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Storage Stability and Sensory Evaluation of Taro Chips Fried in Palm Oil, Palm Olein Oil, Groundnut Oil, Soybean Oil and Their Blends

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Abstract: Taro (*Colocasia esculenta*) chips fried in Palm Oil (PO), Soybean Oil (SBO), Palm Olein Oil (POO), Groundnut Oil (GO) and in 40:60 w/w blend ratio of palm oil: POO; SBO; GO were stored for 0-5 weeks in dark and in fluorescent light. Chips were subjected to weekly chemical and sensory analysis. Results showed that significant ($p<0.05$) differences occurred in the organoleptic properties of taro chips fried in the different oil types during storage. Chips fried in palm oil and groundnut oil blend had the most desired flavour, taste and stability. The highest off-flavour rating was for chips fried in soybean oil while chips fried in palm oil: groundnut oil blend had the least rating ($p<0.05$). The overall acceptability of chips was not significantly ($p>0.05$) affected by dark storage. Peroxide Value (PV) was highest in soybean oil fried chips ($p>0.05$) during storage. Peroxide Value (PV) increased at a slower rate in chips fried in palm oil, palm olein oil/blends.

Key words: Taro chips, blend oils, storage, stability

Introduction

Taro (*Colocasia esculenta*) commonly called cocoyam is a monocot root and a member of the araceae family of plants. Cocoyam is cooked as yam but has an inferior taste resulting in it being considered as a stand-by crop worth eating only during the seasonal famine period. Thus its cultivation has received only limited attention (Agboola, 1987).

Plucknett *et al.* (1970) reported that cocoyam has a wide range of uses examples in religious festivals, as contact poison, mild laxative, in treatment of wounds and snake bites, reducing body temperature in a feverish patient. The starch grains of cocoyam is small, thus it improves digestibility which is an important factor when selecting a starchy food that will not be cumbersome on the digestive system. For this reason, cocoyam can be used as a composite in the manufacture of infant meals, convalescing patients with such problems that require carbohydrate as a source of energy which will not stress their metabolic process. Cocoyam starch is good for peptic ulcer patients, patients with pancreatic disease, chronic liver problems and inflammatory bowel disease and gall bladder disease.

They are two major factors associated with the effective use of cocoyam; the acrid nature and storage factor. Acridity is the sharp irritation and burning of the throat and mouth when the uncooked material is ingested. Such a material is said to be acrid (Sakai and Nwufo, 1972). Acrid component may cause temporary sterility and has been directly linked to death of children and of many experimental and domestic animals. However, the level of acridity in edible tubers is too low for them to pose any serious problem (Esuabana, 1982) unless very large quantity of the tuber is consumed. Acridity is thought to be caused by Calcium oxalate raphides plus a chemical irritant. A number of suggestions, about the chemical irritant include a protinase, alkaloid, glucosides, hormone or sapotoxin (Moy and Nip, 1983). According to Moy *et al.* (1979) removal of acridity by a traditional method involves anaerobic fermentation in an underground pit for several weeks. Other methods include prolonged baking or extraction with ethanol.

Post harvest rot or spoilage of cocoyam tubers is attributed to physical, physiological and pathological factors. Nwufo and Atu (1987) stated that microorganisms take the lead in post harvest rot. Nwufo (1980) listed the following fungi which participate in post harvest rot: *Fusarium solani*, *Botryodiplodia theobromae, Rhizopus stolonifer*, *Aspergillus Niger and Sclerotium rolfsii*. Due to the difficulties in storage, cocoyams are usually utilized or consumed shortly after harvest. Passam (1982) also attributed spoilage of cocoyam to the high respiratory activity of the corm, observing that reduction of storage temperature to an optimum of 7°C and 85% relative humidity increases the storage time. Instead of unsuccessful long term storage, the crops are usually left in the ground and harvested when needed. Onwueme (1987) stated that there is a limit to how long the crop can be left in the soil since the corms and cormels sprout and produce new growth which result in the cocoyam loosing its good values. He went further to suggest November and March/April as ideal time for harvesting cocoyam.

Taro and Tannia contribute about 4.1% of roots and tubers consumed in Africa (F.A.O., 1987) In the food industry, considerable progress has been made in processing acceptable form. In the Carribbean Island, the leaves of *Xanthosoma brascilliense* are used for salad and those of taro are gradually gaining importance as a source of vegetable, rich in minerals and vitamins. In Hawaii a chocolate flavour, taro beverage powder has been produced from cooked taro (Nwana and Onochie, 1979).

Cocoyam is rich in energy or carbohydrate, low in fibre and is a fair source of oils and fats. When compared with tannia and other root crops, it has the highest content of phosphorus (P), magnesium (Mg) and Zinc (Zn). The protein of taro (cocoyam) is well supplied with essential amino acids though in low histidine and lysine. It is fairly rich in carotene, ascorbic acid, thiamine, riboflavin and nicotinic acid. Most of the non-starchy nutrients such as proteins, minerals are concentrated in the outer peels of the corms (Bradbury and Holloway, 1988). Among the various tropical root crops, taro is one of the most efficient producers of calories. The Bun long variety produced in Hawaii has an energy value of 4.2 to 4.4 cal/g (moisture free basis) as compared to 3.9 cal/g for sweet potato and 3.5 to 4.5 cal/g for rice and 1.3 to 1.5 cal/g for cassava (James *et al*., 2002).

Taro is at present under utilized. The possibility of increasing its utilization lies in developing suitable processing technology, securing consumer acceptance and marketable products and achieving economic feasibility. The strategy for solving these problems include setting a criteria for processing technology and product development which could include energy and labour intensity, consumer appeal and convenience, nutritional and storage qualities and ease of packaging and transportation. The problem of how to encourage the utilization of cocoyam as an important food is the basis of this research which will find alternative ways in which cocoyam can be more accepted not only as a delicacy in Nigeria but as a snack. This research aims at determining the quality of taro chips fried in different edible oils and their blends; the physical/chemical parameters of the used oils and their blends; the storage stability of the product in the dark and in fluorescent light and the sensory qualities of the product after storage.

Materials and Methods

The raw taro (*Colocasia esculenta*), palm oil, palm olein oil, soybean oil and groundnut oil were purchased from a local market in Calabar, Nigeria.

Preparation of sample: Prior to the experiment, the oils were mixed to obtain a 40:60 w/w blend ratio. Palm Oil (PO) was 40% while the other oils, Palm Olein Oil (POO), Soybean Oil (SBO), Groundnut Oil (GO) was 60% each.

One kilogram (1kg) of taro was washed, peeled manually with a kitchen knife and trimmed off all undesirable parts. It was washed in cold water at 15°C for 3 minutes to remove surface starch and other unwanted extrenous materials. The water was drained and the taro was sliced to 2mm thickness using a manual kitchen slicer. The sliced taro was blanched in warm water at 80°C for 5 min to removed residual surface starch and deactivate enzyme. It was drained and air-dried for 8 minutes.

Production of Taro Chips: 2.5 Litres of each oil and blend were break-in-heat at 220°C for 10 min. One hundred gramme (100g) of taro slices were fried in a total of 7 oils; 4 pure oils; PO-100%, SBO-100%,POO-100% GO-100% and 3 blends; PO:POO, PO: GO, PO: SBO at a ratio of 40:60 w/w for 5 min at 220°C until crisp and a golden brown in colour. The chips were drained on kitched paper towels and allowed to cool for 2 min. The chips were salted with 1% (w/w) Sodium chloride and sealed in high-density polythene bags of 2mm thickness (50g/bag) using an automated sealer (Model: MEC 299H). Some of the chip samples were stored for 0-5 weeks under fluorescent light while another batch of the samples were stored in the dark at ambient temperature for the same-length of time. The samples stored under light were turned 180°C three times a week for five weeks so that all chips received the same light intensity by the end of storage. At the end of each storage time the samples were subjected to organoleptic analysis while the oils extracted from the freshly fried and stored chips were chemically analyzed for peroxide values.

Chemical analysis

Peroxide Value (PV): Oils used in frying were extracted from the fresh and stored chips with an organic solvent petroleum ether (40°C-60°C), using Soxhelt apparatus and the Peroxide Values (PV) were determined for each oil using the method of Mehlenbacher (1960).

Sensory evaluation: Sensory evaluation for the chip samples were carried out weekly through out the five weeks of storage according to the method of Larmond (1977) using a 9 member untrained but experienced panelists. Five texture characteristics were evaluated based on flavour, colour, off-flavour, taste and overall acceptability of the chips with descriptive analysis after each storage sample. All sessions were held in a sensory panel room kept at 22°C and equipped with partitioned booths and cold white fluorescent lights. Panelists were each provided with 50ml of water at room temperature to rinse their mouths after each sample. Every treatment was evaluated in three replications. The ratings were given numerical value from 1 (extremely inferior to R) to 9 (extremely better than R) and 5 (no difference) while R is the reference sample.

Statistical analysis: The multiple comparison test was used to test for significant difference between the groups

Table 1: Effect of oil type on taro chips

Organoleptic	Condition	PO	POO	GO	SBO	PO/POO	PO/GO	PO/SBO
Flavour	Light	4.00^{bc}	3.44^{cd}	4.53^{ab}	4.25^{b}	3.24^{d}	5.03^{a}	4.57^{ab}
	Dark	4.31^{e}	4.22^{e}	5.56^{b}	5.22^{c}	3.80^{f}	5.83^{a}	4.93^{d}
Colour	Light	3.11^{d}	5.41^{a}	4.87^{ab}	4.39^{bc}	3.80^{cd}	5.15^{ab}	4.46^{bc}
	Dark	3.13^{e}	5.82^{a}	5.24^{b}	4.74^{cd}	5.19^{bc}	5.63^{ab}	4.57^{d}
Off-flavour	Light	3.06^{e}	3.69^{d}	4.55^{bc}	5.11^{a}	3.33^{de}	4.28^{c}	4.82^{ab}
	Dark	2.39^{c}	2.41^{c}	3.74^{a}	3.63^{ab}	2.59^{bc}	3.31^{b}	3.74^{a}
Taste	Light	4.02^{c}	3.13^{e}	5.46^{ab}	4.74^{b}	3.78^{ab}	5.07^{ab}	4.82^{b}
	Dark	4.41^{c}	3.76^{d}	5.91^{a}	5.48^{ab}	3.98^{cd}	5.50^{ab}	5.19^{b}
Overall acceptability	Light	3.87^{b}	2.69^{d}	5.26^{a}	4.7^{a}	3.24^{c}	5.07^{a}	4.80^{a}
	Dark	3.85^{b}	2.82^{c}	5.41^{a}	5.13^{a}	3.58^{b}	5.10^{a}	5.18^{a}

PO:100% pure, POO:100% pure, GO:100% pure, SBO:100% pure, PO:POO-40.60%, PO: GO-40.60%, PO: SBO-40.60%, *The higher the magnitude the greater the preference

Table 2: Effect of storage length on taro chips

Organolaptic	Condition	0	1	2	3	4	5
Flavour	Light	5.95^{a}	5.16^{b}	4.70^{b}	3.90^{c}	3.04^{d}	2.16^{c}
	Dark	6.33^{a}	6.05^{b}	5.41^{c}	4.52^{d}	3.95^{e}	2.76^{f}
Colour	Light	6.02^{a}	5.33^{b}	4.72^{bc}	4.22^{cd}	3.86^{d}	2.59^{c}
	Dark	6.00^{a}	5.76^{a}	5.13^{b}	4.83^{b}	4.13^{c}	3.57^{d}
Off-flavour	Light	2.04^{f}	3.46^{e}	4.00^{d}	5.04^{b}	4.57^{bc}	5.60^{a}
	Dark	1.99^{e}	2.23^{e}	2.89^{d}	3.38^{c}	3.86b	4.35^{a}
Taste	Light	6.00^{a}	5.44^{b}	5.00^{b}	4.02^{c}	3.62^{c}	2.51^{d}
	Dark	6.16^{a}	5.94^{a}	5.32^{b}	4.59^{c}	3.94^{d}	3.40^{e}
Overall acceptability	Light	5.87^{a}	5.21^{b}	4.72^{b}	3.98^{c}	3.33^{d}	2.41^{e}
	Dark	5.87^{a}	5.40^{a}	4.78^{b}	4.08^{c}	3.46^{d}	3.03^{d}

Rating:1-Extremely inferior R, 5-Different from R, 9-Extremely better than Results revealed significant ($p<0.05$) differences in the organoleptic properties of taro chips fried in the different oil types at different storage conditions and lengths

of samples (ANOVA). Also the DUNCAN'S multiple range test was used to determine the significant difference between the samples.

Results and Discussion

Table 1 represents the organoleptic scoring ratings of taro chips fried in different oil types under light and dark storage conditions. The organoleptic scores of taro chips as affected by storage length are given in Table 2. Taro chips stored in the dark were noted to maintain their organoleptic quality better than those stored under light condition.

Flavour: The (taro) chips fried in PO/GO blend had the most desired flavour than those fried in PO/SBO, GO; SBO, PO, POO and the least desired flavour was recorded in chips fried in PO/POO blend under light storage condition. In the dark storage, slight variations were observed in the flavour rating, as chips fried in GO and SBO had better flavour than those fried in PO/SBO. Flavour stability of chips was observed to decrease significantly ($p<0.05$) as storage length increases from week 0-5 under light and dark conditions. However, taro chips stored in the dark were observed to be more flavour stable than those stored under light condition. This significant ($p<0.05$)reduction in flavour stability of chips exposed to light could be as a result of build-up of free radical which reacted with oil by exposure to ultra violet rays. Thus, causing rapid deterioration in chips flavour.

The trend of flavour stability and desirability observed in taro chips could be attributed also to the composition and nature of fatty acid present in the various oils used in frying. Chips fried in PO/GO blend combined the desirable properties of palm oil (presence of antioxidant and balanced fatty acid profile) and groundnut oil (presence of high amount of vitamin E and absence of linolenic acid, to produce chips with the most stable and desired flavour. Ahmed and Young (1982), Porkorny (1989), Pangloli *et al.* (2002) had earlier reported that the desirable flavour of chips is imparted by the production of t, t-2, 4-decadienol when chips are fried in oils containing high amount of linoleic acid. Our result agrees with this report as the most desired flavour was obtained from GO and its blend which contained higher amount of linoleic acid than other oil types used.

The least desired flavour obtained from chips fried in POO and PO/POO blend may be due to the higher amount of polyunsaturated fatty acids present in POO with its relatively low amount of linoleic acid. Thus, resulting to low production of t, t-2, 4-decadienol and increased flavour loss.

Results obtained also correspond to the report of Hawrysh *et al.* (1996) that, the intensity of characteristic chip flavour fried in various oils tends to significantly ($p<0.05$) decrease as storage length increases at 60°C under light and dark conditions.

Colour: The chips fried in POO was rated significantly ($p<0.05$) greater in colour intensity than chips fried in other oil types in both storage conditions while the lowest colour intensity was observed in chips fried in PO.

Colour intensity deteriorated significantly ($p<0.05$) in all chips as storage week increased from 0-5 under light condition. However, in the dark storage, there was no significant ($p>0.05$) change in colour at week 0-3 but it decreased gradually as storage length increased from week 4-5.

Factors which might have imparted colour intensity on chips include; the chemical composition of the taro tubers, slice thickness, frying temperature, duration and number of slices in the fryer (Smith, 1987). In addition, POO contains nonanol and t-2 decanal which are formed during oleic acid oxidation and might be responsible for the greater colour intensity observed.

Result obtained disagree with the report of Pangloli *et al.* (2002) that colour intensity of potato chips fried in various oil types remain relatively constant at different storage length. Variation in results could be due to the frying method and temperature employed as well as the type of chips used. The least colour intensity observed in chips fried in PO could be as a result of the characteristic red colour of palm oil.

Off flavour: Off-flavour is a function of rancidity. Auto oxidation occurs during the drying and hardening of oils. The degree of off-flavour in chips is dependent on the degree of saturation of oil used in frying, concentration of antioxidant and the storage conditions. Off-flavour was observed to correlate negatively with flavour under light storage condition. The highest off-flavour was observed in chips fried in SBO followed by those fried in PO/SBO, GO, PO/GO, PO, PO/POO while lowest in chips fried in PO under light condition. In dark storage the highest and least off-flavours were observed in chips fried in PO/SBO and PO, respectively.

Off-flavour increased gradually at storage week 0-2 but rapidly at week 3-5 under light condition. No significant ($p>0.05$) change was recorded at week 0-2 whereas, a gradual increase was observed at week 3-5 for off-flavour in chips in the dark condition.

The highest off-flavour observed in chips fried in SBO could be due to the formation of hexanal and pentanal which impacted the offensive odour noted in chips as reported by Jeon and Bassette (1984). Hawrysh *et al.* (1996) noted also that the fishy flavour in fried chips was due to the presence of linolenic acid in frying oil after 4-6 weeks of storage. Our result corresponds to this observation as SBO which was noticed to contain the highest amount of linolenic acid content had the highest off-flavour.

Similarly, Shao (1999) reported that significant increase in the oxidative rancidity of taro chips fried in SBO may also be due to the significant high amount of linolenic acid and low level of tocopherol present in the oil. Pangloli *et al.* (2002) reported that a significant correlation exist between the level of 1-decyne ($r = 0.83$) and off-flavour score with a correlation of 0.93 between off-flavour and rancidity score in chips. It's expected that chips fried in SBO will possess the highest values for 1-decyne and rancidity score since they possess the highest off-flavour score.

The low levels of off-flavour in chips fried in pure PO, POO or their blend could be as a result of the high amount of antioxidant and β carotene they contain thus preventing significant auto oxidation in the fried taro chips.

Taste: This is the sum of the sensations perceived which is attributed to the inherent chemical compounds in the raw taro and to a greater extent by the flavour and off-flavour imparted by the oil types used. Chips fried in GO and PO/GO blend rated significantly ($p<0.05$) higher in taste than those fried in PO/SBO, SBO, PO, PO/POO and least in POO. Taste of chips was observed to reduce gradually as storage length increased especially during light condition.

Results revealed that flavour was moderately correlated with taste ($r = 0.631$). The amount of linolenic acid present in oil evidently imparted taste to fried chips. Chips fried in GO had the best taste since GO had the highest amount of linoleic acid content. The higher amount of polyunsaturated fatty acid in POO could be responsible for autoxidation and rancidity of chips thus imparting the least taste to chips during storage conditions.

Overall acceptability: Taro chips stored in the dark were readily acceptable to the panelists than those stored under light condition. Similar preference for chips fried in GO, PO/GO, SBO and PO/SBO was observed by panelists than those fried in PO, PO/POO and POO.

Overall acceptability of chips was not significantly ($p>0.05$) different under dark condition at storage week 0-2 but decreased significantly ($p<0.05$) at storage week 3-5. Under light condition, a progressive decrease in chip acceptability was observed as storage length increases from week 0-5.

These results imply that chips fried in GO or 40% PO and 60% GO blend were the most flavoured and stable especially under dark storage condition.

Peroxide value: The results of peroxide values of taro chips are summarized in Table 3.

All chips under went oxidation during storage with the extent of oxidation depending upon the type of oil used, storage time and its conditions (Patterson, 1989). PV was highest in chips fried in SBO than those fried in GO, PO/SBO, PO/GO while the least PV was obtained from chips fried in PO, PO/POO and POO which were not significantly ($p>0.05$) different from one another. PV was noted to increase drastically after week 3 of light and dark storage conditions.

Table 3: Peroxide Value of taro chips fried in different oil types /storage length

Effect	Condition	PO	P00	GO	SBO	PO/POO	PO/GO	PO/SBO
Sample	Light	5.60[c]	6.73[c]	14.67[ab]	17.87[a]	8.73[c]	13.19[b]	14.41[ab]
	Dark	4.77[d]	5.89[d]	10.76[b]	12.22[a]	7.23[c]	8.72[bc]	9.78[b]
		0	1	2	3	4	5	
Storage Length	Light	4.41[c]	4.67[c]	6.04[c]	14.12[b]	17.82[b]	22.55[a]	
	Dark	4.38[d]	4.49[d]	5.22[c]	9.22[c]	12.32[b]	15.24[a]	

Off. Superscripts (a, b, c, d, e and f) indicate significance ($p<0.001$) difference along row

These findings agree with the report of Lin (1993) that the PV of chips fried in cotton seed oil (CSO) does not significantly ($p>0.05$) change after 3-4 week of storage in the dark but PV in sunflower oil (SFO) significantly ($p<0.05$) increased after 2 weeks of storage in the same condition.

This report suggests that, PV of chips are dependent mainly on the oil type used in frying while indirectly depend on storage conditions.

Our PV result suggest also that chips fried in PO and POO undergo little autoxidation than those fried in SBO or GO. An addition/inclusion of 60% POO to 40% PO does not have any significant ($p>0.05$) effect on the stability of fried chips especially in dark conditions. Inclusion of 60% SBO or GO to 40% PO causes a definite reduction in the PV of fried chips thus, enhancing their stability status under storage conditions.

Taro chips fried in SBO/GO or their blends stored under light condition oxidized at the same rate to produce the same level of PV throughout the storage length. In the dark storage, chips fried in SBO oxidized faster than those fried in GO and PO/SBO blend.

However, under same storage conditions PV increased at a slower rate in the chips fried in PO; POO and their blends. This was probably due to the presence of a high amount of β carotene in PO/POO (Basiron, 1996) that quenches singlet oxygen thereby reducing the photo-oxidative rate in taro chips (Nawar, 1996).

Conclusion: These results suggest that taro chips fried in palm oil: groundnut oil blend had the most desired flavour, taste and stability. Therefore, high sensory quality taro chips would be obtained using PO:GO blend. The high sensory score of taro chips signifies that taro chip production will be viable snack food product option.

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