashiorkor and endemic goiter (Akintola *et al.*, 1998).

The main objectives of this research is to investigate the nutritional content and anti nutritional factors of the sweet and bitter varieties of cassava. The study will enable cassava farmers and consumers to know the nutritional and anti-nutritional values derived from different cassava varieties and avoid consumption of high toxic varieties that could be used for other purpose such as bio-fuel, in order to maintain and sustain food security. It will also provide knowledge on the nutritional implication of feeding on staples of low nutritive quality, which will help to ensure better health condition of people in developing countries.

MATERIALS AND METHODS

Apparatus/Instrument:

- Spectrophotometer (Jenway GN 6400)
- Atomic Absorption Spectrophotometer (Shimadzu AA 650)
- Soxhlet Extraction Apparatus (Osk, Japan 158)

Reagents: All the reagents and standard used in this work were of analytical grade. The methods used in this work for the various determinations of the samples are the standard methods

Collection of samples: Cassava tubers were collected from a local farm located at Sabon Gayan, Chukun local government Kaduna state in 2009. The sweet and bitter varieties were properly washed with water, the peels were removed separately then the pulps were cut into smaller sizes. The samples were labeled A and B, respectively and oven dried at 40°C for 18 h. Each sample was grinded to its powder form using mortar and pestle and used for analyzing as sample A (sweet cassava) and sample B (Bitter cassava). All the analysis were conducted in National Research Institute of Chemical Technology (NARICT) Zaria May-August 2009.

Determination of moisture content: The method described by AOAC (1980) was adopted. Two crucibles were properly washed and allowed to dry in an air oven at 110°C for 10 min to a constant weight. The crucibles were allowed to cooled in a desiccators for 30 min, then labeled A and B and weighed (W_1). 2.0 g of each sample was accurately weighed into the previously labeled crucibles and reweighed (W_2). The crucibles containing the samples were placed in an oven maintained at 103°C for 14 h. They were removed and transferred to desiccators to cooled, finally weighed (W_3). The percentage moisture content was calculated.

Determination of ash content: The AOAC (1980) method was used. Two porcelain crucibles were washed and dried in an oven to a constant weight at 100°C for 10 min. They were allowed to cool in a desiccators, then labeled A and B and weighed (W_1). 2.0 g of each sample were weighed into each of the previously weighed porcelain crucibles and reweighed (W_2). The crucibles containing the samples were transferred into a furnace, which was set at 550°C for 8 h to ensure proper ashing. They were then removed and allowed to cool in the desiccators then finally weighed (W_3). The percentage ash content was calculated.

Determination of crude fiber: The method described by AOAC (1980) was used. 2.0 g of sample A and B were weighed into two separate round bottom flasks labeled A and B, respectively. 100 mL of 0.25 M sulphuric acid solutions was added to each sample in the flask, and the mixtures were boiled under reflux for 30 min. The hot solutions were quickly filtered under suction. The residues were thoroughly washed with hot water until acid

free. Each residue was transferred into the labeled flasks and 100 mL of hot 0.3 M sodium hydroxide solutions was added and the mixtures were boiled again under reflux for 30 min and filtered quickly under suction. Each insoluble residue was washed with hot water until it was base free. They were dried to a constant weight in an oven at 100°C for 2 hours, cooled in desiccators and weighed (C_1). The weighed samples were then incinerated, and reweighed (C_2). Percentage crude fibre content was calculated.

Determination of nitrogen and crude protein: Micro Kjeldahl method as described by AOAC (1980) was used. Briefly, 0.5 g of sample A and B were weighed and placed on each nitrogen free filter paper, then folded and dropped into a Kjeldahl digestion tubes labeled A and B, respectively. 3.0 g of digesting mixed catalyst ($\text{CuSO}_4 + \text{Na}_2\text{SO}_4$) and 25 mL of Conc. Na_2SO_4 were added to each sample in the digestion tube. The mixtures in the digestion tubes were transferred to the Kjeldahl digestion apparatus; the heater was regulated at a temperature below the boiling point of the acid until frothing ceased. The mixtures boil vigorously as temperature was increased, until clear (light) green color was obtained. The digests were allowed to cooled then transferred into 100 cm³ volumetric flasks each labeled A and B and diluted with distilled water to make up 100 cm³. 10 mL aliquot of each digest was introduced into the distillation jacket of the micro steam distillation apparatus that was connected to the main, as the water in the distiller flask boils. 20 mL of 40% NaOH was added to each digest in the distillation jacket. 50 mL of 40% boric acid was measured into two 250 mL conical flasks labeled A and B, respectively, four (4) drops of methyl red indicator was added each. The conical flasks containing the mixture were placed onto the distillation apparatus with the outlet tubes inserted into each conical flask and NH_3 was collected through the condenser. The distillation continued until 25 mL of the distillate were trapped into the boric acid solution and color changes from red to yellow. The distillates were then titrated with 0.02 M HCL and the titre values were recorded. Percentage nitrogen and crude protein was calculated.

Determination of crude lipid content: The AOAC (1980) method was used. 5.0 g of sample A and B were placed in two different extraction thimbles respectively then covered with cotton wool. The extraction thimbles containing the samples were placed in the extraction jacket. Two clean dried 500 mL round bottom flasks containing few anti-bumping granules was weighed (W_1) and 300 mL of petroleum ether was poured into each flask fitted with sohxlet extraction units. The

round bottom flasks and the condenser were connected to the sohxlet extractor and cold-water circulation was put on. The heating mantle was switched on the heating rate was adjusted until the solvents were refluxing at a steady rate. Extraction was carried out for 6 h. The solvents were recovered and the oil was dried in the oven at 70°C for 1 h. The round bottom flask and oil was cooled and then weighed (W_2). The lipid content was calculated.

Determination of carbohydrate: The total carbohydrate content was determined by difference method. The sum of the percentage moisture, ash, crude lipid, crude protein and crude fiber was subtracted from 100% Carbohydrate = 100 - (% moisture + % ash + % protein + % lipids + % fiber).

Determination of the mineral content: The method described by AOAC (1980) was adopted. Calcium, phosphorus and iron were analyzed from the triple acid digestion (wet digestion method). Exactly 1 g of sample A and B were weighed each into a 150 mL beaker, and 10 mL of conc. HNO_3 was added to each sample in the beaker and allowed to soak thoroughly. 3 mL of 60% HClO_4 was added and the mixtures were heated slowly at first until frothing ceases. Heating was continued until HNO_3 evaporated; the heating was stopped as charring occurred. 10 mL conc HNO_3 was added and heating continued until white fumes were observed. The digests were allowed to cool and 10 mL conc. HCL was added and transferred to 50 mL volumetric flask. The volume of the solutions was made up to the mark with distilled water, and then transferred to a bigger flask. The solutions were further diluted to 100 mL with distilled water. Calcium, phosphorus and iron were measured using atomic absorption spectrophotometer (Shimadzu AA, 650 model).

Determination of cyanogenic glycoside: The alkaline pictrate method of Oke (1969) was adopted. 5.0 g of sample A and B were weighed each and dissolved in 50 mL distilled water in corked conical flasks. The mixtures were allowed to stay overnight and then filtered. The extracts (filtrates) was collected and labeled A and B. Different concentration of hydrogen cyanic acid (HCN) was prepared containing 0.02 to 0.10 mg/mL cyanide. The absorbance of each was taken in a spectrophotometer at 490 nm and the cyanide standard curve was plotted. 1 mL of each sample filtrate and standard cyanide solution was measured into three (3) test tubes respectively and 4 mL of alkaline pictrate solution was added to each and incubated in a water bath for 15 min. After color development (reddish brown), the absorbance of each

content in the test tubes was taken in a spectrophotometer at 490 nm against a blank containing only 1 mL distilled water and 4 mL alkaline pictrate solution (1 g of pictrate and 5 g of sodium carbonate (Na_2CO_3) were dissolved in a warm water in 200 mL flasks and made up to 200 mL with distilled water). The cyanide content for each sample was extrapolated from the cyanide curve.

Determination of trypsin inhibitor: The method outlined by Kakade *et al.* (1971) was employed. 0.2 g of sample A and B were weighed into a screw cap centrifuge tube each. 10 mL of 0.1 M phosphate buffer was added and the contents were shaken at room temperature for 1 h on a shaker. Each suspension obtained was centrifuged at 5000 rpm for 5 min and filtered through Whatman No. 42 filter paper. The volume of each filtrate was adjusted to 2 mL with phosphate buffer in test tubes. The test tubes were transferred to a water bath, maintained at 37°C. 6 mL of 5% TCA solution was poured into one test tube to serve as a blank. 2 mL of casein solution was added to each of the test tubes, which was previously kept at 37°C, then incubated for 20 min. The reactions were stopped after 20 min by adding 6 mL of TCA solution to the experimental tubes and were shaken. The reactions were allowed to proceed for 1 h at a room temperature. Each mixture was filtered through Whatman No 42 filter paper. Absorbance of filtrates from each sample and trypsin standard solutions were read in a spectrophotometer at 280 nm.

Determination of phytate: The phytic acid was determined using the procedure described by Markkar *et al.* (1993). 2.0 g of each sample (A and B) were weighed into 250 mL conical flask. 100 mL of 2% concentrated HCL acid was used to soak each sample in the conical flask for 3 h and then filtered through a double layer of hardened filter papers. 50 mL of each filtrate was placed in 250 mL beaker and 100 mL of distilled water was added to each to give proper acidity. 10 mL of 0.3% ammonium thiocyanate solution was added into each solution as indicator. Each solution was titrated with standard iron chloride solution, which contained 0.00195 g iron per mL. The end point color was slightly brownish - yellow which persisted for 5 min. The percentage phytic acid was calculated.

Determination of tannins: The method described by Markkar *et al.* (1993) was adopted. Briefly, 400 mg of sample A and B were placed into two conical flasks each and 40 mL diethyl ether containing 1% acetic acid (v/v) was added, then the mixtures were properly mixed to removed the pigment materials. Each supernatant was

carefully discarded after 5 min and 20 mL of 70% aqueous acetone was added and the flasks were sealed with cotton plug covered with aluminum foil, then kept in electrical shaker for 2 h for extraction. Each content in the flasks was filtered through Whatman filter paper and samples (filtrates) were used for analyzing. 50 mL of tannins extract from each sample was taken into test tubes and the volume of each was made up to 1.0 mL with distilled water. 0.5 mL Folic ciocalteu reagent was added to each and mixed properly. Then 2.5 mL of 20% sodium carbonate solution was added and mixed. The mixtures were kept for 40 min at room temperature, after which absorbance was taken using spectrophotometer and concentration was estimated from the tannic acid standard curve.

Determination of oxalate: Oxalate was determined by using the method of Oke (1969). 1.0g of sample A and B were placed each in a 250 mL volumetric flask, 190 mL of distilled water and 10 mL of 6 m HCL were added. Each mixture was warmed on a water bath at 90°C for 4 h and the digested samples were centrifuged at a speed of 2,000 rpm for 5 min. The supernatant were then diluted to 250 mL. Three (3) 50 mL aliquots of each supernatant were evaporated to 25 mL, and then the brown precipitate was filtered off and washed. The combined solution and washings were titrated with concentrated ammonia solution in drops until Salmon pink color of methyl orange changed to faint yellow. The solutions were heated on a water bath to 90°C and the oxalate was precipitated with 10 mL of 5% calcium chloride (CaCl_2) solution. The solutions were allowed to stand overnight then centrifuged. Each precipitate was washed into a beaker with hot 25% H_2SO_4 , diluted to 125 mL with distilled water and after warming to 90°C it was titrated against 0.05 m KMnO_4 .

RESULTS AND DISCUSSION

The nutritional content and anti nutritional factors of the sweet and bitter varieties of cassava were investigated. The results of the proximate analysis of sweet and bitter cassava are shown in Table 1. The results of some mineral analyses of sweet and bitter cassava are shown in Table 2. The results of the level of some anti-nutritional factors found in cassava are shown in Table 3

The results of the nutritional content analyzed in this study, which consist of the proximate and mineral composition as given in Table 1 and Fig. 1 showed that the Moisture content of the sweet cassava was higher (0.82%) than that of bitter cassava (0.14%), when

Table 1: Proximate composition of sweet and bitter cassava

Parameters (%)	Sweet cassava(%)	Bitter cassava(%)
moisture	0.82±0.01	0.14±0.10
Ash	2.71±0.20	1.85±0.30
crude fibre	4.40±0.20	4.61±0.21
crude protein	2.69±0.12	3.37±0.20
crude lipid	3.92±0.10	3.82±0.50
total carbohydrate	85.46±0.4	86.21±0.20

Values are mean of duplicate determinations

Table 2: The results of some minerals of sweet and bitter cassava

Element	Sweet cassava (mg/100g)	Bitter cassava (mg/100g)
Calcium	33±0.01	30±0.20
Phosphorus	52±0.10	80±0.02
Iron	30±0.11	18±0.30

Values are mean of duplicate determinations

Table 3: Anti-nutritional composition of sweet and bitter cassava

Parameter	Sweet cassava mg/100g	Bitter cassava mg/100g
Cyanogenic Glycoside	0.46±0.10	0.65±0.10
Trypsin inhibitor	1.00±0.10	4.00±0.20
Oxalates	22.00±0.20	44.00±0.40
Phytates	216±0.20	304±0.30
Tannin	0.40±0.01	0.60±0.22

Values are mean of duplicate determination

compared. The values obtained were lower than that reported by Frederick, (2008) whose analysis was on fresh weight. Differences in moisture content as compared to that of literature were due to loosed of water (moisture) by the sample during drying process. This also applies to other parameters, which were determined. The high values of ash content (2.71%) in the sweet cassava indicate a high mineral content in it, than the bitter variety, which contains low ash (1.85%). The values correspond with that reported by Frederick, (2008). There was a significant increase in crude fibre content (4.61%) in the bitter cassava than the sweet (4.40%). This was as a result of high cellulose that it contains than the sweet cassava with decrease contents. The results were within the normal range with that presented by Kadashi, (2005). Crude protein content (3.37%) of the bitter cassava was higher compared to sweet variety (2.69%), which is an indication that it contains more nitrogenous substances than the sweet cassava. The crude lipids content (3.92) in the sweet cassava was significantly higher than the bitter variety (3.82%), therefore the sweet cassava is a better source of lipid when compared. These results are also within a normal range as reported by Kadashi (2005). Total carbohydrate content is significantly lower (85.46%) in the sweet cassava compared to the bitter having higher value (86.21%) as given in Table 1. The calcium content of the sweet cassava variety is higher (33 mg/100g compared to the bitter cassava (30 mg/100g). This could be due to low level of oxalic acid and phytic

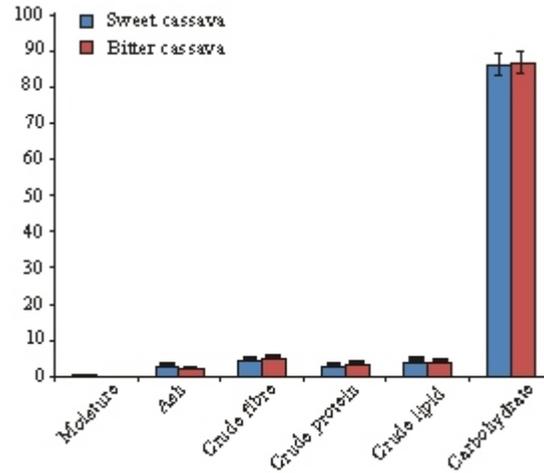


Fig.1: Proximate composition of sweet and bitter cassava

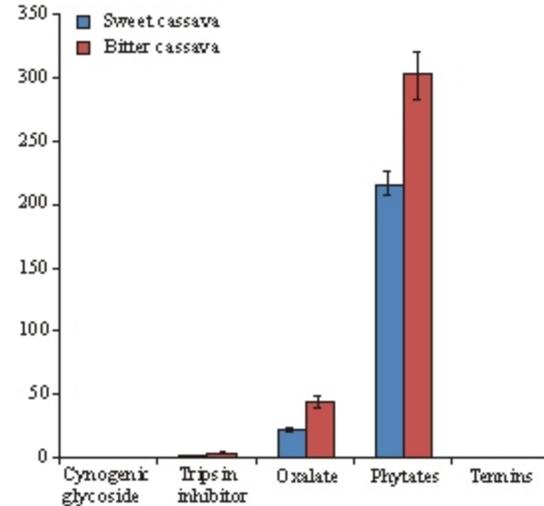


Fig. 2: Anti-nutritional composition of sweet and bitter cassava

acids (Fig. 2) being the major chelators of calcium, hence releasing calcium for biological activities. Oxalic acid, phytic acid, excess fat and phosphate interferes with calcium absorption because of the function of complexes with calcium (Goodhart and Shils, 1973). The major role of calcium also increases the permeability of the cell membrane and is also involved in the transmission of nerve impulses, 800 g of calcium is recommended per day for an adult person. The phosphorus content of the bitter cassava was higher (0.8%) compare to the sweet variety (0.52%) as shown in Table 1. This might be as a result of lower calcium content in the bitter cassava which phosphate interferes with. Phosphorus combines with

calcium in bones and teeth (Davidson and Stanley, 1975). Daily require of phosphorus is 800 mg for adults (0.03%). Iron content in the sweet cassava is higher than the bitter cassava (0.18%). The results of phosphorus and iron in sweet and bitter cassava are in order with the result analysed by Kadashi (2005). Iron is required for the synthesis of hemoglobin and myoglobin, which are oxygen carriers in the blood and muscle, respectively. The daily requirement for men and non-menstruating and pregnant women it is 18 mg. The result of some anti-nutritional factors found in cassava which were analysed showed that, the level of toxic substances such as Cyanogenic Glycoside, Trypsin inhibitor, oxalates, Phytates and Tannin were higher in the bitter cassava compared to the sweet variety (Fig. 2). However, some of these toxic substances can be reduced during processing of cassava, which include cooking, fermentation and soaking. This confirms the report of other researchers (Aregheore and Agunbiader, 1991) that cooking and fermentation do indeed destroy anti-nutritional factors. Phytic acid and oxalic acid usually forms insoluble salts with mineral element such as zinc, calcium and iron to prevent their utilization. The low content of these anti nutrients in the sweet cassava would therefore permit the absorption of these elements, which they form complexes with (Gilani *et al.*, 2005).

CONCLUSION

The results of the nutritional content analyzed in this study, which consist of the proximate and mineral composition showed that, the moisture content, ash and lipid were higher in the sweet cassava than the bitter variety. The fiber content, protein and carbohydrate content of the bitter cassava were lower in the sweet cassava compared to the bitter cassava. Calcium and iron content were higher in the sweet cassava than the bitter cassava variety. The sweet cassava contained low phosphorus compared to the bitter variety, which was found to have a high content. The results of the anti-nutritional content analysed indicate that the bitter cassava contains a high level of cyanogenic glycoside, trypsin inhibitor, oxalate, phytate and tannin than sweet variety.

RECOMMENDATION

The quantity of various nutrients and anti-nutrient found in cassava, which both human and animals consume varies in the different varieties, which are grouped into sweet and bitter cassava. Each day we requires enough energy, for daily activities and cassava is

a good source of carbohydrate. Because the sweet cassava contains high nutrient and low anti-nutrient composition compared to the bitter variety, it is recommended that it should be used for consumption after being properly process. The bitter variety with high anti-nutrient factors, and low nutrient should be process more, and its consumption should be limited. This is because these toxic substances could accumulate in the body and could lead to decline in certain aspects of health, such as function of the nervous system, causing poisoning disease, such as tropical ataxia neuropathy. The reliance on cassava as a food source also result in exposure to the goitrogenic effects of thiocyanate responsible for endemic goiters and malnutrition diseases such as kwashiorkor. The bitter variety of cassava should be used in industries such as food industries and chemicals industries where the anti-nutritional content could be detoxified better. This will also make the sweet cassava variety to available for consumption.

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