

# Sensory Profile, Nutritional and Shelf-Life Analysis of Cassava Par-Fried Frozen Slices Developed with Raw Cassava Roots

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## Abstract

Cassava (*Manihot esculanta* Crantz) is nutritionally strategic famine reserve crop in areas of unreliable rainfall, poor soil or unfavourable climate. Presence of toxic compounds and high perishability has limited the consumption of cassava roots. An experiment was carried out to develop par-fried frozen slices of cassava in order to increase the consumption of cassava roots. Mature undamaged fresh cassava roots of cultivar 'MU 51' were cleaned, peeled and cut in to longitudinal cubes (0.8×0.8×10 cm). The cubes were blanched, partial fried and stored, deep freeze and stored in freezer after packing in 300 gauge LDPE pouches. The experiment revealed that extended hot water blanching for 10 minutes and initial freezing for 12 hours, increase the sensory qualities of frozen fries significantly. Moisture content, carbohydrate content, mineral content, fat content, protein content and crude fibre contents of the sample were 56.71±0.80%, 32.18±0.19%, 0.42±0.02%, 9.13±0.05%, 1.18±0.06% and 0.20±0.03% respectively. Cyanide content of the cassava frozen fries sample was 1.42±0.12 ppm. According to the microbiological and chemical testing results, cassava frozen fries were safe for consumption up to 3 months at freezer storage.

*Keywords: Cassava, freezing, sensory attributes, frozen fries, shelf life analysis*

## 1. Introduction

Cassava (*Manihot esculanta* Crantz) is long tuberous root crop which tolerates drought and low fertility and is sometime a nutritionally strategic famine reserve crop in areas of unreliable rainfall, poor soil or unfavourable climate (Sarkiyayi and Agar, 2010, Somendrika et al., 2016, Somendrika et al., 2017). Presence of toxic compounds and high perishability has limited the consumption of cassava roots. The toxicity of is caused by the presence of the cyanogenic glycoside linamarin, together with much smaller amounts of the closely related lotaustralin (Gleadow and Woodrow, 2002) and the spoiling after 2-3 days after harvest occur, due to post-harvest physiological deterioration (Han et al., 2001).

Importance of cassava in the socio-economic development of rural areas has gained recognition during the last few years (Wijesinghe and Sarananda, 2008). Cassava is mostly grown by poor farmers and increasing the utilisation of cassava products will result rural industrial development and strengthen the income for producers, processors and traders.

There are numerous ways of processing and consuming cassava depending on the locality. Two broad categories of consumption are boiled roots, and processing into dry granules and flour which may or may not be fermented (Onabolu, 1998).

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Freezing is a quick, convenient, and popular way to preserve foods. Freezing retards the growth of bacteria, molds, and yeasts by reducing the available water for the microorganisms. It has been a major factor in bringing convenience foods to the housewife, restaurant and institutional feeding establishments (Wijesinghe and Sarananda, 2008).

French fries are par-fired potatoes preserved in frozen storage with an upsurge in the global consumption in recent years. French fry processing is comprised of a number of unit operations namely blanching, drying, par-frying and freezing (Agblor and Scanlon, 2000).

This study was carried out to develop cassava based par-fried frozen product with better sensory and nutritional profiles, and to study the stability with the storage period of the developed product.

## 2. Materials and Methods

### 2.1 Sample preparation

Cassava variety ‘MU 51’ was selected for the experiment. Mature undamaged fresh cassava roots of cultivar ‘MU 51’ were procured from designated supplier of cassava from Colombo, Sri Lanka. Then the roots were washed with water to remove soil. The cleaned roots were peeled using sharp stainless steel knife and washed with clean water. The peeled roots were cut in to longitudinal cubes (0.8×0.8×10 cm). The cubes were dipped in clean water for 1 hour. After that the cubes were blanched using hot water blanching for 10 minutes and dried for 1 hour in a dehydrator (60° C).

Next the partially dried cubes were deep fried for 1 minute in an oil bath maintained at 165±5° C temperature. Excess oil in the cubes was removed by blotting with paper towels and freezing of the samples were done in a domestic ordinary freezer (-18° C) for 12 hours. Finally the cubes were packed in 300 gauge (76.2 micron) low-density polyethylene pouches.

### 2.2 Effect of blanching time and duration of deep freezing on sensory qualities of cassava frozen fries

An experiment was designed using two factor factorial method to determine the effect of blanching time (5 minutes and 10 minutes) and duration of deep freezing (6 hours and 12 hours) on sensory qualities of cassava frozen fries. Four samples were prepared as follows.

- a. Treatment 01 a<sub>0</sub>b<sub>0</sub>-Hot water blanching for 5 minutes and Freezing for 6 hours (B5F6)
- b. Treatment 02 a<sub>0</sub>b<sub>1</sub>-Hot water blanching for 5 minutes and Freezing for 12 hours (B5F12)
- c. Treatment 03 a<sub>1</sub>b<sub>0</sub>-Hot water blanching for 10 minutes and Freezing for 6 hours (B10F6)
- d. Treatment 04 a<sub>1</sub>b<sub>1</sub>-Hot water blanching for 10 minutes and Freezing for 12 hours (B10F12)

Table 1: Experimental design for cassava frozen fries production.

		Blanching	
		a <sub>0</sub>	a <sub>1</sub>
Freezing	b <sub>0</sub>	a <sub>0</sub> b <sub>0</sub> (Sample 567)	a <sub>1</sub> b <sub>0</sub> (Sample 791)
	b <sub>1</sub>	a <sub>0</sub> b <sub>1</sub> (Sample 286)	a <sub>1</sub> b <sub>1</sub> (Sample 354)

### 2.3 Sensory Evaluation

A descriptive sensory evaluation of cassava frozen fries on colour, surface appearance, taste, crispiness, smell, after taste and overall acceptability were carried out using 5 point hedonic scale (as 5 for ‘like extremely’ down to 1 for ‘dislike extremely’) with the participation of 30 sensory panellists.

#### 2.4 Proximate composition analysis

Proximate analysis was conducted for moisture, ash, crude fibre, protein, total fat, and carbohydrate according to methods described in AOAC (1990) for the sample with best sensory attributes (sample-B10F12) with three replicates in each.

#### 2.5 Analysing HCN content

HCN content of samples was analysed using Spectrophotometric Determination of Cyanide (Picric acid) method described by (Wood, 1965).

#### 2.6 Evaluating the quality characteristics with the storage

Cassava frozen fries samples were prepared and stored for 3 months in frozen conditions (-18° C) to evaluate the quality characteristics. Moisture content, microbiological analysis and peroxide content were recorded as the quality characteristics for frozen fries samples. All the testing was carried out with three replicates.

##### a. Analysing Moisture content

Moisture content was analysed using oven dried method described by AOAC (1980) (AOAC, 1980). This method involves the measurement of weight loss due to the evaporation of water in an oven maintained at 105° C.

##### b. Microbiological analysis

Total plate count of the cassava frozen fries sample was performed using Colony count at 30° C. Coliform detection and enumeration of frozen fries sample was carried by the Most Probable Number (MPN) method (SLS 516: Part 3 Section 1:2013). Enumeration of yeast and moulds were performed using colony count techniques (SLS 516: Part 2 section 1: 2013).

##### c. Analysing the Peroxide value

Peroxide value was determined according to Iodometric (visual) end point determination method of SLS 313-3: section 7:2009.

#### 2.7 Statistical analysis

Completely randomised design with 3 replicates was used for the experiment. Parametric data were statistically analysed using ANOVA and mean separation was done using DMRT 5%. Non-parametric data were analysed using Kruskal Wallis test in Minitab statistical package.

### 3. Results and Discussion

#### 3.1 Sensory Evaluation

##### a. Effect of blanching and freezing on sensory qualities of cassava frozen fries

Results of the sensory analysis are given in the Table 2. Sample treated with 10 minutes hot water blanching and 6 hours freezing had the best colour and surface appearance even though a significant difference does not exist in between samples treated with 5 minutes hot water blanching and 12 hours freezing and sample treated with 10 minutes hot water blanching and 12 hours freezing (Figure 1). Both samples treat with 10 minutes hot water blanching had higher acceptance on colour and surface appearance over the samples threat with 5 minutes hot water blanching. Those observations tallied with the observations of Aguilar and others (1997) which stated that blanching improves the quality of a similar product (potato french fries) (Aguilar et al., 1997). Various reactions such as pigments destruction, enzymatic browning and non-enzymatic browning (Millard reaction) can occur during processing and therefore, affect its colour and visual appearance (Cornwell and Wrolstad, 1981). Blanching causes the leaching out of soluble solids (including reducing sugars that can lead to

nonenzymatic browning during frying) and reducing the enzymic activity that may otherwise cause undesirable odor, flavor, color, or texture (O'Connor et al., 2001).

Blanching causes the starch retrogradation and leaching of amylose (Aguilar et al., 1997). However retention of colour can be used as a quality indicator to evaluate sensory properties of the product.

The sample treated with 5 minutes hot water blanching and 12 hours freezing had the highest mean ranking for the crispiness compared with other three samples. Blanching improves the firmness, increase the porosity and some TPA parameters (chewiness, cohesiveness) where it decreases the limpness and oil content (Aguilar et al., 1997). Thus samples treated with 10 minutes blanching had low crispiness.

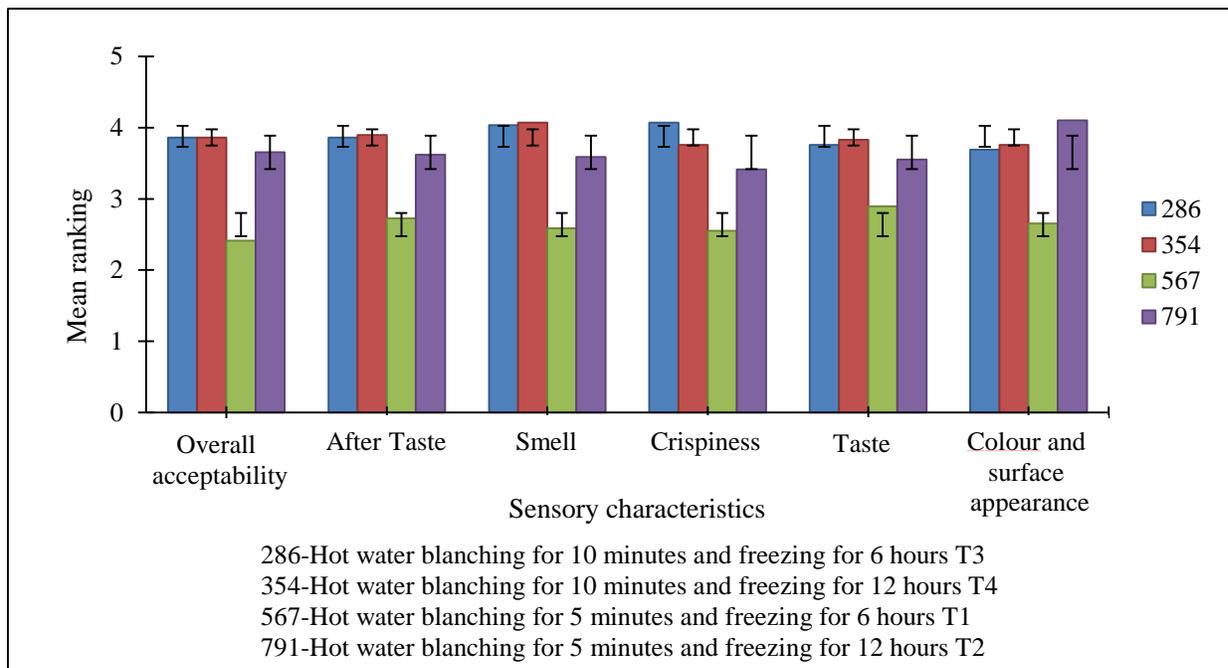


Figure 1. Mean ranking of samples vs sensory characteristics.

There were no significant difference exist in between the smell and the after taste of sample B5F12, B10F12 and B10F6. Sample B5F12 (5 minutes hot water blanching and 12 hours freezing) had the highest median value for smell where sample B10F12 (10 minutes hot water blanching and 12 hours freezing) had the highest median value for after taste.

Table 2: Estimated mean ranking values for sensory characteristics of cassava frozen fries.

Sensory attribute	Sample			
	286	354	567	791
Colour and surface appearance	3.733±0.828 <sup>a</sup>	3.800±0.925 <sup>a</sup>	2.667±0.661 <sup>b</sup>	4.133±0.937 <sup>a</sup>
Taste	3.733±0.785 <sup>a</sup>	3.833±0.913 <sup>a</sup>	2.900±0.662 <sup>b</sup>	3.533±1.252 <sup>a</sup>
Crispiness	4.067±0.785 <sup>a</sup>	3.767±0.817 <sup>a</sup>	2.533±0.819 <sup>b</sup>	3.367±1.299 <sup>a</sup>
Smell	4.067±0.740 <sup>a</sup>	4.100±0.712 <sup>a</sup>	2.567±0.817 <sup>b</sup>	3.567±0.935 <sup>a</sup>
After taste	3.867±0.681 <sup>a</sup>	3.900±0.923 <sup>a</sup>	2.733±0.785 <sup>b</sup>	3.600±1.133 <sup>a</sup>
Overall acceptability	3.867±0.629 <sup>a</sup>	3.900±0.803 <sup>a</sup>	2.400±0.724 <sup>b</sup>	3.633±1.098 <sup>a</sup>

Data are expressed as mean±SD; Means±SD followed by the same letter, within a row, are not significantly different (p>0.05).

Sample treated with 10 minutes hot water blanching and 12 hours freezing was having the highest overall acceptability and even though a significant difference did not exist in between samples treated with 5 minutes hot water blanching and 12 hours freezing and sample treated with 10 minutes hot water blanching and 6 hours freezing (Figure 2).

According to the results sensory characteristics of sample 5 minutes hot water blanching and 6 hours freezing were significantly differ from other three samples. Further it showed the least preference compared to other three samples (Figure 2).

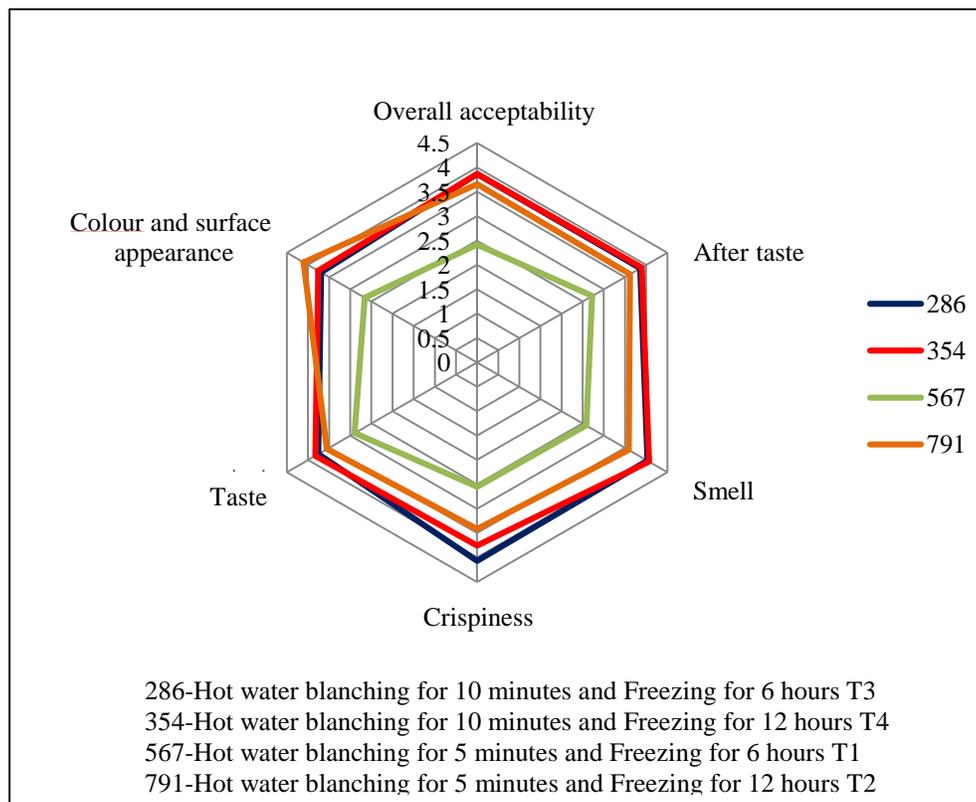


Figure 2. Web diagram of mean ranking of samples vs sensory characteristics.

### 3.2 Proximate composition and cyanide content

The proximate composition of cassava frozen fries sample is given in Table 3. Moisture content, carbohydrate content, mineral content, fat content, protein content and crude fibre contents of the sample were  $56.71 \pm 0.80\%$ ,  $32.18 \pm 0.19\%$ ,  $0.42 \pm 0.02\%$ ,  $9.13 \pm 0.05\%$ ,  $1.18 \pm 0.06\%$  and  $0.20 \pm 0.03\%$  respectively. Cyanide content of the cassava frozen fries sample was  $1.42 \pm 0.12$  ppm. Moisture content of the cassava frozen fries was significantly lower than in the cassava fresh roots and the fat content of the sample was significantly greater than to the fresh cassava roots. As the product fries, the inner moisture is converted to steam, creating a pressure gradient as the surface dries out and causing oil to adhere to product's surface at the damaged areas. Most of the oil enters the product from the adhering oil being pulled into the product, when the product is removed from the fryer adhering oil enters the product due to vacuum created by condensation of water vapour in the pores (Debnath et al., 2003).

Fresh cassava roots were having significantly high amount of mineral ash compared to cassava frozen fries. Even though minerals are heat stable under normal processing conditions, in food products, however, can gain or lose minerals based on the various processing conditions they are exposed to, such

as the addition of salt or leaching of minerals during blanching (Rickman et al., 2007). Therefore some minerals from cassava fresh roots might have leached while blanching of cassava frozen fries.

There was no any significant difference exist in between protein contents of the sample and the fresh root. Fibre can be lost during processing, during separation steps such as peeling, filtration, or stem removal. Some studies have also suggested that heat processing can change the solubility and other physicochemical properties of fibre (Rickman et al., 2007, Kunzek et al., 1999). In this study similar results were observed as processed sample had significantly lower amount of crude fibre compared to the raw cassava root.

Carbohydrate content of the sample was significantly less than the fresh root as a result of diffusion of sugars and other water soluble compounds while blanching (Agbolor, 1997, Pedreschi et al., 2009, Saldivar et al., 2010).

Table 3: Proximate composition of Cassava frozen fries and raw cassava roots (wb).

Nutrient	Composition of frozen fries	Composition of raw cassava root
Moisture%	56.71±0.80 <sup>a</sup>	62.25±0.38 <sup>b</sup>
Mineral Ash%	0.42±0.02 <sup>a</sup>	1.26±0.04 <sup>b</sup>
Fat%	9.13±0.05 <sup>a</sup>	0.29±0.04 <sup>b</sup>
Protein%	1.18±0.06 <sup>a</sup>	1.13±0.19 <sup>a</sup>
Crude Fibre%	0.20±0.03 <sup>a</sup>	0.89±0.02 <sup>b</sup>
carbohydrate%	32.18±0.19 <sup>a</sup>	34.19±0.32 <sup>b</sup>
Cyanide content in ppm	1.42±0.12 <sup>a</sup>	23.12±0.86 <sup>b</sup>

Data are expressed as mean±SD; Means±SD followed by the same letter, within a row, are not significantly different (p>0.05).

Cyanide content of cassava frozen fries sample was significantly lower than that of fresh cassava roots and while processing the cyanide content has reduced over 94% from 23.12±0.86 ppm in the fresh cassava roots in to 1.42±0.12 ppm in cassava frozen fries sample.

### 3.3 Evaluating the quality characteristics with the storage

#### a. Analysing Moisture content

Control of initial moisture content and moisture migration is critical to the quality and safety of foods (Labuza and Hyman, 1998). Changes in the amount of moisture of food can affect the physical and chemical composition along with the safety and shelf-life of a food (Labuza and Hyman, 1998). Table 4 indicates the moisture content variation of frozen fries during the storage period of three months.

Table 4: Moisture content variation with the storage time at frozen storage.

Duration	Initial	4 weeks	8 weeks	12 weeks
Moisture content	50.83±1.33 <sup>a</sup>	52.13±1.66 <sup>a</sup>	53.67±1.34 <sup>a</sup>	54.77±1.85 <sup>a</sup>

Data are expressed as mean±SD; Means±SD followed by the same letter, within a row, are not significantly different (p>0.05).

According to the results, moisture content of cassava frozen fries had increased during 12 weeks (Figure 3). During frozen storage, the existence of temperature gradients within a product may result in moisture migration, relocating the water within the product. This is a consequence of the temperature dependence of water vapour pressure. Water vapour tends to transfer to regions of low vapour pressure

(Sun, 2016, Erickson and Hung, 2012, Evans, 2009). Even though the moisture content increased with storage time there was no significant difference exist ( $p>0.05$ ) between the moisture content during the three month storage time.

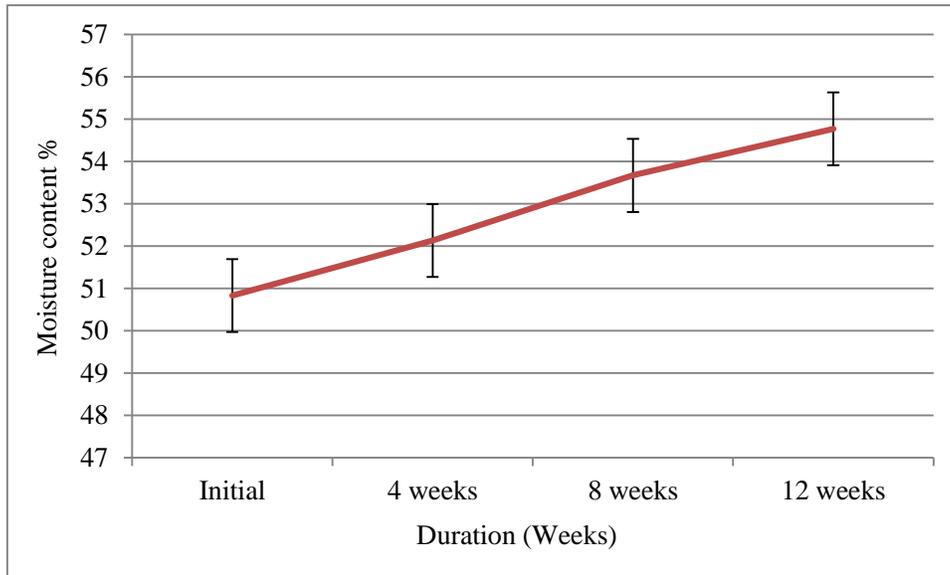


Figure 3. Moisture content of frozen fries vs. storage duration.

*b. Microbiological analysis*

Freezing has become a very important means for food preservation. Frozen foods have two properties that control microbiological activity. One is the limiting water activity ( $a_w$ ); the other is that the temperature of the product is too low to allow microbial growth (SPECK and RAY, 1977, Jay, 2012, Jay et al., 2008).

Consequently, examination of frozen foods for indicator or pathogenic bacteria is important in monitoring frozen food quality (Hartsell, 1951). Indicator bacteria, such as the coliform group and Escherichia coli, are detected in foods by selective enumeration methods(SPECK and RAY, 1977).

A total count of viable aerobic bacteria is a most important indicator of frozen foods and initial bacterial level will affect the shelf-life of a chilled product. The results showed that the total plate counts and yeast and mould counts were decreasing during the storage and the coliforms were not detected from the initial sample (Table 5).

Elliott and Michener (1960) stated that foods causing poisoning outbreaks usually had total viable counts above 10 million per gram (Elliott and Michener, 1961). Some investigators have said a high count affects flavour adversely before actual spoilage is evident, and the value of total viable counts reflects the hygienic conditions that occurred during processing (Aycicek et al., 2006).

Table 5: Microbiology testing results variation with the storage time at frozen storage.

Duration	Initial	4 weeks	8 weeks	12 weeks
Aerobic plate count (CFU/g)	$1.2 \times 10^2$	<10	<10	<10
Yeast and moulds count (CFU/g)	$1.0 \times 10^2$	<10	<10	<10
Coliforms (MPN/g)	Not detected	Not detected	Not detected	Not detected

There is no standard available for microbiological standards of frozen foods. According to Goresline (1959), if a standard aerobic plate count of 100,000 per gram and a coliform level of 10 per gram were enforced for precooked frozen meals, the presence of pathogens was a remote possibility (Goresline and Haugh, 1959).

Even though the initial counts of total plate count and yeast and moulds were greater than the final counts (Table 5) the values were not in the hazardous range according to the literature. Frozen foods are normally cooked or heated by the consumer or eaten soon after defrosting. Then as long as thawing instructions are followed, spoilage is not a problem (Wijesinghe and Sarananda, 2008).

### c. Peroxide value analysis

Lipid oxidation is one of the major deteriorative reactions in frying oils and fried foods, and often results in a significant loss of quality (Alexander, 1978). It is well known that lipid oxidation can lead to changes in functional, sensory (development of off flavours, palatability problems), and nutritive values (loss of fat-soluble vitamins) and even the safety (production of food poisoning toxins) of fried foods (Wu and Nawar, 1986, Pearson et al., 1983, Nawar, 1985).

The peroxide value is often useful indicator of the oxidative deterioration of fats and oils (Matthäus, 2006). The extent of oil deterioration was best reflected in the changes in peroxide content (Che Man and Tan, 1999). An advantage of peroxide value determination is that it directly measures the lipid peroxides, which are the primary lipid oxidation products (Shantha and DECKER, 1994).

The peroxide value through the shelf life was determined using iodometric titrations which also used to measure the peroxide value in the AOAC official method (Helrick, 1990) and the American Oil Chemists' Society (Mehlenbacher and Hopper, 1958) method. According to the results a reading for peroxide value was not obtained even after 12 weeks of storage time (Table 6).

Table 6: Peroxide value variation with the storage time at frozen storage.

Duration	Initial	4 weeks	8 weeks	12 weeks
Peroxide value (meqO <sub>2</sub> /kg)	0±0	0±0	0±0	0±0

## 4. Conclusion

Longitudinal cubes of cleaned, peeled cassava can be developed in to frozen fries with better sensory qualities after blanching for 10 minutes, partial frying for 1 minute (165° C) and deep freezing for 12 hours. The pre-treatments result the reduced cyanide content and increased sensory qualities in final product. Cassava frozen fries packed in 300 gauge LDPE can be stored in frozen conditions (-18° C) for three months.

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