Global Scientific JOURNALS

GSJ: Volume 12, Issue 2, February 2024, Online: ISSN 2320-9186
www.globalscientificjournal.com

HYDROCYANIC ACID (HCN) CONTENT OF CASSAVA IN THREE DIFFERENT PROCESSING METHOD

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KeyWords
Hydrocyanic Acid (HCN); Cassava; Traditional Variety; Cyanide Contents; Hydrogen Cyanide; Cyanide Poisoning

ABSTRACT

This study was conducted to analyze the hydrocyanic acid (HCN) content of cassava in two locations (Balo-i, Lanao del Norte and Dulay, Lanao del Sur at four different preparation techniques such as fresh, boiled, dried, and grated white cassava. Specifically, this study sakes to determine preparation techniques that gave the lowest content of hydrocyanic acid in cassava, to determine variation on the hydrocyanic acid content of cassava grown in two locations, and to determine which treatment combination that produces the highest hydrocyanic acid. There are two locations where sample materials were taken; one is from a farm in Balo-i, Lanao Del Norte and the other sample materials are from a farm in Dulay, Marawi City, Lanao Del Sur. The experiment was conducted in a 2 x 4 factorial experiments and the experimental design used is Complete Block Design (CBD) in Completely Randomized Design (CRD). Location of the source of sampled cassava represents Factor A and the sample preparation technique represents Factor B. Each factor has sub-factors, The cassava variety used in the study is the white or known as traditional variety. This variety was adopted by majority of farmers in the provinces of Lanao del Norte and Lanao del Sur. Based on the result of the study, the cyanide content of white cassava taken from both locations (Balo-i farm and Dulay farm) are the same at constant laboratory detectable values of less than 0.05 mg/g. The same findings are observed from the results produced from different preparation techniques such as fresh, boiled, grated, and dried. Further, treatment combinations revealed the same findings of no different cyanide content.

I. INTRODUCTION

The Cassava (*Manihot esculenta*, *Crantz*) is a tropical root crop, which was originally from Amazonia. This crop was described as a 21st century crop, the "food of the poor, but then became a multipurpose crop that responds to the priorities of developing countries to trends in the global economy and to the challenge of climate change as stated by Food and Agriculture Organization (FAO-Rome, 2013). Cassava plays an important role in the economy and one of the most significant contributions is in industry, in which this crop serves as raw materials in the production of confectionary flour, thickener paste, binder and stabilizer for many processed food products, pharmaceutical, textile, mining, manufacturing (FA0-Rome, 2013).

Subsequently, cassava turns out to as one of the important crops. It ranks as the largest root crops grown in the country. The data shown from Philippine Statistics Authority (2013), a total of 219,020 hectare was cultivated for production and the yield had reached to 1,739,724 metric tons and Mindanao is the highest producer of this crop (Racedi, 2013). In the Philippines, mostly the root crops are grown in the backyard or small farms. Table 1 presents data on volume of root crops production and the area utilized for the respective crops. It shows that cassava is the largest root crops grown in the Philippines based on the data. Mindanao is the lead producer of cassava (Gatchallian and De Leon, 1992). This also implies that Filipino is one of the million that are consuming cassava as staple substitutes.

Table 1. Production data of selected root crops in the Philippines (BAEStat, 1988), Gatchallian and De Leon, 1992.

Root Crops	Area (hectares)	Production (metric tons)
1. Cassava	219,020	1,739,724
2. Sweet Potato	164, 610	843,674
3. Gabi	29, 890	108,830
4. Ubi	5, 610	27,336

5. Paogaliang	3,280	11,147
6. Tugui	920	5,342

Being ranked as the largest root crops grown in the country, the smallholder farmers with low-income had contributed a portion to the annual production percentage. They have a good chance to produce this crop because in production operation, no requirements of mechanization and purchased of inputs is required making the farming operation more suitable to their economic condition. In addition, the growth requirement of cassava is not only limited to areas that is high in organic matter or fertile soil, but it can thrive in marginal areas with poor soils and unpredictable rainfall.

Cassava roots should not be eaten raw because they contain highly toxic cyanogen compounds and antinutrients in the form of cyanogenic glucoside (95% linamarin and 5% lotaustratin), cyanohydrin and free cyanide (Montagnac, et al., 2009). Linamarin and lotaustrin are decomposed by linamrase, a naturally occuring enzyme in cassava, liberating hydrogen cyanide (HCN). Cyanide is the most toxic factor restricting the consumption of cassava roots and leaves. The cyanogenic potential of cassava roots and leaves range from 2 to > 1000PPM HCN, fresh weight (Odoemelan, 2005; Komolafe and Arawande, 2011) as cited by Orjiekwe, et al., 2013.

According to Dan Fletcher (Feb. 22, 2010), that if cassava is prepared incorrectly, the cassava plant can produce cyanide, a deadly compound when consumed. The lethal dose of free HCN for an adult is 50-60 mg but the toxicity of bound HCN is less clearly understood. However, Navarro said (2005) that hydrocyanic acid can be found naturally in root crops. He added that if the preparation of the food is not proper, or if the food has not been properly rinsed and cooked well, it can cause poisoning. In addition, the Plant Resources of Southeast Asia (PROSEA), gave an information that cassava tubers (roots) and leaves contain hydrocyanic acid (HCN).

Hydrogen cyanide or HCN is a volatile compound. It evaporates rapidly in the air at temperatures over 280C and dissolves readily in water. It may easily be lost during transport, storage, and analysis of specimens. The normal range of cyanogen content of cassava tubers falls between 15 and 400 mg HCN/kg fresh weight (Coursey, 1973). The concentration varies greatly between varieties and with environmental and cultural conditions.

According to Fernandez et. Al (2005), this is dangerous and when more than what the body can handle, this chemical can kill man and animals alike. Another statement presented by Wobeto et.al (007), he said that cassava is an important food, but it contains toxic and anti- nutritional substances that interfere with digestion and uptake of nutrients. These cyanogenic glucosides that are toxic for humans and can lead to serious health disorders. The consumption of cassava products with high cyanogens levels may cause acute intoxications (Mlingi et al., 1992), aggravate goiter (Bourdoux et al., 1982) and, in severe circumstances, induce paralytic diseases (Tylleskar et al., 1992) as cited by Lambri, et al., 2013. To avoid dietary cyanide exposure, the glycosides, and their metabolites, collectively known as cyanogens, must be removed by processing before consumption.

According to Nabisan (2011) processing techniques and procedures differ with countries and localities within a country according to food cultures, environmental factor such as availability of water and fuel wood, the cassava varieties used, and the types of processing equipment and technologies available. The processing methods generally adopted include a combination of procedures, such as peeling, slicing, boiling, drying, grating, pounding, or milling and sieving.

Cassava is the key source of carbohydrates for subsistence farmers in some areas of the country. Being a staple food by some Filipinos, food preparation should be taken as one consideration to avoid food poisoning because cassava plant contains potentially toxic levels of a cyanogen called linamarin if not properly processed. Linamarin and lotaustrin are decomposed by linamrase, a naturally occurring enzyme in cassava, releasing hydrogen cyanide (HCN). Despite the fact that cassava as one of the chief source of carbohydrates, and raw materials in preparing appetizers among Filipinos, the need to conduct a study about the processing method that can remove or reduce the toxicity levels or known as hydrogen cyanide (HCN) is very essential.

II. RELATED LITERATURE

Botanical description

Cassava is locally known as kamoteng kahoy in Ilokano, balinghoy in Bisaya, or Manioc in English, in French it is called as tapioca, manioc, in Malay it is called as ubi kayu. The kamoteng-kahoy is an erect; smooth, half-woody or shrubby plant, 1.5 - 3 meters in height, growing in stout and fleshy root. Leaves are alternate and smooth (except for some of the upper leaves, which are entire) and dividing into the base into three to seven narrow segments, 10 to 20 cm long. Flowers are about 1 centimeter long. Fruits are about capsule, ovoid, 1.5 centimeter long six, narrow longitudinal wing.

Distribution

Cassava which is also known as tapioca is a common root crop in Asia. It is said that cassava is indigenous to tropical America, was introduced in the Philippines by Spanish explorers and tradesmen from Mexico in the 9th century. It is planted or semi cultivated in settled areas throughout the Philippines for its fleshy and starchy root.

Properties

There are two well-known varieties of cassava, the bitter and sweet. The bitter is characterized as more robust and planted for its starch and source of tapioca. The roots containing hydrocyanic acid considered as poisonous but easily dissipated by heat. The cassava root is harmless when fresh but becomes poisonous when stale or at state of decay. Thorough peeling of the tubers before cooking removes the chances of poisoning.

The sweet variety is not good for starch production than the bitter variety but is non-poisonous. A cassava variety is classified as bitter when HCN is about 200 parts per million and above. These varieties are usually used for feed and for industrial purposes. The most common of this type is Hawaiian 5 which is popularly used in Mindanao, particularly in Lanao del Sur), Datu 1, Java Brown, Sultan 1 and vcv-1. It is tasty and grown for use as vegetable.

Cassava tuber is not only good for food or feed, but it is considered as antiseptic. The bark of trunk considered anti-rheumatic. While leaves have an anti- inflammatory and anti-microbial activity as reported. The parts used are the tubers, bark, leaves and latex.

Cassava can grow under poor soil conditions and can withstand drought. It is therefore usually considered as an important famine reserve crop in countries with unreliable rainfall. Although cassava can grow on poor soils, adequate levels of nitrogen (N) and potassium (K) are required for optimum top growth and tuber yields (Obigbesan and Fayemi 1976).

Cassava roots can be utilized in any of the four categories arbitrarily classified by Gatchallian and de Leon (1992) such as staple substitutes and snack foods; as vegetables; as spices; and others. But most tropical countries cassava is a staple food, particularly in tropical Africa (Hahn, SK and Keyser, J., 1985).

Even though cassava is an important food, it contains toxic and ant nutritional substances that interfere with digestion and uptake of nutrients (Wobeto and others 2007). Cassava contains cyanogenic glucosides that are toxic for humans and can lead to serious health disorders.

The issue on cyanide poisoning transpired after the incident that happened when one-hundred ten (110) mostly grade school children in Bohol were the victims and thirty children died after they ate tasty delicacy made from cassava flour (Fernandez, et.al. 2005).

According to the Plant Resources of Southeast Asia (PROSEA), a cassava tuber (roots) and leaves contain hydrocyanic acid (HCN). This HCN is dangerous and when more than what the body can handle, this chemical can kill man and animals alike (Fernandez et.al. 2005).

All cassava cultivars (cultivated varieties) contain cyanogenic glucoside, according to PROSEA. Glycoside content such as HCN (or prussic acid) in the central part of fresh storage root of cassava that varies from 30 to 200 milligram (mg) per kilogram (kg) and can sometimes even more.

The glycosides are hydrolyzed to HCN by the endogenous enzyme linamrase, which is present in the human digestive tract. All the traditional cassava processing methods reduce or remove the toxicity by releasing HCN from the glycosides. Since HCN is soluble in water and has a boiling point of 25°C it can be removed by soaking. Boiling fresh cassava has little effect on its toxicity as the glycoside linamarine is heat resistant and the enzyme linamrase is inactivated at 75°C (FAO,1995).

Hydrogen cyanide or HCN is a volatile compound. It evaporates rapidly in the air at temperatures over 280C and dissolves readily in water. It may easily be lost during transport, storage, and analysis of specimens. The normal range of cyanogen content of cassava tubers falls between 15 and 400 mg HCN/kg fresh weight (Coursey, 1973). The concentration varies greatly between varieties and with environmental and cultural conditions.

"If the cells of storage roots are crushed, glucoside and enzymes make contact and the HCN is split off. This is the key component of removing HCN. The volatile HCN should be allowed to escape", PROSEA said.

Another DOH epidemiologist, Dr. Chito Navarro said that cyanide is inherent in root crops. "Cyanide can be found naturally in root crops. If the preparation of the food is not proper, or if the food has not been properly rinsed and cooked well, it can cause poisoning (Navarro, 2005). The consumption of cassava and its products is believed to be the source of cyanide poisoning with symptoms of vomiting, nausea, dizziness, stomach pains, weakness, headache, and diarrhea and occasionally death (Mling et al. 1992, Akintonwa et al. 1994).

Moreover, high dietary cyanogen exposure from poorly processed cassava roots may be associated with the occurrence of the neurological disorder konzo –an irreversible paralysis of the legs (Ernesto et al. 2002).

According to Dan Fletcher (Feb. 22, 2010), if cassava is prepared incorrectly, the cassava plant can produce cyanide, a deadly compound when consumed. The lethal dose of free HCN for an adult is 50-60 mg but the toxicity of bound HCN is less clearly understood.

According to Orjiekwe et.al. (2013), processed cassava has a lower hydrocyanide cyanide content which ranges from 5 to 10 ppm. The cyanide level of 5 to 10 ppm in the cassava products falls within the acceptable limits of the 10 HCN equivalents per kilogram dry weight as recommended by FAO (1988) for safe in cassava products. Therefore, cassava grown in areas of Lanao provinces is safe for food.

Some Methods and Processing Techniques in Reducing HCN

Cassava processing procedures vary, depending on products, from simple processing (peel, boil, and heat) to complicated procedures for processing into gari, for example, which involve many more steps, namely peeling, grating, pressing, fermenting, sifting, and roasting. Some of these steps reduce cyanide more effectively than others.

Processing techniques and procedures differ with countries and localities within a country according to food cultures, environmental factor such as availability of water and fuel wood, the cassava varieties used, and the types of processing equipment and technologies available. The most important traditional culinary preparations of cassava in the Philippines is "boiled roots", cassava cake, and tapay or "fermented cassava roots".

The processing methods generally adopted include a combination of procedures, such as peeling, slicing, fermentation, boiling, drying, pounding, or milling and sieving. However, especially for the varieties which are high in HCN, the most popular and efficient processing method for their removal is fermentation (Nambisan, 2011).

Traditional processing and cooking methods for cassava can, if efficiently carried out, reduce the cyanide content to non-toxic levels. An efficient processing method will release the enzyme linamarase by disintegrating the microstructure of the cassava root. On bringing this enzyme into contact with linamarin the glucoside is converted into hydrogen cyanide. The liberated cyanide will dissolve in the water when fermentation is affected by prolonged soaking and will evaporate when the fermented cassava is dried.

Sun drying fresh cassava pieces for short periods is an inefficient detoxification process. Cyanide will not be completely liberated,

and the enzyme will be destroyed during drying. Sun drying processing techniques reduces only 60 to 70 percent of the total cyanide content in the first two months of preservation. Cyanide residues can be quite high in the dry tubers, from 30 to 100 mg/kg (Casadei, 1988).

The reduction of cyanides depends on whether the product is placed in cold water (27°C) or directly into boiling water (100°C). After 30 minutes cooking, the remaining cyanides are, in the first case, 8 percent of the initial value, and in the second case about 30 percent (Easers, 1986). The potentially toxic HCN content in cassava roots was significantly reduced by potassium application. At lower doses of potassium application, root HCN content is relatively high. It substantially decreased at higher rates of potassium which indicates the need for further experimentation with more cultivars and other sources of potassium. Although potassium is found important in reducing the HCN content of cassava roots, other locally available and cheap sources of potassium such as wood ash can alternatively be used by the mainly subsistent farmers who usually cultivate the crop.

One strategy to reduce the cyanide content of processed cassava is to improve processing methods used for conversion of roots to storable cassava products such as flour. The major methods of flour making in Africa involve sun drying of peeled roots followed by crushing in a pestle and mortar and sieving. This method retains 25 to 33% of the original linamarin present (Cardoso et al. 2005).

In most parts of Africa and South America, fermentation plays a significant socio-economic role being a highly desirable technique in removing HCN which was practiced by the rural communities (Chelule et al., 2010).

Drying. Drying is the simplest method of processing cassava. Drying reduces moisture, volume and cyanide content of roots, thereby prolonging product shelf life. This processing is practiced primarily in areas with fewer water supplies. Total cyanide content of cassava chips could be decreased by only 10-30 percent through fast air drying. Slow sun-drying, however, produces greater loss of cyanide. Sun drying the peeled cut pieces of roots gave a HCN concentration lower than 10 mg/100g and loss was more effective than oven drying (Mahungu et al. 1987). Fernadez et.al. (2005) added that sun-drying reduces toxicity but another DOH epidemiologist, Dr. Chito Navarro (2005), said cyanide is difficult to remove since it is inherent in root crops. Most of the poisonous hydrocyanic acid from the cortical layers of roots is removed by thorough peelings of tubers. Tubers contain 26 to 40 percent starch and 1.5 to 2 percent proteins.

Boiling. Boiling the peeled roots of cassava did not effectively remove HCN. Pounding the boiled roots into "pounded fufu" decreased the HCN concentration by only 10 percent. Therefore, only cultivars containing low cyanide are recommended for this method of preparation (Mahungu et al. 1987, FAO, 1995). Among local growers and consumers, one of the common food preparations for cassava is boiling; however, PROSEA gave warning that boiling is not always a guarantee that a food product is safe, as the HCN may be caught in starch paste.

Grating. Grating cassava is another method of detoxification; this is done by packing the grated cassava in sacks and pressed under pressure by putting heavy object over the pack (FAO 1995).

Utilization of Cassava in Animal Feed

The cassava tuberous root is primarily a source of carbohydrate and can completely replace maize as an energy source in feeds for pigs and poultry. Properly dried whole cassava tuberous roots can replace maize in non-ruminant rations if the HCN does not exceed 100 ppm in finished feeds. Since cassava is low in protein, it is necessary to supplement cassava-based diets with animal proteins for the supply of methionine and lysine (O.O. Tewe and G.N. Egbunike. 1986).

The significance and potential of cassava especially as an animal feed are now widely recognized in Philippine Agriculture (PCARRD, 2010). While the deadly variety of cassava is inedible for humans, it could be still processed into animal feed (Fernadez et.al. 2005).

Agronomic and Nutritional potentials of Cassava

One consideration in growing cassava is the soil and the nutrients available in it. It is a common knowledge that soil is composed of different microorganism that acts as decomposers. Dr. Manuel Mapue (2005) an Epidemiologist from Department of Health said that cyanide could be produced by certain decomposing elements in the soil. In this condition, there might be a possibility that the highest amount of hydrocyanic on the peel of cassava is contributed by HCN produced by some decomposing elements in the soil.

Obigbesan and Fayemi (1976) stated that the potentially toxic HCN content in cassava roots was significantly reduced by potassium application. At lower doses of potassium application root HCN content was relatively high. It substantially decreased at higher rates of potassium, which indicates the need for further experimentation with more cultivars and other sources of potassium. Although potassium is found important in reducing the HCN content of cassava roots, other locally available and cheap sources of potassium such as wood ash can alternatively are used by the mainly subsistent farmers who usually cultivate the crop. Cassava can grow under poor soil conditions and can withstand drought. It is therefore usually considered as an important famine reserve crop in countries with unreliable rainfall. Although cassava can grow on poor soils, adequate levels of nitrogen (N) and potassium (K) are required for optimum top growth and tuber yields.

Numerous authors have stated that there is significant reduction in the hydrocyanic acid (HCN) content of cassava tubers in response to potassium fertilization (Susan John et al. 2005, El-Sharkawy and Cadavid 2000, Tandon and Sekhon 1988).

It is therefore crucial to characterize cassava cultivars based on their cyanogenic potential and assess factors affecting level of HCN in cassava roots such as growing conditions and plant nutrients so that cultivars for household consumption and industrial use can easily be identified and better strategies to reduce HCN content in cassava can be devised.

III. METHODOLOGY

Research Design

The study involves the 2x4 factorial experiments and the experimental design used is complete randomized design (CRD). Loca-

tion of the source of sampled cassava represents as factor A and the sample preparation technique represents as factor B. Each factor has sub-factors, as shown below:

For Factor A - 2 locations

a_1 = farm in Balo-i, Lanao del Norte
a_2 = farm in Dulay, Marawi City, Lanao del Sur

For Factor B, sample preparation techniques:

b_1 = fresh cassava tuber
b_2 = boiled cassava
b_3 = grated cassava
b_4 = dried cassava (chips)

The treatment combinations are the following:

$T_1 = a_1b_1$ = farm in Balo-i, Lanao del Norte x fresh cassava tuber
$T_2 = a_1b_2$ = farm in Balo-i, Lanao del Norte x boiled cassava
$T_3 = a_1b_3$ = farm in Balo-i, Lanao del Norte x grated cassava
$T_4 = a_1b_4$ = farm in Balo-i, Lanao del Norte x dried cassava (chips)
$T_5 = a_2b_1$ = farm in Dulay, Marawi City x fresh cassava tuber
$T_6 = a_2b_2$ = farm in Dulay, Marawi City x boiled cassava
$T_7 = a_2b_3$ = farm in Dulay, Marawi City x grated cassava
$T_8 = a_2b_4$ = farm in Dulay, Marawi City x dried cassava (chips)

There are two locations of sample materials; one is from a farm in Balo-i, Lanao del Norte and the other sample materials are from a farm in Dulay, Marawi City, Lanao del Sur.

Locale of the Study

The study was conducted at the Plant Science Department, College of Agriculture, Mindanao State University, Marawi City from October 21 to 25, 2016. The sample materials were prepared a day before they were submitted to the laboratory of First Analytical Services and Technical Cooperative (FAST) located at Lapasan, Cagayan de Oro City. Analyzing the hydrogen cyanide content of the sample materials took from November 3 to 14, 2015.

Data Gathered

The data gathered from each treatment combination in three replications was the hydrogen cyanide (HCN) content in milligram per 200 grams of fresh, boiled, dried and grated cassava.

Research Instruments

This study used the white cassava variety in different preparation techniques (fresh, boiled, grated, and dried) and were subjected to HCN analysis done at FAST Laboratory in Lapasan, Cagayan de Oro City.

Randomization

There were eight treatment combinations used in the study. Each treatment combinations were replicated three times, and the total experimental unit was twenty-four. Randomization scheme followed was by draw lots. Each of the replicated treatment combination (24 experimental units) was written in small piece of paper, placed in a box. Drawing of lot was done, one at a time, without replacement. Each drawn piece of lot was considered the experimental unit. Figure 1 shows the randomized layout in CRD (Completely Randomized Layout).

T_1 (a_1b_1)	T_7 (a_2b_3)	T_8 (a_2b_4)	T_4 (a_1b_4)	T_5 (a_2b_1)	T_1 (a_1b_1)
T_2 (a_1b_2)	T_5 (a_2b_1)	T_6 (a_2b_2)	T_3 (a_1b_3)	T_4 (a_1b_4)	T_7 (a_2b_3)
T_8 (a_2b_4)	T_4 (a_1b_4)	T_2 (a_1b_2)	T_5 (a_2b_1)	T_8 (a_2b_4)	T_3 (a_1b_3)
T_3 (a_1b_3)	T_6 (a_2b_2)	T_1 (a_1b_1)	T_7 (a_2b_3)	T_6 (a_2b)	T_2 (a_1b_2)

Figure 1. Randomized Layout in CRD (Completely Randomized Layout) of the Experiment

Sampling Procedures

A total of twelve kilograms of cassava tubers was collected from a farm in Balo-i Lanao del Sur (a_1) and another twelve kilograms was from a farm in Dulay, Marawi City (a_2), representing Factor A (location). The twelve kilograms taken from each location was divided into four experimental units representing levels of Factor B (preparation technique. Each experimental unit weighed three kilo-

grams of tubers to represent the four levels of Factor B (preparation technique) namely: b_1 (fresh), b_2 (boiled), b_3 (grated) and b_4 (dried). Since the study had three replications, the three kilogram in every experimental unit was divided equally into three for the three replications so that each replication is weighing one kilogram. The one kilogram of cassava tubers was packed and marked according to treatment combinations shown earlier.

For laboratory analysis, only 400 grams was taken from each treatment combination that served as sample materials as required by the First Analytical Services and Technical Cooperative (FAST) at Lapasan, Cagayan de Oro City.

Sample Preparation

The **s**ample materials analyzed at the laboratory of FAST were in the form of fresh, boiled, dried, and grated cassava. All the samples (cassava tubers) were washed to remove the adhering soil and then peeled.

For fresh sample (b_1), 200 grams peeled cassava roots were taken from each treatment combination. They were then sliced into 4 inches long, washed, packed, and analyzed.

For boiled cassava tuber (b_2), 200 grams peeled cassava roots were taken from each treatment combination. They were then sliced into 4 inches long, placed in a pot with water just to cover the peeled cassava roots, boiled for 30 minutes, drained using strainer after boiling, packed, and analyzed.

For grated (b_3) cassava, the cassava roots were grated using a traditional kitchen grater. These were placed in a muslin bag squeezing repeatedly to remove excess water from the pulp, followed by packing for laboratory analysis.

For dried (b_4) sample materials, the peeled fresh cassava roots taken from treatment combination were sliced into chips and 400 grams as sample material was submitted to the Integrated Soils and Plant Tissue Laboratory of the College of Agriculture Soils Laboratory, MSU- Marawi City for oven- drying. The required moisture content after drying of 10% was observed.

Procedure in Determining Moisture Content of Cassava

The drying of cassava chips was done by following the laboratory procedure. The laboratory activities were started by transferring 150 g thinly sliced cassava to a tare aluminum tin graduated to 0.01 g. The drying period was done 24 hours. It started by setting the oven into 100◦ C in temperature. When the required period for drying (24 hours) was observed, the dried sample materials were removed from the oven, cooled, and weighed. The drying procedure was repeated for one hour, setting again the oven to 100 ^{0}C until constant weight was attained.

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The moisture content was then computed following the given formula:

$$\text{MC } (\%) = \frac{\text{A} - \text{B}}{A}\ x\ 100$$

Where:

A = weight of aluminum + fresh cassava (weight)
B= weight of aluminum + cassava (weight after drying)

Statistical Analysis

The study was 2 x 4 factorial experiments done in CRD (Completely Randomized Design). Hence, it follows that CRD ANOVA (Analysis of Variance) for the said experiment was used.

Laboratory Analytical Method

The HCN content from different treatment combinations was determined through laboratory analytical method, which was performed at FAST Laboratories, Lapasan Cagayan de Oro City. Acid titrimetric method was used.

IV. RESULTS AND DISCUSSION

HCN (hydrocyanic acid) content of cassava

Table 1 presents the mean of the HCN content of white variety cassava that is grown in two different locations using different methods of food preparation techniques.

Table 1. Mean of HCN (hydrocyanic acid) Content of Cassava

Treatment Description	Treatments Combinations	Mean
Balo-i, fresh	T_1 (a_1b_1)	< 0.05
Balo-i, boiled	T_2 (a_1b_2)	< 0.05
Balo-i, grated	T_3 (a_1b_3)	< 0.05
Balo-i dried	T_4 (a_1b_4)	< 0.05
Dulay, fresh	T_5 (a_2b_1)	< 0.05
Dulay, boiled	T_6 (a_2b_2)	< 0.05
Dulay, grated	T_7 (a_2b_3)	< 0.05

Dulay dried	T_8 (a_2b_4)	< 0.05

As shown in table 1 it was found out that based on the result on laboratory analysis of (FAST), the HCN in every sample are the same with 0.05 milligram hydrocyanic acid per 200 grams of sample materials.

The FAST laboratories result indicated that the cyanide content for all the treatments reached their limits of detection of HCN content are same for all different treatments and better said failed to detect its differences because of the value for the different treatments are lower than their limits of measurable content for cyanide. Accortding to Coursey (1973), the normal range of cyanogen content of cassava tubers falls between 15-400 mg hydrocyanic acid (HCN) content per kilogram fresh weight.

Cross Tabulation

Table 2 shows the cross-tabulation values for the experiment since the study was a factorial experiment.

Table 2. Cross Tabulations for Cyanide Content in mg/g for Different Treatments

Location		Cyanide Content in mg/g	Preparation Technique				Total
			Fresh	Boiled	Grated	Dried	
Balo-i, LDN	Cyanide	less than 0.05	3	3	3	3	12
	Total		3	3	3	3	12
Dulay, LDS	Cyanide	less than 0.05	3	3	3	3	12
	Total		3	3	3	3	12
Total	Cyanide	less than 0.05	6	6	6	6	24
	Total		6	6	6	6	24

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This cross tabulation was done to determine whether the location or preparation techniques can reduce to the content of hydrocyanic acid in cassava tubers. It can be noted in this table that there are no differences among the HCN content in every sample material. This implies that places where cassava plants are planted do not have effect on the HCN content of white cassava. Similarly, regardless of the preparation technique, HCN are not affected by the different treatment combinations. The location where cassava is growing, and food preparation techniques has no influence on the hydrogen acid (HCN) in cassava. According to Fernandez, et.al (2005) of Plant Resources of Southeast Asia (PROSEA), all cassava cultivars contain cynogenic glucosides which is found in the central part of fresh storage root of cassava that varies from 30 to 200 milligram (mg) per kilogram (kg). However, Orjiekwe (2013), stated that processed cassava has a lower hydrocyanic cynide from 5 to 10 ppm is the acceptable level and safe for human.

Correlation Measures for Different Treatments Combinations

Correlation measures for different treatment combinations were also done for further analysis of the HCN content of white cassava.

Table 3 Correlation Measures for Cyanide Content in mg/g for different Treatment Combinations

Location			Values
	Nominal by Nominal	Contingency Coefficient	.[a]
Balo-i, LDN			
	N of Valid Cases		12
	Nominal by Nominal	Contingency Coefficient	.[a]
Dulay, LDS			
	N of Valid Cases		12
	Nominal by Nominal	Contingency Coefficient	.[a]
Total			24

	N of Valid Cases		

[a] No statistics are computed because Cyanide content is constant.

The table 3 indicates that no symmetry can obviously be seen. This is due to the constant values of the HCN contents of the cassava tuber found in the different treatment combinations.

Another angle for further analysis is "Case Processing Summary" for the different treatment combinations. Computed values are indicated in Table 4.

Case Processing Summary

Table 4 represents the data on HCN of Cassava and further analysis using case processing summary on the different treatment combinations.

Table 4. Case Processing Summary for Different Treatment Combination

Particulars	Cases					
	Included		Excluded		Total	
	N	Percent	**N**	**Percent**	**N**	**Percent**
Cyanide Location	24	100	0	0	24	100
Cyanide Process	24	100	0	0	24	100

Table 4 represents the data on HCN of cassava and further analysis using case processing summary on the different treatment combinations was performed. However, HCN content can not be determined since based on the result on the laboratory analysis for HCN detection, the value of HCN is the same. On the other hand, the result of the study as to HCN content which is 0.05 mg/gram is witin the acceptable level. This result conformed to the statement of Orjiekwe, et al (2013) that cyanide level of 5 to 10 ppm in cassava products falls within the acceptable limits of 10 mg HCN equivalent per kilogram dry weight and this level was also the recommendation made by Food and Agriculture Organization (FAO, 1988).

Conclusion

Thus, it can be concluded that the white variety of cassava in terms of different preparation techniques and of different locations has the same hydrocyanic acid content of less than 0.05 mg/g of sample material. That all 8 treatment combinations produce the same hydrocyanic acid content of less than 0.05 mg/g of sample material.

The finding that white cassava variety taken from either Balo-i, Lanao del Norte and Dulay, Lanao del Sure are very much smaller than any cassava cyanide content based on the cited related literature would imply that the cassava of the same variety used in the study are safe for animal and human consumption. The failure of the study in detecting any numerical cyanide content difference does not imply that white variety cassava in Lanao del Norte and Lanao del Sur and prepared by any technique used in the study is very safe for animal and human consumption.

Recommendation

Based on the conclusions derived from the study, it is recommended that a similar study should be conducted.

A study on the Hydrocyanic Acid (HCN) content of cassava as influenced by the different levels of nitrogen, phosphorus, and potassium fertilizer. This is very important since fertilizer amount for cassava production has contribution to HCN content, and this must be taken into consideration since higher HCN content is lethal to human.

A study about growing cassava at two different climatic condition (dry and wet). This is also important study because there are authors stating that HCN content of cassava varies based on the climatic condition of the growing sites.

A study on analysis of HCN content of matured and young cassava leaves in relation to food preparation. Hence, cassava leaves are used as vegetables by every household. Research results found out that cassava leaves contain hydrocyanic acid (HCN). The danger is its effect to health when taken daily as part of every household diet. A study on the other method of analyzing the HCN content of cassava that does not only limit its detection of HCN is also recommended, like other studies used a modified version of the Alkaline Picrate Impetrated filter paper method by Nwokoro et al., 2010 as reported by Orjeikwe, et.al., 2013. This is also an important study to prove or disprove the significant level of the HCN content of prepared cassava samples. A study on increasing the replications in every treatment and the weights of the samples for HCN content detection to mg/kg as used by other researchers will also be suggested so that favorable result on the HCN content of cassava in relation to food preparation is acquired.

References

[1] Boiling. 2013. Encyclopædia Britannica. Encyclopædia Britannica Ultimate Reference Suite. Chicago: Encyclopædia Britannica.
[2] Bandera, A. (2020). Phytochemical screening and return on investment of pechay (Brassica napus L. subsp. chinensis var. Black Behi) as influenced by inorganic fertilizers (ground and foliar application) and organic fertilizer. International Journal of Agriculture and Food Science. Volume 2; Issue 1; Page No. 24-30. www.agriculturaljournals.com
[3] Chelule PK, Mokoena MP, Gqaleni N. 2010. Advantages of traditional lactic acid bacteria fermentation of food in Africa. Technology and Education Topics in Applied Microbiology and Microbial Biotechnology. Ed. Méndez-Vilas.
[4] Coursey, D.G., Haynes, P.H. 1970. Root crops and their potential as food in the tropics. World Crops July/Aug
[5] Drying.(2016,May26). Retrieved from Extension Education website: http:// www.extension.edu/food/food/preserving/drying.
[6] FAO . 1995. Cassava. Food and Agriculture Organization. South Pacific Commission – Health Service. South Pacfic Foods.
[7] Fernandez,Rudy and Crisostomo,Shella.March11,2005.What makes cassava poisonous?PhilStar Global. www.philstar.com/news. viewed November 11, 2015
[8] Food. Comprehensive Reviews in Food Science and Food Safety, 8: 17–27
[9] Gatchalian, M.M. and De Leon, S.Y.1992. Introduction to Food Technology. Merriam and Webster Bookstore, Inc. Manila, Philippines.
[10] Grating. (2016, May 26). Retrieved from Extension Education Website: http:// www.extension.edu/food/food/grating.
[11] Hahn, S.K. 1984. Tropical root crops. Their improvement and utilization. IITA paper presented at Conference on "Advancing Agricultural Production in Africa". 13-17 February 1984, Arusha, Tanzania.
[12] Hahn, S.K. and Keyser, J. 1985. Cassava: a basic food of Africa. Outlook on Agriculture. 4:95 – 100.
[13] Heuberger C. 2005. Cyanide content of cassava and fermented products with focus on attiéké and attiéké garba. Diss. ETH No. 16247. Dissertation submitted to the Swiss Federal Institute of Technology, Zurich, for the degree of Doctor of Natural Sciences.
[14] Hydrogen cyanide. 2013. Encyclopædia Britannica. Encyclopædia Britannica Ultimate Reference Suite. Chicago: Encyclopædia Britannica.
[15] Halstrom F, Moller KD. 1945. Content of cyanide in human organs from cases of poisoning with cyanide taken by mouth, with contribution to toxicology of cyanide. Pharmacol Toxicol 1:18.
[16] Lambri M, Fumi MD, Roda A, Faveri DM. 2013. Improved processing methods to reduce the total cyanide content of cassava roots from Burundi. Afr. J. Biotechnol. 12(19):2685 – 2691.
[17] Montagnac, J. A., Davis, C. R. and Tanumihardjo, S. A. 2009. Processing Techniques to Reduce Toxicity and Antinutrients of Cassava for Use as a Staple.
[18] O.O. Tewe and G.N. Egbunike .1986. Cassava in Livestock Feed in Africa. FAO CORPORATE REPOSITORY. Proceedings of IITA/ILCA/University. page1-2
[19] Philbrick, D.J., Hill, D.C. & Alexander, J.C. 1977. Physiological and biochemical changes associated with linamarin and administration to rats. Toxicol. Asql. Pharmacol., (42): 539.
[20] RECIDE, ROMEO S. September 2014.Major Crops Statistics of the Philippines is a publication of the Philippine Statistics Authority. Ben-Lor Building, 1184 Quezon Avenue, Quezon City, Philippines 1100.p 193 -198
[21] Siritunga D, Sayre RT. 2003. Generation of cyanogen-free transgenic cassava. Planta 217:367–73.
[22] Staple Food. (2016, May 26). Retrieved from Bussiness Dictionary Website: http://www.businessdictionary.com/definition/staple-food.html
[23] Teles FFF. 2002. Chronic poisoning by hydrogen cyanide in cassava and its prevention in Africa and Latin America. Food Nutr Bull 23:407–412.
[24] Topouzis D. 2003. Addressing the impact of HIV/AIDS on ministries of agriculture: Focus on eastern and southern Africa. Rome , Italy : A Joint FAO/UNAIDS Publication.
[25] Toxicity. (2015, September 24). Retrieved from Medecine Net Newsletter Website: http://www.medicinenet.com/script/main/art.asp?articlekey=34093
[26] Wobeto C, Corrêa AD, De Abreu CMP, Dos Santos CD, Pereira HV. 2007. Antinutrients in the cassava (Manihot esculenta Crantz) leaf powder at three ages of the plant. Cienc Technol Aliment 27:108–12.
[27] Yi, X.K. etal., (2009). Thin – layer drying of charateristics and modeling chinese jujubes. Transaction of the CSAE. 25(9): 329-332

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