



HARVESTING DATE INFLUENCES CASSAVA (*Manihot Esculenta Crantz*) YIELD AND QUALITY OF BASED-PRODUCTS

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ABSTRACT

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In order to evaluate cassava roots yield of two varieties at three harvesting dates and assess the effect of harvesting date on physico-chemical composition of roots and quality of gari and baton de manioc, a study was done. Cassava roots of a popular variety (local white) and the improved variety 8034 were harvested in small holder farmers' fields in the mono-modal humid forest zone and the bimodal humid forest zone of Cameroon. At harvest, the yield was evaluated, the physico-chemical composition of roots evaluated and a sensory test carried out on gari and baton de manioc after processing. Results showed that harvesting date has an effect on the cassava roots yield, for both local white and variety 8034. Cassava yield varied according to agro-ecological zones, with higher yield in the mono-modal humid forest zone than the bimodal humid forest zone. The nutrient content in cassava root varied with the variety and age of roots. There was an increase with the age of roots for K, P and dry matter content for the variety 8034. With the local white variety, there was an increase in total N and dry matter content. In contrary, there was a gradual decrease of percentage Mg, K, Na with the age of cassava roots for the variety 8034. Baton de manioc obtained from variety 8034 at 10-12 months and gari obtained from same variety were scored the highest global quality.

Contribution/Originality: This study is one of very few studies which have investigated the right harvesting time and the best cassava variety to be used to obtain good cassava based-products.

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a shrub grown in the tropics and subtropics for its underground starchy tuberous roots. Cassava roots are a major staple food for more than 800 million people in the world [1]; [2]. In Africa, cassava production has more than tripled since 1961 from 33 million tons per year to 101 million tons [3]. The world annual global production was estimated at approximately 276 million metric tons in 2013. According to FAO IFAD WFP The State of Food Insecurity in the World [4] cassava roots produced in Cameroon was estimated at 4 287 177 tons in 2013.

Cassava roots can be boiled and consumed fresh, but its popularity is due largely to its usage in the production of foods like gari, fufu, chip, baton de manioc, industrial starch, etc. These are sold both in Cameroon and elsewhere in Central Africa for the rapidly growing urban populations [5]. The major challenges to the development of the cassava subsector in Cameroon include many factors among which are the limited adoption of improved seeds, high

labor cost: low level of mechanization, poor field management. These poor practices lead to low yield. Cameroon's cassava yield in 2013 was averagely 14.7 t/ha, meanwhile 21.8 t/ha were obtained in Thailand [3]. IITA (International Institute for Tropical Agriculture (IITA) and African National Agricultural Research Systems (NARS) have played leading roles in the development of improved cassava varieties that are multiple disease and pest resistant, early maturing, and high yielding. African countries have released an estimated 384 high yielding cassava varieties between 1970 and 2014. In addition to high yield, and good levels of multiple disease and pest resistance, these cassava varieties have good acceptable quality for food, feed and industrial uses in Africa. While the combination of these new varieties and better agronomic practices could increase yields per unit area by at least 40 %, the rate of adoption by smallholder farmers has been low. In addition, small holder farmers have limited knowledge on the good agronomy practices, including the use of adaptable seeds, planting density, weed and fertilizer management. In addition, the production cycle of each variety of cassava may not be respected by farmers, as the cassava root yield is affected by age at harvest [6].

Gari and baton de manioc are among the most popular fermented and eaten cassava based-products in Cameroon and other parts of Central and West Africa. Traditionally, cassava processors get cassava roots for processing either from their farms or buy in the market or from other farmers; in more cases, the age or variety is not known. Consequently, this influences the quality of the end product. In these conditions, the quality of cassava based-products may not be consistent even when produced by one processor and this using a standard procedure.

Previous studies have discussed the effect of the age of the harvested cassava roots on organoleptic properties of cooked roots and physio-chemical characteristics of extracted starch [7]; [8]. These parameters can influence the quality of flour and ultimately the final products made from the flour. However, little is known about the variation of the physico-chemical composition of cassava roots as well as the quality of cassava based-products with the age of the roots.

The objectives of this study were therefore (1) evaluate cassava roots yield of two varieties at three harvesting dates, (2) evaluate the effect of harvesting date on the physico-chemical composition of the roots and the quality of gari and baton de manioc, through a sensory analysis.

2. MATERIAL AND METHODS

2.1. Study Site

The study was carried out in the mono-modal humid forest agro-ecological zone (zone 4) and the bimodal humid forest agro-ecological zone (zone 5), of Cameroon, specifically in Southwest and Centre regions. In zone 5, three villages were taken into consideration: Mefomo (3° 50' 32"N, 11° 16' 5"E, 715 m), Nkolmelen (3° 58' 21"N, 11° 16' 37"E, 565 m) and Ntang (3° 49' 56"N, 11° 15' 37"E, 699 m). In zone 4, cassava roots were sampled at Batoke (4° 2' 1"N, 9° 6' 15"E, 107 m) and Ekona (4° 12' 36"N, 9° 19' 25"E, 437 m).

2.2. Material

Two cassava varieties namely 8034 and a popular local variety call 'local white' were used as vegetative materials. Other materials like a scale balance, bags, water, disposable plates, cups and spoons, frying pan, leaves, etc. were used.

3. METHODS

3.1. Sampling and Sample Size

The selection of villages and farms was done randomly. Harvesting was done as follow: Three harvesting dates after planting for each variety at 8-10 months, 10-12 months and above 14 months. Two cassava based-products (gari and baton de manioc) were evaluated for each cassava variety.

3.2. Harvesting of Roots Data Collection on Yield

Cassava roots of each variety and each age were harvested separately by hand. For each farm, five plants were randomly selected and harvested. Roots from were weighed and recorded per plant, using a scale balance. This exercise was repeated three times and the mean recorded. The yield of fresh cassava roots was calculated using equation (1), Hayford [9].

$$\text{Root yield (t/ha)} = \frac{10.000 * \text{weight of roots from harvested stands}}{\text{number of plants harvested}} \quad (1)$$

3.3. Production of Gari and Baton De Manioc

The processing of cassava roots into gari and baton de manioc, was done at the food technology laboratory at the Institute of Agricultural Research for Development (IRAD) Nkolbisson. For the processing of both cassava based- products, a popular processing scheme was used. Each variety harvested at each age for processed separately.

3.4. Production of Gari and Data Collection

The harvested cassava roots were peeled, cleaned and grated manually. The grated cassava was packed in jute bag (each sample in a bag), tied and a heavy load was placed on the bag to remove excess water and to initiate the process of fermentation for 3 days (72 hours) at room temperature. The excess water was removed totally from the permeated cassava to ensure easy toasting of the gari. About one kg of each sample was then toasted in a pan for about 20 minutes to produce a fresh yellow gari by adding a bite of palm oil (Figure 1).

Before processing peeled cassava roots into gari, the weight of roots was recorded, as well after processing, gari was weighed.

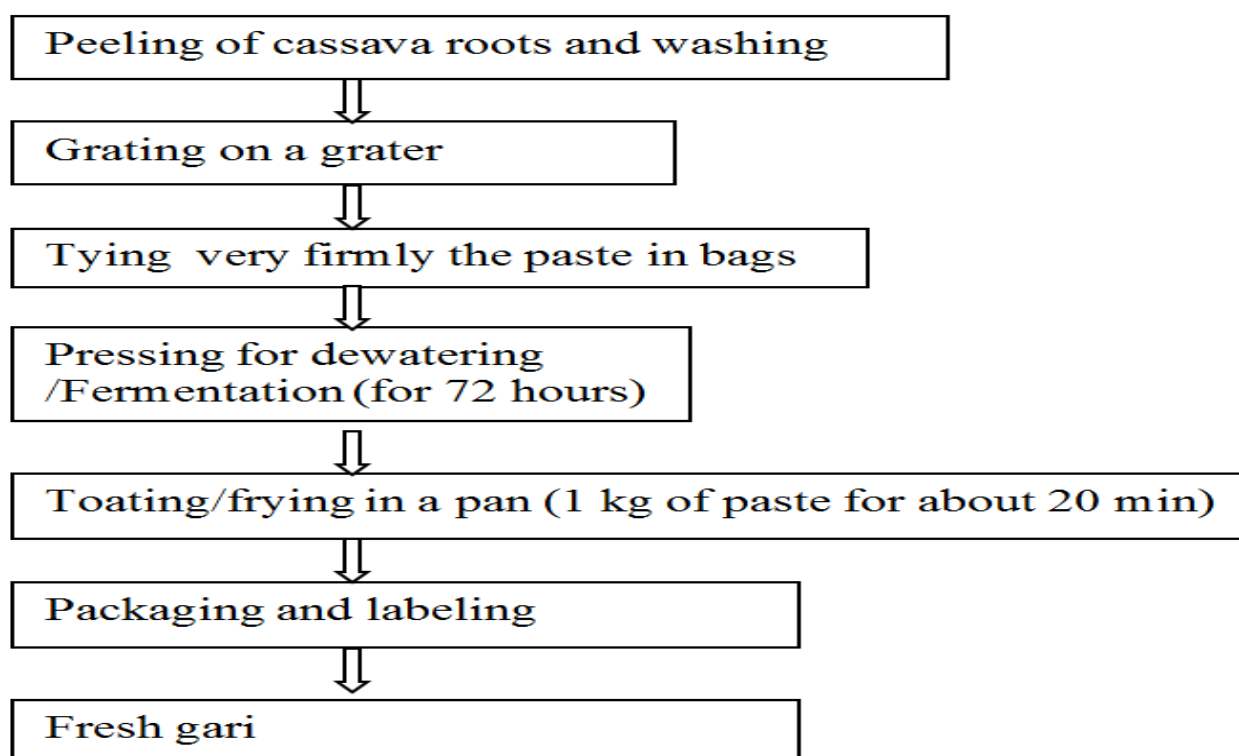


Figure-1. Steps of gari processing from cassava roots

3.5. Production of Baton De Manioc and Data Collection

The harvested cassava roots were peeled, cleaned and cut into small pieces manually. The small pieces of cassava roots were soaked in water (in plastic containers) for 72 hours in room temperature. The soft roots were

then removed from water washed (fibres were removed). The paste was obtained after grinding in the machine and the excess water was removed by pressing in jute bags. The paste was wrapped and tied in leaves and cooked with water for about 45 min to obtain baton de manioc (Figure 2).

Before processing peeled cassava roots into baton de manioc, the weight of roots was recorded; after processing, baton de manioc was weighed as well.

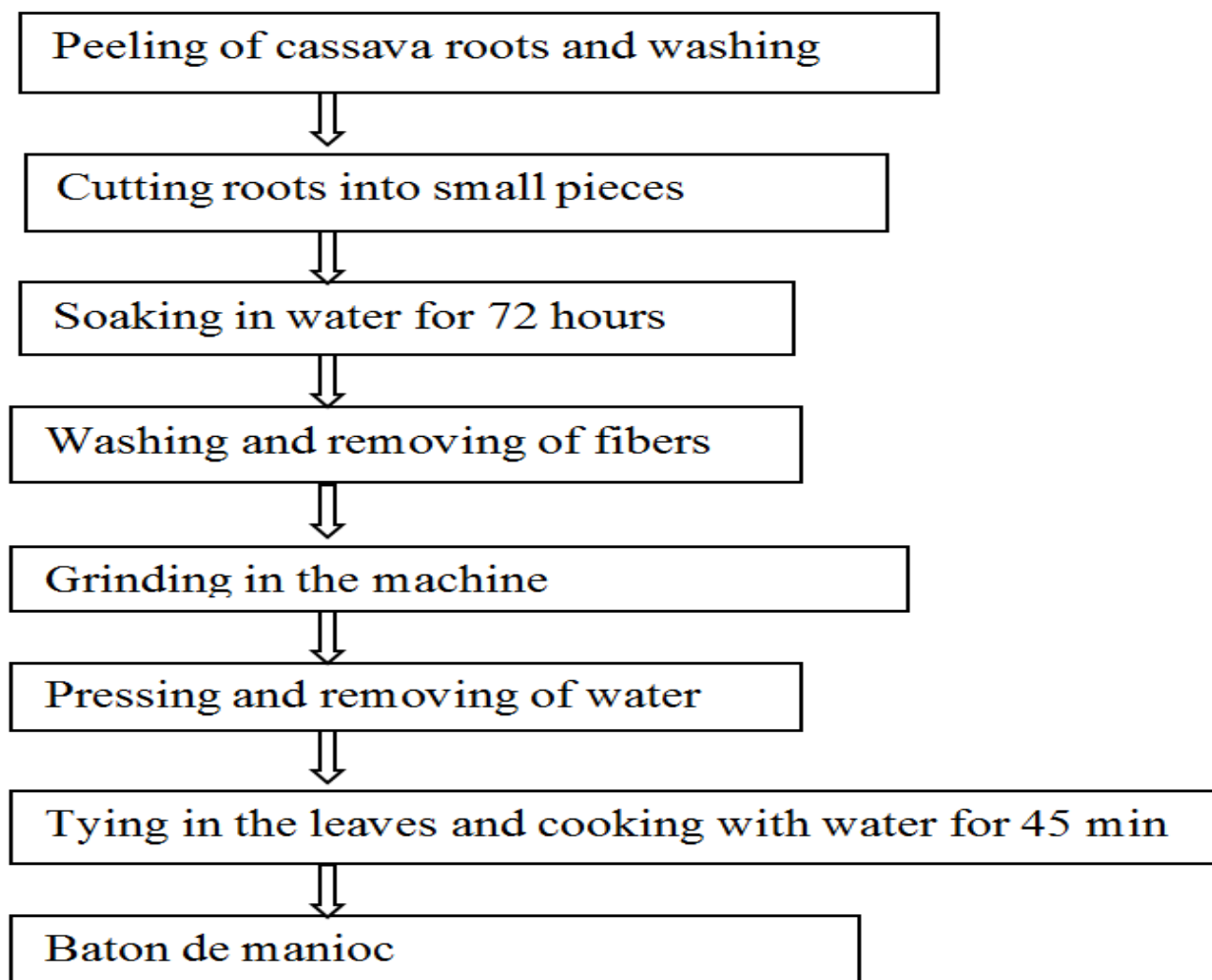


Figure-2. Steps of baton de manioc processing from cassava roots

3.6. Evaluation of Dry Matter and Nutrients Content

The dry matter and nutrient content was performed on fresh cassava roots of the two varieties, harvested at three different ages each. The nutrients evaluated were Ca, Mg, K, Na, total N, total P.

3.7. Sensory Evaluation

A descriptive test was done on gari and baton de manioc, in order to determine differences between the tested products to be evaluated. A panel of 12 qualified persons did the evaluation, at the food technology laboratory of IRAD Nkolbisson. Parameters taking into consideration for baton de manioc were flavor, texture (elasticity, sticky and fiber) and global quality; for gari, there were flavor, texture (granular, crispy, melty, buttery) and global quality. For both cassava based-products, parameters were scored using a scale of 0 (very disagreeable) to 5 (very pleasant). All data were collected with three replications.

3.8. Data Analysis

The statistical program used for the analysis was SAS. The effect harvesting date on nutrient content of cassava roots was evaluated using ANOVA test through the General Linear Model Procedure (GLM Proc). When the F -test was significant ($p < 0.05$), the Duncan test for paired comparisons was used to compare means.

4. RESULTS AND DISCUSSION

4.1. Variation of Cassava Yield with Harvesting Date

Generally, there was an increase in cassava yield with harvest time, irrespective of variety and zone. Cassava roots yield more when harvested late [10]. Show that the best yield of fresh roots was obtained at 18 months after planting, for the varieties evaluated. The variety 8034, an improved variety registered high yields than the local white cassava variety at both sites (Figure 3). Higher cassava yields was observed from 8034 as compare to local varieties by the authors [11].

Cassava yields were higher in the mono-modal humid forest ecological zone (zone 4) than the bimodal humid forest agro-ecological zone (zone 5). This is probably due to the very fertile andosol (volcanic soil) around the Mount Cameroon zone. Meanwhile the soils of the zone 5 are mostly acidic ferralsol. Similarly, the level of rainfall is higher (400-11000 mm per year) in the zone 4 than zone 5 (1600-2000 mm per year). Increase rainfall increases water availability for growth.

There was a high variability in yield of local white variety as observed with the standard error of the means (Figure 3). This could be due to the nonuniformity of planting material used by farmers during the production.

Generally, the average yield obtained from local white variety was low (10.31 t/ha) as compare to 12 to 56 t/ha obtained in farmers field by authors [12] or 34.5 t/ha obtained by Khang, et al. [13] on-station. This low yields may be due to poor agronomy practices done by farmers. Planting density was not respected by farmers: planting density was very high, with about 0.5 m between plants. High cassava root yield is obtained with lower densities of 0.8x0.8 m, 1.0x1.0 m, or 13594 plants per hectare [14]; [15]. Furthermore, farmers' cassava fields were not weeded, while the adverse effect of the weed on cassava yield has been discussed by many authors [12]; [16]; [17].

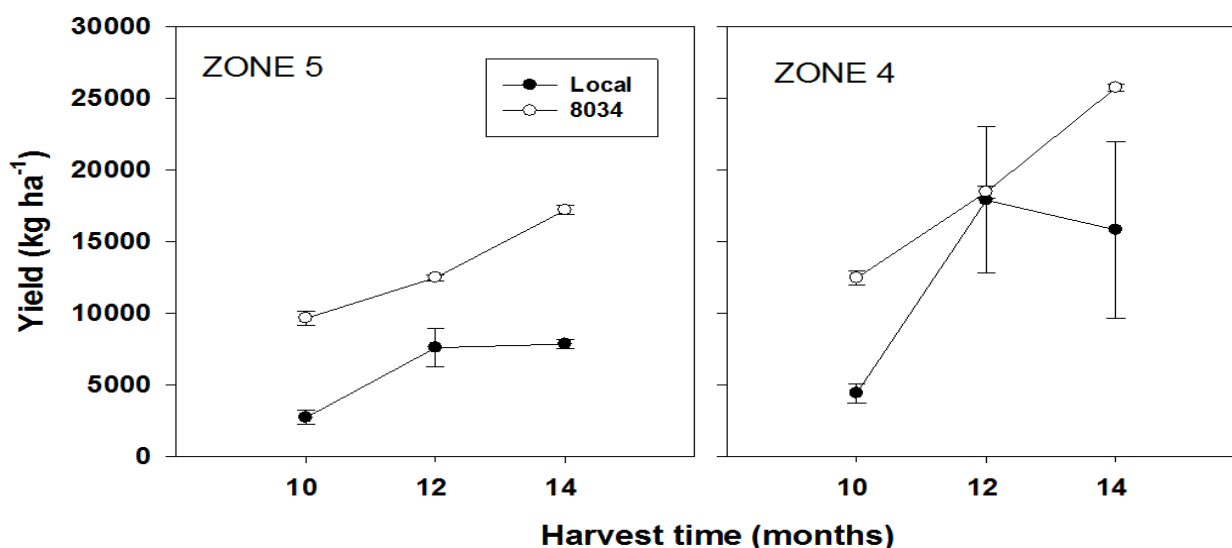


Figure-3. Effect of harvesting time on yield of cassava (local and improved variety 8034) in the bi-modal humid forest (zone 5) and mono-modal humid forest (zone 4) agro-ecological zones of Cameroon. Bars are standard error of means (n=5).

4.2. Variation of Nutrient Content in Cassava Roots With Respect to the Variety and the Harvesting Date

In general, the nutrient content of 8034 and the local white cassava varieties evaluated was in the same range as those described earlier by [18-20]. The nutrient content in cassava root varied with the variety and the age of roots (Table 1). A significantly difference was observed between the cassava variety 8034 and the local white

variety, with respect to the total N, K, Na, P and dry matter content. There was an increase from 0.79 %c to 0.97 %a for K, 0.07 %b to 0.13 %a for P and 28.10 %c to 38.43 %a for dry matter content; 0.46 %b to 0.54 %a for total N and 37.60 %b to 41.03 %a for dry matter content, respectively for the improved variety 8034 and the local white variety (Table 1). In the other hand, the percentage of Mg decreased ($p < 0.05$) with the age of cassava roots for the variety 8034. There was also a gradual decrease of the percentage Mg, K, Na with the age of roots and varied from 0.12 %a, to 0.05 %c, 0.66 %a to 0.38 %c, 6.16 %a to 5.77 %b respectively for Mg, K, Na and from 8 to 10 to above 14 months old in variety 8034 (Table 1).

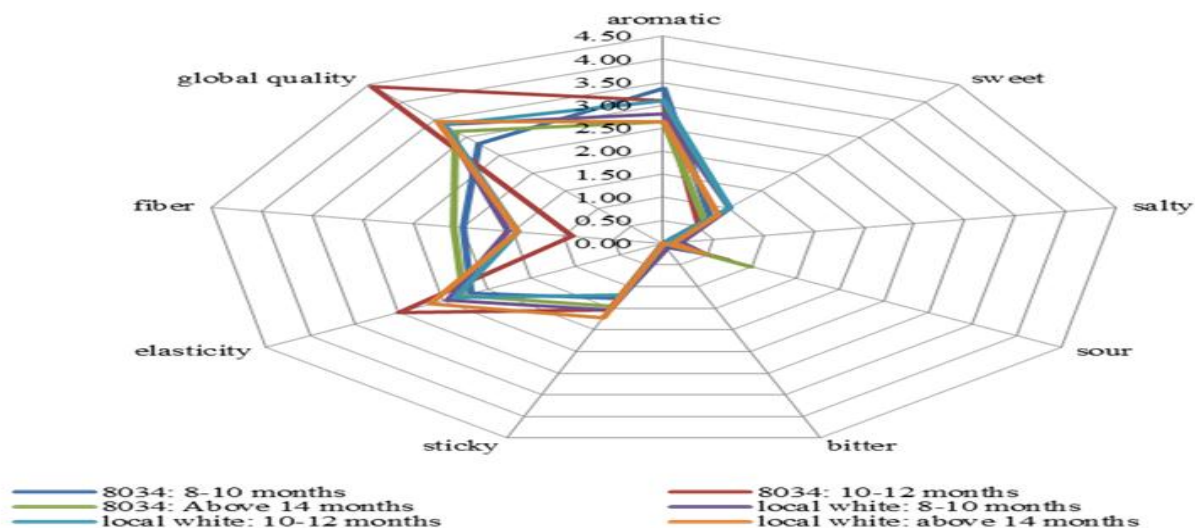
The dry matter content and the total N were higher in the local white variety as compare to the variety 8034, meanwhile the mean value of K, Na, and P content were higher in 8034 than those of the local white variety (data not shown on tables and figures).

Table-1. Variation of the nutrient content in the roots of two cassava varieties harvested at three ages

Cassava variety	Age of roots (months)	Total N (%)	Ca (%)	Mg (%)	K (%)	Na (%)	P (%)	DM (%)
8034	8-10	0.33±0.04 a	0.07±0.06 a	0.10±0.06 a	0.79±0.006 c	9.30±0.173 b	0.07±0.011 b	28.10±0.06 c
	10- 12	0.35±0.02 a	0.06±0.06 a	0.09±0.06 a	0.83±0.006 b	12.73±0.014 a	0.11±0.06 a	31.49±0.25 b
	Above 14	0.34±0.04 b	0.06±0.006 a	0.07±0.06 b	0.97±0.006 a	7.76±0.034 c	0.13±0.06 a	38.43±0.109 a
Local white variety	8-10	0.46±0.06 b	0.05±0.06 a	0.12±0.06 a	0.66±0.06 a	6.16±0.011 a	0.08±0.017 a	37.60±0.28 b
	10- 12	0.30±0.06 c	0.05±0.06 a	0.09±0.06 b	0.61±0.006 b	6.156±0.026 a	0.05±0.017 a	38.16±0.017 b
	Above 14	0.54±0.06 a	0.06±0.06 a	0.05±0.06 c	0.38±0.006 c	5.77±0.040 c	0.07±0.08 a	41.03±0.09 a

4.3. Sensory Evaluation

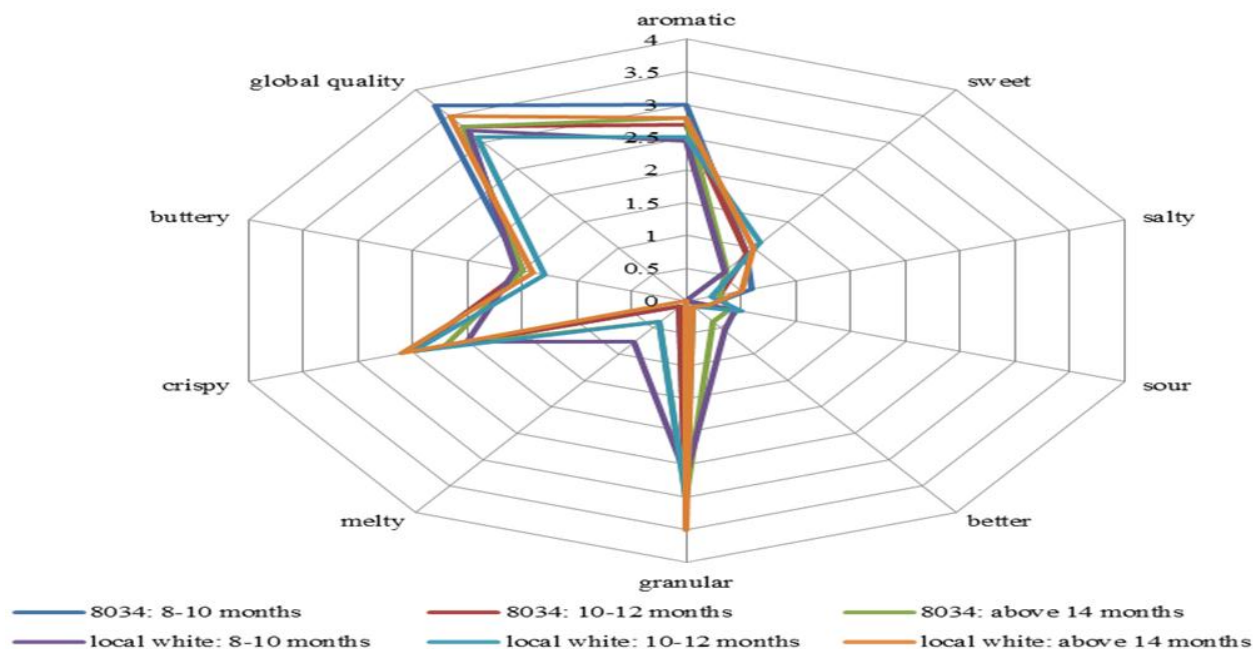
Results obtained on baton de manioc showed that, generally all the baton de manioc samples could be described as moderately aromatic, lowly sweet, sticky or fibrous, no salty or bitter, lowly to moderately elastic (Figure 4), with slight variations according to the cassava varieties and the harvesting date. Baton de manioc produced using cassava roots of the variety 8034 harvested at 10-12 months old was scored the highest global quality. This baton de manioc sample was particularly described as moderately aromatic or elastic, no sticky or fibrous. The use of cassava roots for the production of baton de manioc is one the criteria of cassava variety preference selected by farmers in Cameroon [21].



Six point scale for the evaluation of the intensities of taste, texture and aromas	Six point scale for the evaluation of the overall quality of baton de manioc
0 Absent	0 Very bad
1 Very low	1 Bad
2 Low	2 Not so good
3 Normal	3 Good
4 High	4 Very good
5 Very high	5 Excellent

Figure-4. Description of baton de manioc according cassava roots variety and age

Concerning gari, all the samples evaluated could be described as moderately to highly aromatic or granular, lowly sweet, sour or buttery and moderately crispy. The gari sample produced using the cassava variety 8034 harvested at 8-10 months old was scored the highest global quality (Figure 5). Reference Levai, et al. [22] showed that consumers prefer gari as snack which is not too sour to the taste. Like for baton de manioc, one of the criteria of cassava variety preference selected by farmers in Cameroon is the use its roots for the production of gari [21].



Six point scale for the evaluation of the intensities of taste, texture and aromas	Six point scale for the evaluation of the overall quality of gari
0 Absent	0 Very bad
1 Very low	1 Bad
2 Low	2 Not so good
3 Normal	3 Good
4 High	4 Very good
5 Very high	5 Excellent

Figure-5. Description of gari according cassava roots variety and age

5. CONCLUSION

This study aimed to investigate the effect of three harvest dates of two cassava varieties on yield and quality of cassava based-products in two agro-ecological zones in Cameroon.

Results showed an increase in cassava yield with harvest date, irrespective of variety and zone. Cassava yield varied according to agro-ecological zones. Yields were higher in the mono-modal humid forest agro-ecological zone (zone 4) than the bimodal humid forest agro-ecological zone (zone 5), probably due to the very fertile andosol (volcanic soil) around the Mount Cameroon zone. Meanwhile the soils of the zone 5 are mostly acidic ferral soils.

There was a variation of the nutrient content with the variety and the age of roots with respect to the total N, K, Na, P and dry matter content.

Finally, sensory test showed that baton de manioc and gari produced using roots of cassava variety 8034 harvested respectively at 10-12 months and 8-10 months old were scored the highest global quality. This cassava variety is therefore good for processing as previously described.

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Competing Interests: The authors declare that they have no competing interests.

Contributors/Acknowledgement: All authors contributed equally to the conception and design of the study.

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