



THE QUALITY OF FRIED CHIPS VARIES WITH CASSAVA (*MANIHOT ESCULENTA* CRANTZ) VARIETIES AND SOAKING REGIME

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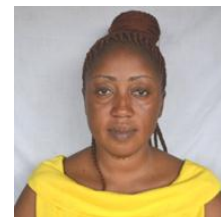
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ABSTRACT

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Fried cassava chips are largely accepted in Cameroon but their quality is not consistent. This study investigated the appropriate cassava varieties and soaking regime for processing good quality fried cassava chips. Fried chips were processed from four cassava varieties (0110, 8034, 92/0326, makumba) using four soaking regimes which were: unpeeled roots, soaked for 72 h, peeled roots, soaked for 24 h, peeled roots, soaked for 14 h and peeled sliced roots, soaked for 24 h. The proximate composition, physical characteristic and sensory test were done to evaluate the quality of fried chips obtained. Fried chips processed from variety 0110 presented the highest carbohydrate (77.94 ± 0.34 %) and the lowest moisture (1.75 ± 0.22 %) and fat content (15.11 ± 0.30 %). The variety 8034 showed higher level of Ca, K, and Fe than other varieties. Variety 0110 was more salty, crispy and crumbly with higher global quality. Fried cassava chips processed from peeled soaked roots for 24 h scored the highest global quality as compared to other soaking regimes. Therefore, cassava varieties and soaking regimes influence the quality of fried chips. Socio-economic studies are warranted before large-scale dissemination of results to users.

Contribution/Originality: This study is one of very few studies which have investigated the variation of the quality of fried chips with respect to different cassava varieties.

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) roots is one of the staple foods classified among the five main crops of Cameroon (Mvodo and Dapeng, 2012). The national production is estimated at 4 287 177 tons in 2013 (FAO (Food and Agriculture Organization), 2015). In Cameroon, each household consumes about 75 kg per year of products derived from cassava roots (IRAD (Institut de la Recherche Agronomique pour le Développement), 2013). Cassava being an important source of carbohydrate with a low proportion of lipid and protein (Chijindu and Boateng, 2008) it is equally a major source of food energy (Chiwona-Karlun *et al.*, 2015). Cassava remains a subsistence crop partly because of its rapid deterioration after harvest (Njukwe *et al.*, 2014). The roots deteriorate quickly because of the internal heat generated from high respiration rate of the tissues (Ikujenlola and Opawale, 2007) and subsequent

infection and rotting by microbes. Due to its short shelf-life after harvest, cassava roots must be processed 24 hours after harvest in order to reduce post-harvest losses (Abong *et al.*, 2016).

According to Diallo *et al.* (2013) cassava varieties are either classified as sweet or bitter. Bitter varieties have high concentration of cyanogenic glycoside which can only be eaten after soaking or when processed into local products like Gari, Fufu, Baton de manioc. Meanwhile, sweet varieties have a high concentration of free sugars but low concentration of cyanogenic glycoside (King and Bradbury, 1995). Sweet varieties can therefore be eaten raw or processed into several products such as Gari, Donut and fried chips.

Frying being one of the oldest methods known to human kind for preparing food (Ata-Ur-Rehman *et al.*, 2006) the technology is widely applicable in local marketing with the production of plantain, potato and cassava chips. Chips are handy and light, usually seasoned with salt including other flavorings and can be eaten between regular meals (Lusas, 2001). These products are obtained by cutting the raw material into slices or parallelepipeds of few millimeters thick, then frying them in vegetable or palm oil for a few minutes at high temperature. Fried foods have desirable flavor, color, and crispy texture, which makes deep-fat fried foods very attractive to consumers (Boskou *et al.*, 2006).

Several improved cassava varieties have been developed and introduced by the Institute of Agricultural Research for Development (IRAD) and the International Institute for Tropical Agriculture (IITA). These varieties possess characteristics such as short cycled, disease tolerance and resistance, high-yielding and multipurpose. Some of these varieties such as 8034, 8017, 8061, 92/0326 and 96/1414 are suitable for processing into locally consumed products (bobolo, gari, fufu) including fried chips and starch which is useful in the brewery and pharmaceutical industries.

Considering that fried chips is one of the innovative products developed by research in Cameroon, fried cassava chips is greatly appreciated by consumers and is increasingly gaining space in their eating habits. However, local processors do not always master or practice the best processing methods. In addition, it is likely that cassava varieties may differ in the quality of processed chips. The purpose of the present study was to determine the likely suitable cassava variety and establish the most appropriate soaking regime for processing cassava chips.

2. MATERIAL AND METHODS

2.1. Plant Material

Three improved white fleshed cassava varieties namely 0110, 8034, 92/0326 and a local red variety called makumba were used. All the four varieties had sweet cassava roots and were harvested at about 15 months after planting. The frying ingredients were vegetable oil and salt.

2.2. Methods

2.2.1. Production of Cassava Chips

The processing of cassava roots into fried chips was done at the food technology laboratory of the Institute of Agricultural Research for Development (IRAD) Nkolbisson. Four different soaking regimes were evaluated. Fried cassava chips were processed from each variety and each soaking regime separately. The different soaking regimes used described included;

Unpeeled Soaked Roots for 72 H (SUP-72H)

Unpeeled cassava roots(300 g) of each variety were washed with clean water and soaked in a basin for 3 days. After the soaking period, the roots were peeled and cut into thin slices of 2 mm. The sliced roots (chips) were thereafter soaked in a salty solution (20 g of salt /l of water) for 5 minutes.

Peeled Soaked Roots for 24 H (SPR -24H)

Cassava roots(300 g) of each variety were washed with clean water and peeled before soaking for 24 H. After the soaking period, the roots were peeled and cut into thin slices of 2 mm. Then, the sliced roots (chips) were soaked in a salty solution (20 g of salt /l of water) for 5 minutes.

Peeled Soaked Roots for 14H (SPR -14H)

Cassava roots(300 g) of each variety were washed and peeled before soaking in water for 14 H. After the soaking period, the roots were cut into thin 2mm slices. The slices (chips) were later soaked into a salt solution (20 g of salt /l of water) for 5 minutes.

Peeled Sliced Roots Soaked for 24 H (SPRS -24H)

Cassava roots (300 g) of each variety were washed, peeled and cut into thin slices of 2 mm before soaking in a basin of water for 24 H. The sliced roots (chips) were soaked in a salt solution (20 g of salt /l of water) for 5 minutes.

2.2.2. Frying of Soaked Cassava Chips

Cassava chips were fried at 170 °C in a fryer for 6 minutes. Fried cassava chips were left to cool down and packaging was done thereafter.

2.2.3. Sensory Analysis

A sensory test was conducted in the Food Technology laboratory of IRAD. Sensory quality characteristics evaluated were; aroma intensity, basic taste (sweet, salty, bitter), texture (crispy, buttery, crumbly,) and overall quality. A trained panel of 12testers (4 men and 8 women) used a six-point rating scale ('0= absent' to '5 = very high') to evaluate the intensity of basic taste, aroma and texture). A six-point scale was also used to evaluate the overall quality of the cassava chips with '0 = very bad' to '5 = excellent'.

2.2.4. Physical Analysis

The hardness and crispness of cassava fried chips were determined by texture analyzer (brook field lfra). The parameters (CIE L*, a*, and b* color space) of surface color were measured by color Reader analyzer (Color reader CR-10,MADE IN JAPAN). The average value of the three measurements was recorded. Color readings were displayed as L* a* b* values where L* represents the lightness/darkness dimension. The positive and negative a* values indicate redness and greenness, respectively, and b*indicates yellowness for a positive value and blueness for a negative value. White calibration plate was used to standardize the equipment prior to color measurements.

2.2.5. Chemical Analysis of Fried Cassava Chips

Moisture content was determined by the gravimetric method (Künsch *et al.*, 1999). While lipid extraction was performed using Avanti Soxtec with petroleum ether as the solvent (Anon, 1990). Total nitrogen was determined by the Kjeldahl method using 6.25 as the total protein nitrogen conversion factor. Carbohydrate content was determined by calculation using the difference method and dietary fiber was determined by A.O.A.C (1970). Mineral content (P, K, Ca, Zn, Mg, Na, Cu, Fe, Mn, Zn, Al) was determined by atomic absorption spectrophotometer (Varian Vista, Victoria, Autralie).

2.2.6. Statistical Analysis

Data was subjected to Statistical Analysis of Variance (ANOVA) at 5 % level. The means were separated using Duncan Multiple Range Test procedure. The analysis was done using SAS software version 9.1. (2005).

3. RESULTS AND DISCUSSION

3.1. Sensory Evaluation of Fried Cassava Chips

The acceptability of fried cassava chips differed significantly with varieties and soaking regimes. The cassava variety 0110 presented the highest global quality when soaked using all the four soaking regimes (Data partially presented on Fig.1 and Fig. 2). The components score of sensory attributes like salty, crispy, crumbly were higher for 0110 variety than others. These results indicate that the variety 0110 was the most appropriate compared to 8034, 92/0326, Makumba varieties to produce chips (Fig. 1 and Fig. 2).

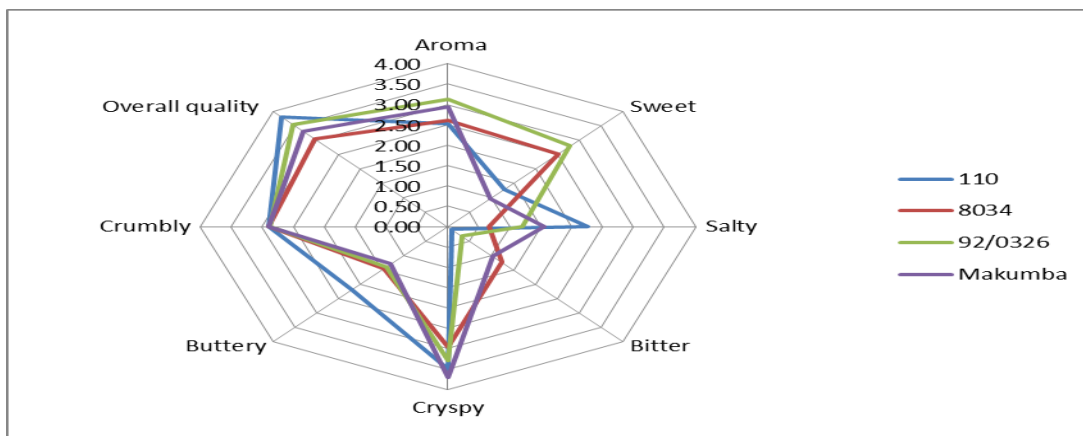


Figure-1. Acceptability of fried cassava chips according to the different varieties and soaking regime SUP-72H

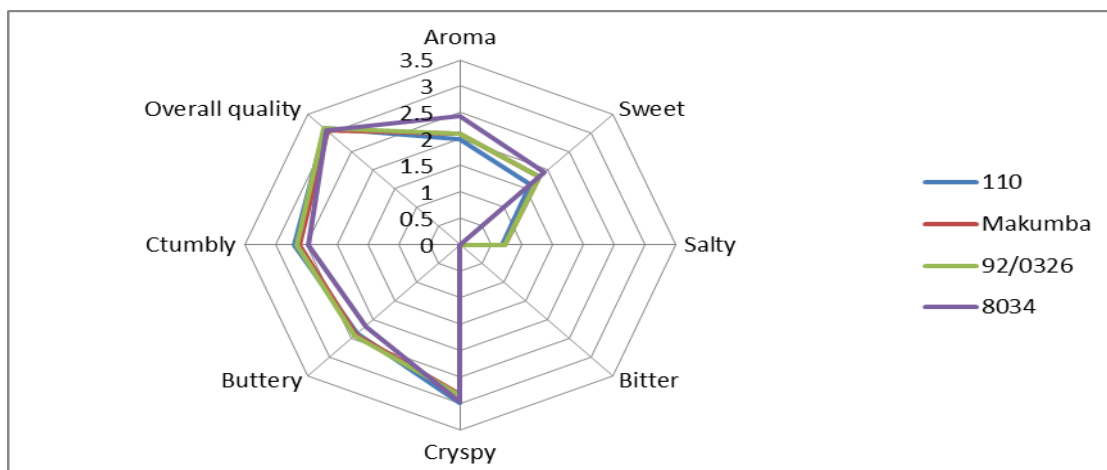


Figure-2. Acceptability of fried cassava chips according to the different varieties and soaking regime SPR-24H

A comparison between the four soaking regimes showed that fried chips obtained from peeled soaked roots for 24H (SPR-24H) had the highest overall quality, irrespective of the varieties. The figures 3 and 4 illustrate the acceptability of fried cassava chips with respect to the four soaking regimes and for the varieties 0110 and 92/0326 respectively. For the other two cassava varieties, the same trend was observed (data not shown).

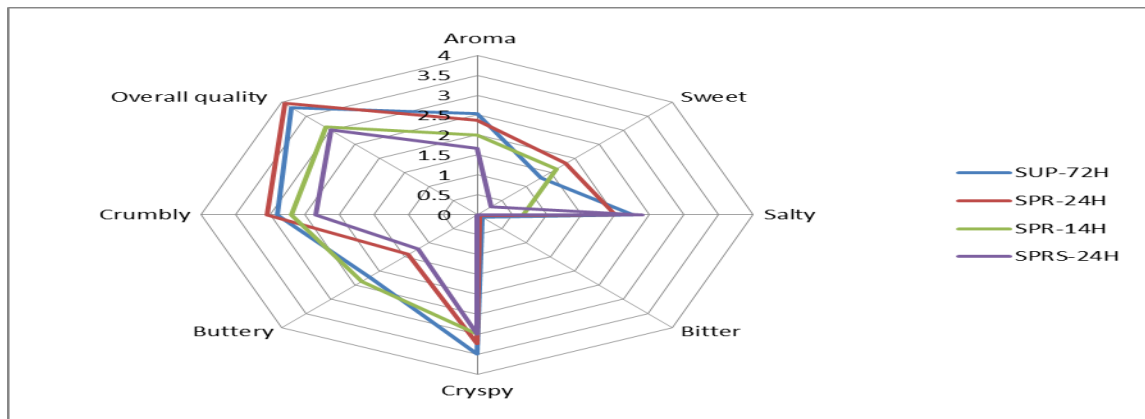


Figure-3. Acceptability of fried cassava chips according to the different soaking regime for 0110 variety

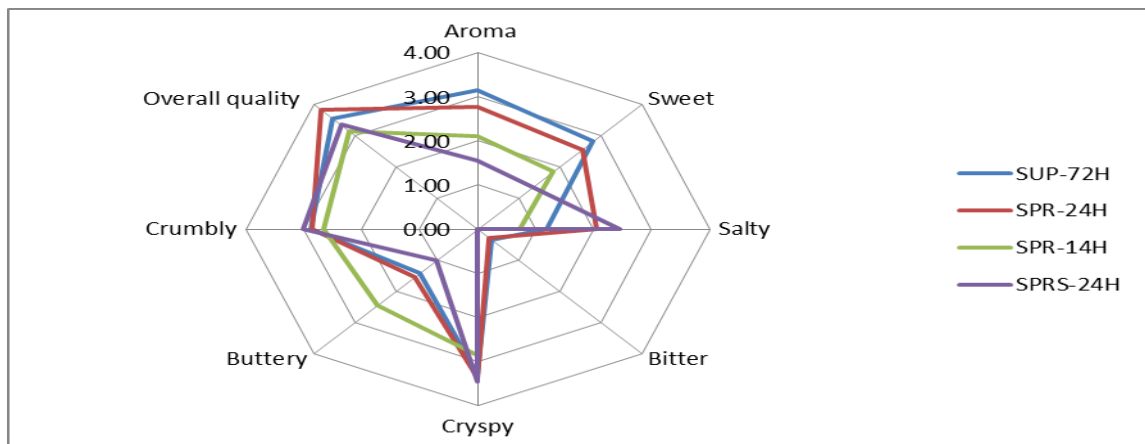


Figure-4. Acceptability of fried cassava chips according to the different soaking regimes for 92/0326 variety SUP-72H =Soak unpeeled roots for 72H; SPR -24H =Soak peeled roots for 24H; SPR -14H =Soak peeled roots for 14H; SPRS -24H=Soak peeled roots and sliced for 24H

3.2. Physical Properties of fried Cassava Chips

Color is considered to be the most representative indicator of quality in fried chips (García-Segovia *et al.*, 2016). The color attribute (L^* a^* b^*) and texture parameters of fried cassava chips are presented in Table 1. Fried chips from the cassava varieties were different ($p < 0.05$) with respect to L^* and b^* for the color. Chips from cassava variety 0110 had a deeper golden color as compared to those of the other varieties. The color of fried chips may be affected by the chemical composition of the raw cassava roots, which determines processing capability (Lisinska and Leszczynski, 1989). Fried cassava chips as a result found in the markets are usually of deep golden color. Consequently, this characteristic appears to be a significant attribute of fried products and is decisive in determining consumer acceptance (Krokida *et al.*, 2001).

The hardness and crispiness of fried cassava chips differed with varieties. The highest breaking force was observed with 92/0326 variety. The high breaking could result from the rapid moisture loss on the surface of its fried chips as compare to that of the other varieties (Oyedeji *et al.*, 2017). Crispiness is a unique characteristic and an important parameter to be controlled in deep-fat fried products (Predreschi and Moyano, 2005; Thanatuksorn *et al.*, 2007). Local cassava variety Makumba fried chips presented the highest crispiness. This could be attributed to the relatively low moisture content of the cassava roots of this variety. However, the quantity of water content in the raw material influences the crispiness of the chips (Lisinska and Leszczynski, 1989).

Table-1. Color attribute (L* a* b*) and texture measurement of fry chips to the different cassava varieties

Fried chips (Cassava varieties)	Color			Hardness(N)	texture crispness(N)
	L*	a*	b*		
8034	58.5±0.52 ^b	6.93±1.87 ^a	23.33±0.4 ^c	198.52±103.85 ^a	37.0 ^a
110	54.33±0.81 ^d	6.23±0.85 ^a	22.86±0.70 ^c	238.78±86.62 ^a	36.5 ^a
92/0326	74.66±0.76 ^a	6.23±0.83 ^a	24.46±0.60 ^b	268.60±103.39 ^b	18.79 ^b
Makumba	56.8±0.78 ^c	8.3±0.53 ^a	28.58±0.47 ^a	228.68±80.07 ^a	41.70 ^c

Means with similar letters in a column are not significantly (P<0.05) different

The color (L* a* b*) and texture attributes of fried chips from the cassava variety 0110 obtained from the four soaking regimes (Table 2), were different (p<0.05) with respect to their color and texture.

Likewise for the global quality, chips of variety 0110 produced after peeling and soaking the roots for 24 h had a deeper golden color of which is much more appreciated by consumers. Results obtained from this study shows clearly that the more the soaking duration of cassava roots, the more the deeper golden colored are the fried chips obtained. During soaking, there is a tendency for an increase in food nutrients like proteins and carbohydrate (El-Adawy *et al.*, 2000). Furthermore, the maillard reaction takes in to consideration the level of proteins and carbohydrates leading to a deeper golden color after frying. In the course of this study, fried cassava chips from SPR-24H had a deeper golden color compared to chips from SPS-14H, indicating that the soaking duration of cassava roots influences the color of fried cassava chips.

In addition, the peeled soaked roots for 24 h produced the most crispy fried chips. These results may be attributed to the duration of fermentation of the cassava roots.

Table-2. Color and texture of fried cassava chips of variety 0110 from four soaking regimes

Pre-treatment	Color			Hardness	Texture Crispy
	L*	a*	b*		
SUP-72H	60.36±0.50 ^b	6±0.34 ^a	24.23±0.55 ^a	138.86±119.876 ^a	15.29 ^a
SPR-24H	55.3±0.86 ^c	3±0.79 ^b	19.86±0.64 ^b	176.719±72.395 ^a	25.54 ^b
SPR-14H	66.6±0.85 ^a	3.7±0.60 ^b	19.1±0.91 ^b	176.167±109.794 ^a	14.66 ^c
SPRS-24H	55.13±0.55 ^c	2.13±0.05 ^c	7.6±0.55 ^c	179.61±60.29 ^a	14.66 ^b

SUP-72H =Soak unpeeled roots for 72H; SPR -24H =Soak peeled roots for 24H; SPR -14H =Soak peeled roots for 14H; SPRS -24H=Soak peeled roots and sliced for 24H.

Means with similar letters in a column are not significantly (P<0.05) different

3.3. Physico-Chemical Composition of Fried Cassava Chips

The physicochemical characteristics of fried cassava chips obtained from the different varieties using peeled soaked roots for 24 h are presented in Table 3. A significant difference (p< 0.05) was observed between the four cassava varieties in all the physic-chemical attributes, except for protein. The moisture content of fried cassava roots varied from 1.75±0.22 (variety 0110) to 3.54±0.6% (variety 92/0326). The fried chips obtained from the variety 0110 presented the lowest moisture content as compare to that of the variety 92/0326. This low moisture content of fried cassava chips is advantageous given that it will permit better storage conditions. Though water content (moisture) tends to evaporate as soon as the raw material gets in contact with the hot frying oil (Yodkraisri and Bhat, 2012).

The carbohydrate content of the fried cassava chips from the four varieties were significantly different (p<0.05) with the least for variety 92/0326 (58.60±1.45) and highest for variety 0110 (77.94±0.34%). The high carbohydrate content of fried cassava chips reflected that of raw cassava roots, for which carbohydrate is the main component. Cassava root contain about 80 % of starch (Purseglove, 1991). The lipid content ranged from 15.11±0.30 % (0110 variety) to 32.43±0.32 % (variety 92/0326). The fat content of cassava root generally range from 0.1 % to 0.3 % (Montagnac *et al.*, 2009). The high value in fat in the fried chips may be due to the addition of vegetal oil during the

frying process. It is important to note that oil content in a product can depend on the frying temperature, frying time, as well as its moisture content (Moreira *et al.*, 1997; Sharma *et al.*, 2000; Yagua and Moreira, 2011).

Protein content did not show any significant difference ($p > 0.05$) for the different fried cassava chips. The protein content of chips ranged from 1.09 ± 0.61 to 1.62 ± 0.33 % for varieties 0110 and 92/0326 respectively. This low protein content observed in the four cassava varieties corroborated with the results obtained by (Nassar and Costa, 1978; Nassar and Dorea, 1982; Yeoh and Truong, 1996; Charles *et al.*, 2005; Ceballos *et al.*, 2006; Sankaran *et al.*, 2008; Li *et al.*, 2012). The total fiber contents of fried cassava chips ranged from 2.2 ± 0.11 (variety 0110) to 3.37 ± 0.26 % (variety 8034). Fried chips from the variety 8034 had the highest fiber content owing to its high root fiber content.

Table-3. Proximate composition of fried cassava chips to the different varieties and soak peeled roots for 24H (SPR -24H)

Fried chips (Cassava varieties)	Moisture (%)	Carbohydrate (%)	Fat (%)	Protein (%)	Total fibre (%)
8034	2.9 ± 0.33^b	72.1 ± 0.74^b	19.52 ± 0.14^a	1.13 ± 0.37^a	3.37 ± 0.26^a
110	1.75 ± 0.22^c	77.94 ± 0.34^a	15.11 ± 0.35^b	1.09 ± 0.61^a	2.2 ± 0.11^c
92/0326	3.54 ± 0.6^a	58.60 ± 1.45^c	32.43 ± 0.32^c	1.62 ± 0.33^a	2.53 ± 0.7^b
Makumba	2.43 ± 0.55^b	71.41 ± 0.95^b	20.79 ± 0.38^d	1.13 ± 0.37^a	3.00 ± 0.06^b

Means with similar letters in a column are not significantly ($P < 0.05$) different

3.3. Mineral Composition of Fried Cassava Chips

The mineral composition of fried chips presented in Table 4 showed some significant differences ($p < 0.05$) in mineral content for the four cassava varieties peeled and soaked for 24 h (SPR -24H). Generally, the mineral content was higher in fried chips of the cassava variety 8034. This was the case for Ca, K, Cu and Fe. In contrast to the fried chips from local cassava variety "makumba" which presented the lowest mineral content, although the level of k and Cu were higher compared to that of the other varieties. The cassava variety 8034 is an improved variety currently on promotion by IRAD and other projects in Cameroon. This variety was selected because of its high yield, diseases tolerance, appreciable mineral composition and adaptability to multiple uses.

Table-4. Mineral content of fried chips from four cassava varieties

Fried chips (Cassava varieties)	Mineral elements						
	Ca (%)	Mg (%)	k (%)	Zn(ug/g)	Cu (ug/g)	Mn (ug/g)	Fe (ug/g)
8034	0.09 ± 0.01^a	0.05 ± 0.00^b	0.78 ± 0.01^a	18.3 ± 0.18^a	6.96 ± 0.19^a	24.25 ± 0.35^b	6.54 ± 0.05^b
110	0.05 ± 0.04^b	0.03 ± 0.00^c	0.29 ± 0.08^d	13.32 ± 0.96^b	2.99 ± 0.26^c	38.79 ± 0.4^a	6.53 ± 0.32^b
92/0326	0.02 ± 0.01^b	0.06 ± 0.02^a	0.41 ± 0.01^c	9.65 ± 0.21^c	2.9 ± 0.14^c	22.68 ± 0.04^c	6.57 ± 0.04^b
Makumba	0.02 ± 0.00^b	0.03 ± 0.01^c	0.6 ± 0.14^b	14.61 ± 0.15^b	4.00 ± 0.00^b	10.92 ± 0.11^d	10.92 ± 0.59^a

Means with similar letters in a column are not significantly ($p < 0.05$) different

4. CONCLUSION

In this study, different cassava varieties and soaking regimes were investigated for the production of fried cassava chips. The quality and the acceptability of fried cassava chips differed with the cassava variety, as well as pre treatment of roots (peeled or unpeeled) and the soaking duration. Fried chips processed from the cassava variety 0110 were the best in terms of the overall quality, the color, the moisture status, the carbohydrate and fat contents. The most appreciable cassava chips were obtained after soaking peeled cassava roots for 24 h duration.

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

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