Production and Quality Evaluation of Gari from Mixtures of Trifoliate Yam (Discorea dumentorum) and Cassava (Manihot esculenta)

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ABSTRACT

This study aimed at evaluating gari produced from mixture of trifoliate yam and cassava tubers. Trifoliate yam and Cassava tubers were in the ratio 100:0; 0:100; 90:10; 80:20; 70:30; 60:40, 50:50, respectively. Proximate, functional, anti-nutritional and sensory evaluation were carried out on the gari using standard methods. The moisture, protein, ash, fat, fibre and carbohydrate ranged from 2.17-5.83%, 1.97-3.50%, 1.58-2.80%, 1.31-2.34%, 0.96-1.71% and 83.82-90.85%, respectively. Sample P2B (100% Trifoliate yam) had the highest value of moisture, protein, ash, fat and fibre. The bulk density, water absorption capacity, oil absorption capacity, swelling capacity and solubility ranged from 0.61-0.67%, 197.33-336.00 g/ml, 78.93-140.53 g/ml, 9.59-11.47 g/ml and 3.95-7.03%, respectively. The value of phytate, tannin, cyanide and saponin ranged from 0.12-0.59%, 0.26-0.50%, 0.28-0.47% and 0.35-1.77%, respectively. The isolates identified were catalase positive and negative. The proximate composition revealed that the gari contains appreciable amount of protein, fat, fibre and carbohydrate. The anti-nutritional content of the gari showed that the gari will not have negative effect on human. The sensory result showed that gari could be produced from trifoliate yam and cassava tubers without affecting the sensory attributes.

Keywords: *D. dumetorum*, Functional properties, Gari, Proximate properties, Trifoliate yam

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1. INTRODUCTION

One of the most domesticated crop but highly underutilized is Trifoliate yam (*Dioscorea dumetorum*). *D. dumetorum* has been reported to be the most nutritious species of the eight yam species commonly grown and consumed in West and Central Africa. Its tubers are rich in protein (9.6%), fairly balanced in essential amino acids (chemical score of 0.94), and its starch is easily digestible (Siadjeu *et al.*, 2016; Siadjeu, Mayland-Quellhorst and Albach, *2018*).

It is an important food security crop and it is mostly consumed in West Africa. It originated in tropical Africa and occurs in both wild and cultivated forms. Its cultivation is mainly in West and Central Africa especially Nigeria and Cameroon (Obidiegwu *et al.,* 2020). The local names in Nigeria are: Kosanrogo in Hausa, Ona in Ibo and Esuru in Yoruba. Other common names are three-leaved (trifoliate) yam, bitter yam, cluster yam and sweet yam in Cameroon. In Yoruba tribe of Nigeria, the wild type is called Esuru-Igbo or Gudugudu. It is the most nutritious of the commonly cultivated yam species. It is a good source of carbohydrate, protein, vitamins and minerals when compared with other common species of yam (Alozie *et al.,* 2010). The amino acid profile of the yam has been reported to be quite balanced in essential amino acids with slight deficiency in sulphur containing amino acids and lysine as the most limiting (Alozie *et al.,* 2009).

However, unlike other yam species, *D. dumetorum* begins to harden about 24 hours after harvest which limits the storage stability of the tuber. This hardening affects the cooking time of the yam which might take 12 hours or more, leads to reduction in moisture and starch content and increase in sugars and structural polysaccharides which is characterized by loss of ability to soften during cooking (Medoua *et al*., 2005). The tuber is also manifested in the loss of culinary quality due to a combination of factors resulting from the normal but inadvertently deleterious reactions leading to textural changes. Microstructural studies showed that lignification and thickening of cell walls are one of the characteristic features of the hardening process (Afoakwa and Sefa-Debeh, 2002). Several studies were focused on the biochemical modifications related to postharvest hardening and the understanding of hardening mechanism (Medoua *et al.,* 2005). Another reason that was reported for the underutilization is the toxic principles, the prominent among them being dioscorine (a convulsive alkaloid with molecular formular, $C_{13}H_{19}O_2N$ (alkaloid dihydrodioscorine). However, these are soluble in water and can be reduced by soaking and boiling.

Cassava ranks fourth in the list of major crops in developing countries after rice, wheat and maize and it is used for the production of a variety of West African foods. In its natural state, it is toxic to man as it may contain high levels of linamarin, a cyanogenic glucoside. Hence, processing it through fermentation enhances its detoxification, quality and safety (Edward *et al.,* 2012). Gari is a dehydrated pre-gelatinized granular fermented food product that is usually made from the starchy tuberous roots of cassava (*Manihot esculenta*). It is classified or grouped based on texture, length of fermentation, region or place where it is produced and colour imparted by the addition or non- addition of palm oil. It has a high swelling capability and can absorb up to four times its volume in water (Jekayinfa and Olajide, 2007). Recent research effort in Nigeria has led to the production of a pre-gelatinized fermented breakfast food product that physically resembles cassava gari using trifoliate yam (Ukpabi and Oti, 2010); Ukpabi and Akobudun, 2014).

Trifoliate yam is underutilized because it has significant food and/or industrial potentials which remain unused through lack of clear approach for its assessment and development. For example, trifoliate yam flour can be used to produce stiff dough (also known as amala). When trifoliate yam is used for production of gari, it will reduce the high increase in demand for cassava which is the usual raw material for gari. This can also help to meet the increase demand for gari and increase the planting and propagation of the yam.

2. MATERIALS AND METHODS

The tubers of the experimental trifoliate yam cultivar for this research was gotten from the Molete market in Ibadan, Oyo State while cassava roots were gotten from Lagos State Polytechnic farm, Ikorodu, Lagos State, Nigeria. The production and analysis of gari was done at the Food Technology laboratory, Lagos State Polytechnic.

2.1 Preparation of Gari

The gari production was done according to Adekanye *et al.* (2013) with modified local cassava gari processing. The trifoliate yam and cassava was grinded in the ratio (100:0, 0:100; 90:10, 80:20, 70:30, 60:40, 50:50 and 0:100), respectively. Wholesome tubers of trifoliate yam and cassava were used as raw-materials, with peeling done manually with sharp kitchen knives. The peeled tubers were collected in large basins and washed with clean tap water. The washed peeled tubers were adequately grated with grating machine used for gari processing. The pulp was put in a double-layered 50 kg rice sack. The tightly woven, double layered polypropylene sack had its mouth twisted and tied up (with rope) for simultaneous dewatering and fermentation that lasted for 72 hours. The resulting gari was manually broken, pulverized and sifted with a 4 mm sieve. The sieved gari was then toasted or garified in a firewood heated cast-iron gari-processing pan in batches. The toasting was done in each batch by using a bowl section to constantly stir the dewatered sieved mash against the hot surface of the pan until gelatinized grains were formed. The hot freshly produced gari was allowed to cool to ambient room temperature. The flow chart for the preparation of gari is shown in Figure 1.

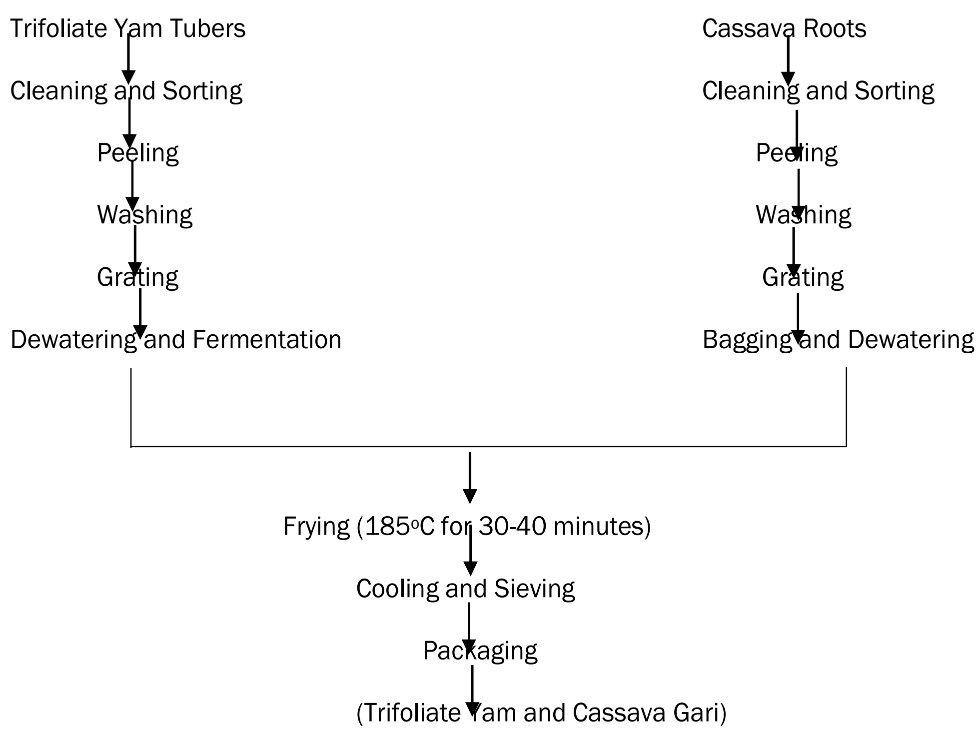

Figure 1: Flow Chart for Gari Produced from Trifoliate Yam and Cassava Roots
Source: Adekanye *et al.* (2013) (with modifications)

2.2 Determination of Antinutrients

The saponin and phytate were determined using the method of AOAC (2005). Tannin was determined using the Folin Deni Reagent as described by Makkar *et al.* (1993). Oxalates was determined using the method described by Iwuoha and Kalu (2004).

2.3 Proximate Analysis

The moisture, protein, fat, fibre, ash and carbohydrate were determined using the methods described by AOAC (2005).

2.4 Determination of Functional Properties Of the Gari

The water absorption capacity, oil absorption capacity, bulk density, swelling and solubility were determined using the method described by AOAC (2006).

2.5 Sensory Evaluation

Semi trained panelists were given a hedonic scale questionnaire to evaluate the gari and eba (stiff dough). The gari and eba (stiff dough) was evaluated through general appearance, flavour, taste, mouth feel and over all acceptability. They were scored on a scale of 9 points in which (1- extremely dislike 2 - dislike very much,3 - dislike moderately, 4- dislike slightly. 5 neither like nor dislike, 6 - like slightly, 7- like moderately, 8 - like very much, 9 - like extremely). During sensory evaluation panelists were instructed to drink water or mouth wash after each sample.

2.6 Statistical Analysis

The analyses were carried out in triplicates. The results obtained were statistically analyzed using one-way Analysis of Variance (ANOVA) (SPSS 17.0) to test for significant differences ($p \leq 0.05$) between the samples. The mean values for the samples were separated using Duncan's Multiple Range Test (DMRT).

3. RESULTS AND DISCUSSION

The proximate composition of the gari produced from cassava and trifoliate yam is shown in Table 1. The moisture content ranged from 7.83-10.83 g/ml. There was significant difference ($p > 0.05$) between the samples. The traditional methods of processing cassava root into gari involved substantial elimination of water from the raw roots resulting to a relatively more stable product with comparatively longer shelf-life (Oluwole *et al.,* 2004; Kamalu and Ogbome, 2012). The moisture content obtained in this study is lower than the value (11.38-12.60 g/ml) reported by Bankole *et al.* (2013) who worked on gari fortified with Bambara Groundnut flour. Also lower than the range recommended by Abu *et al.* (2006) which indicated that the maximum moisture content of gari is 12%.

Table 1: Proximate Composition of the Gari Produced from Cassava and Trifoliate yam

Sample	Moisture	Protein	Ash	Fat	Fibre	CHO
P2B	10.83±1.26[a]	3.50±0.00[a]	2.80±0.00[a]	2.34±0.00[a]	1.71±0.00[a]	83.82±1.23[d]
G8C	8.17±0.29[c]	3.33±0.00[b]	2.66±0.00[b]	2.22±0.00[b]	1.62±0.00[b]	88.00±0.29[b]
Q4T	9.33±0.58[ab]	2.54±0.00[e]	2.03±0.00[e]	1.69±0.00[e]	1.24±0.00[e]	88.16±0.58[b]
M3G	7.33±0.29[bc]	3.02±0.00[c]	2.42±0.00[c]	2.02±0.00[c]	1.48±0.00[c]	88.23±0.29[b]
R5L	7.83±1.04[bc]	1.97±0.00[g]	1.58±0.00[g]	1.31±0.00[g]	0.96±0.00[g]	90.85±1.04[a]
W9X	10.67±1.53[a]	2.80±0.00[d]	2.24±0.00[d]	1.87±0.00[d]	1.37±0.00[d]	86.05±1.53[c]
A6Y	8.00±0.00[bc]	2.23±0.00[f]	1.79±0.00[f]	1.49±0.00[f]	1.08±0.00[f]	90.40±0.00[a]

*Mean ± standard deviation with same superscripts along the column are not significantly different at ($p > 0.05$)
Key;
P2B 100% Trifoliate yam+0% Cassava Tuber; G8C 90% Trifoliate yam+10% Cassava Tuber
Q4T 80% Trifoliate yam+20% Cassava Tuber; M3G 70% Trifoliate yam+30% Cassava Tuber
R5L 60% Trifoliate yam+40% Cassava Tuber; W9X 50% Trifoliate yam+50% Cassava Tuber
A6Y 0% Trifoliate yam+100% Cassava Tuber

The protein content ranged from 1.97-3.50%. There was significant difference ($p > 0.05$) between the samples. According to Montagnac *et al.* (2009), cassava root is a poor source of protein. The protein values obtained in this study could be as a result of fermentation processes in which cassava and trifoliate yam were subjected into and incorporation of trifoliate yam which is slightly high in protein than cassava. Hence, this result confirmed that trifoliate yam gari is slightly proteinous and nutritious than cassava gari. Ash content in a food indicates good amount of mineral (Ikuomola *et al.,* 2017). The value of ash ranged from 1.58-2.80%. There was significant difference ($p > 0.05$) between the samples. Increase in ash content up to 0.5 g/ml was an indication of an increase in the mineral content of the gari as reported by Adeleke and Odedeji (2010).

The values obtained in this study were close (1.10-3.30 g/ml) reported by Ekunola (2006) for gari obtained from 100% cassava and breadfruit. elements. Fats provide the most concentrated source of chemical energy and heat. They support certain body organs and help with the transportation and storage of fat-soluble vitamins A, D, E, and K (Anne and Allison, 2006). The fat content ranged from 1.31-2.34 g/ml. There was significant difference ($p > 0.05$) between the samples. The highest value (2.34 g/ml) of fat obtained in sample P2B showed that trifoliate yam contains appreciable amount of fat. The fat content obtained in this study is similar to the value (1.21-1.48 g/ml) reported by Bamidele *et al.* (2014) who worked on gari from cocoyam and cassava tuber. But higher than the value (1.20 g/ml) reported by Ukpabi and Enoch (2014) who worked on fermented breakfast food produced from edible trifoliate yam.

The fibre content ranged from 0.96-1.71 g/ml. There was significant difference ($p > 0.05$) between the samples. The fibre content obtained in this study is still within the nutritionally maximum level of 3.0% (Ibeh *et al.,* 1991). According to Ugwu and Oranye (2006), fibre which is a measure of the undigested components of foods such as cellulose and lignin plays a very important role in nutrition because it adds bulk and aids proper digestion of foods. The fibre obtained in this is slightly lower than the value (1.96-2.69 g/ml) reported by Ajifoloku and Adeniran (2018) who worked on proximate and mineral composition of co-fermented breadfruit and cassava into gari analogue.

The functional properties of the gari produced from trifoliate yam and cassava is shown in Table 2. Functionality of foods is the properties of food ingredient other than a nutritional attribute, which has a great impact on its application. The functional characteristics determines the utilization and use of food material for various food products (Hasmadi *et al.,* 2020). According to Adejuyitan *et al.* (2009), bulk density is the measure of heaviness of flour. The value of bulk density ranged from 0.61-0.67 g/ml. The bulk density is always influenced by particle size and the density of such food product which determines the packaging and handling method of such material (Ezeocha *et al.* 2011).

The values obtained in this study are comparable to that of Komolafe and Arawande (2010) who reported the bulk density of gari to be between 0.55-0.82 g/ml. There was significant different ($p > 0.05$) between the samples for water absorption capacity. Chen and Lin (2002) reported that the water absorption capacity of any food product, either flour or grain, is the ability of such product to entrap a large amount of water. The entrapped water by the food molecule will be useful in making the food sample to swell (Ezeocha *et al.* 2011). The values obtained in this study are within the range (215-445 g/ml) reported by Arawande and Komolafe (2010) who worked on gari produced from three cultivars of cassava.

Table 2: Functional Properties of the Gari Produced from Trifoliate Yam and Cassava

Sample	Bulk Density (g/ml)	Water Absorption Capacity (g/ml)	Oil Absorption Capacity (g/ml)	Swelling Capacity (g/ml)	Solubility (%)
P2B	0.66 ± 0.01^{a}	197.33 ± 8.74^{d}	78.93 ± 3.49^{d}	9.59 ± 0.26^{d}	3.95 ± 0.17^{d}
G8C	0.67 ± 0.00^{a}	336.00 ± 18.00^{a}	134.40 ± 7.20^{a}	10.29 ± 0.76^{abc}	6.72 ± 0.36^{a}
Q4T	0.67 ± 0.02^{a}	214.00 ± 6.25^{cd}	85.60 ± 2.49^{cd}	9.71 ± 1.09^{cd}	4.28 ± 0.12^{cd}
M3G	0.61 ± 0.02^{b}	229.33 ± 4.51^{c}	91.73 ± 1.80^{c}	10.07 ± 0.07^{abc}	4.59 ± 0.09^{c}
R5L	0.65 ± 0.02^{a}	273.33 ± 15.18^{b}	109.33 ± 6.07^{b}	11.47 ± 0.76^{a}	5.47 ± 0.30^{b}
W9X	0.67 ± 0.01^{a}	283.67 ± 10.21^{b}	113.47 ± 4.09^{b}	11.26 ± 1.19^{ab}	5.67 ± 0.20^{b}
A6Y	0.66 ± 0.01^{a}	351.33 ± 33.95^{a}	140.53 ± 13.58^{a}	11.43 ± 0.93^{a}	7.03 ± 0.68^{a}

*Mean ± standard deviation with same superscripts along the column are not significantly different at ($p>0.05$)
Key;
P2B 100% Trifoliate yam+0% Cassava Tuber; G8C 90% Trifoliate yam+10% Cassava Tuber
Q4T 80% Trifoliate yam+20% Cassava Tuber; M3G 70% Trifoliate yam+30% Cassava Tuber
R5L 60% Trifoliate yam+40% Cassava Tuber; W9X 50% Trifoliate yam+50% Cassava Tuber
A6Y 0% Trifoliate yam+100% Cassava Tuber

Oil absorption capacity is highly related to lipophilic properties of the starch molecule in cassava flour (Danbaba *et al.,* 2014). The value of oil absorption capacity ranged from 78.93-140.53 g/ml. There was significant different ($p > 0.05$) between all other samples. Mbougueng *et al.* (2008) stated that the variation values show oil absorption capacity is depended on the degree of probability of hydroxyl group to form hydrogen and the covalent bond between the starch granule network. The swelling capacity ranged from 9.59-11.47 g/ml. The ability of gari particles to absorb water and swell, depends on the free amylose and moisture content (Achinewu *et al.,* 1998). According to IITA (1990), good quality gari may swell to about three times its initial volume when placed in water. This confirms that sample P2B with the value (9.59 g/ml) may not swell as much as other samples. The value obtained for swelling capacity in this study were higher than when compared to the value (2.77-4.63 g/ml) recorded by Nwancho *et al.* (2014) who worked on gari produced from fresh cassava roots and dry chips.

The value of solubility ranged from 3.95-7.03 %. Srichuwong *et al.* (2005) documented that solubility could imply the amount of amylose leaching out when swelling, thus the higher the solubility the higher the amount of amylose leaching. The lower value of solubility obtained in this study may be as a result of low content of amylose in the composite blends. The value obtained for solubility in this study were higher than the value (0.11-0.54%) reported by Udoro *et al.* (2014) for gari processed from dried cassava chips. The anti-nutritional properties of the gair produced from trifoliate yam and cassava is presented in Table 3. Ojo and Akande (2013) reported that different processing methods such as cooking, fermentation, and soaking have an influence in reducing the antinutritional factor of foods.

Table 3: Anti-nutritional Properties of Gari prepared from Trifoliate Yam and Cassava

Sample	Phytate (mg/100g)	Tannin (mg/100g)	Cyanide (mg/100g)	Saponin (mg/100g)
P2B	0.40 ± 0.00^{c}	0.26 ± 0.02^{d}	0.39 ± 0.03^{b}	1.21 ± 0.01^{c}
G8C	0.59 ± 0.00^{a}	0.29 ± 0.01^{c}	0.39 ± 0.03^{b}	1.77 ± 0.01^{a}
Q4T	0.37 ± 0.00^{d}	0.30 ± 0.01^{c}	0.47 ± 0.04^{a}	1.10 ± 0.06^{d}
M3G	0.42 ± 0.00^{b}	0.36 ± 0.01^{b}	0.46 ± 0.03^{ab}	1.26 ± 0.01^{b}
R5L	0.37 ± 0.00^{d}	0.29 ± 0.01^{c}	0.47 ± 0.01^{a}	1.10 ± 0.01^{d}
W9X	0.12 ± 0.00^{f}	0.50 ± 0.01^{a}	0.41 ± 0.06^{ab}	0.35 ± 0.01^{f}
A6Y	0.24 ± 0.00^{e}	0.36 ± 0.01^{b}	0.28 ± 0.04^{c}	0.73 ± 0.01^{e}

*Mean ± standard deviation with same superscripts along the column are not significantly different at (p>0.05)
Key;
P2B 100% Trifoliate yam+0% Cassava Tuber; G8C 90% Trifoliate yam+10% Cassava Tuber
Q4T 80% Trifoliate yam+20% Cassava Tuber; M3G 70% Trifoliate yam+30% Cassava Tuber
R5L 60% Trifoliate yam+40% Cassava Tuber; W9X 50% Trifoliate yam+50% Cassava Tuber
A6Y 0% Trifoliate yam+100% Cassava Tuber

The phytate content ranged from 0.12-0.59%. The low value of phytate in this study could be attributed to the fermentation process of the gar. In another research, Khalil (2006) found that fermentation helped to reduce the phytic acid (30-38%) in mung bean. The values obtained for phytate in this study is in line with the value (0.19-0.27%) reported by Agugo *et al.* (2019) who worked on mungbean-gari diets. The tannin content ranged from 0.26-0.50%. Tannins affect nutritive value of food by forming a complex with protein (both substrate and enzyme) thereby inhibiting digestion and absorption (Aletor, 1993); they also impart dull colour on cassava products, and this affect the market value of the products. The toxic compound hydrocyanic glycosides, tannin, and phytate were found below the permissible level (1%), indicating that the samples were safe for consumption.

The hydro cyanide content ranged from 0.28-0.47. Research shows that the final level of cyanide in cassava-based products depend on the initial cyanide load and methods applied in processing raw cassava roots (Cardoso *et al.,* 2005; Okoli *et al.,* 2012). The FAO recommended maximum cyanide level in foods to be 10 mgCN/kg dry weight (OECDD, 2009) which is higher than the value obtained in this study. This indicated that the gar in this study will have no negative effect on human. However, according to FSN, (2005) chronic toxicity may ensue when the consumption of cassava-based products is consumed over long period of time. The saponin content ranged from 0.35-1.77. There was significant different (p > 0.05) between all other samples.

The value obtained for saponin in this study is lower than the value (1.47-2.87%) reported Agogo *et al.* (2019) for mungbean-gari diets. The sensory scores of the gari is presented in Table 4. Iwe, (2003) reported that sensory evaluation is the expressions of an individual like or dislike for a product as a result of biological variation in man and what people perceived as appropriate sensory properties. The reason for high scores obtained for color could be due to non-enzymatic browning that took place during toasting of the gari as reported by De Carvalho *et al.* (2014). Statistically, sample A6Y was the most preferable by the panelists but other samples were clearly acceptable too. This indicated that gar can be prepared from trifoliate yam without affecting the sensory properties of the gari.

Table 4: Sensory Scores of the Gari produced from Trifoliate Yam and Cassava

Sample	Taste	Colour	Appearance	Texture	Overall Acceptability
P2B	7.95 ± 1.28^{ab}	7.90 ± 1.12^{a}	7.45 ± 1.19^{a}	7.30 ± 1.42^{b}	7.50 ± 1.24^{b}
G8C	8.00 ± 0.86^{ab}	7.60 ± 0.94^{ab}	7.75 ± 0.79^{a}	8.30 ± 0.73^{a}	8.10 ± 0.85^{ab}
Q4T	7.80 ± 0.95^{ab}	7.70 ± 0.98^{a}	7.35 ± 1.49^{a}	7.35 ± 1.09^{b}	8.05 ± 1.15^{ab}
M3G	8.05 ± 1.15^{ab}	7.60 ± 0.94^{ab}	7.80 ± 1.11^{a}	7.90 ± 1.02^{ab}	7.85 ± 1.09^{ab}
R5L	8.50 ± 0.61^{a}	7.65 ± 1.04^{ab}	7.95 ± 0.99^{a}	7.40 ± 1.14^{b}	7.80 ± 1.01^{ab}
W9X	7.55 ± 1.05^{b}	7.00 ± 0.86^{b}	7.65 ± 0.99^{a}	7.45 ± 1.09^{b}	7.75 ± 1.12^{b}
A6Y	8.25 ± 1.02^{a}	8.20 ± 0.95^{a}	7.60 ± 1.09^{a}	7.90 ± 1.12^{ab}	8.50 ± 0.69^{a}

*Mean ± standard deviation with same superscripts along the column are not significantly different at ($p > 0.05$)

KEY;

P2B 100% Trifoliate yam+0% Cassava Tuber; G8C 90% Trifoliate yam+10% Cassava Tuber
Q4T 80% Trifoliate yam+20% Cassava Tuber; M3G 70% Trifoliate yam+30% Cassava Tuber
R5L 60% Trifoliate yam+40% Cassava Tuber; W9X 50% Trifoliate yam+50% Cassava Tuber
A6Y 0% Trifoliate yam+100% Cassava Tuber

4. CONCLUSION

In conclusion, the study showed that a more nutritious gari can be produced from trifoliate yam. The tannin, saponin, hydro cyanide and oxalate of the gari-were less than 1% which showed that the gari would not have any negative effect on human. The sensory result showed that gari could be produced from trifoliate yam and cassava tubers without affecting the sensory attributes of the gari. Further research work should be carried out on the shelf stability of the gari.