MICROBIAL AND PHYSIOCHEMICAL CHANGES IN PROCESSED CASHEW NUTS STORED IN DIFFERENT PACKAGING MATERIALS

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ABSTRACT
Roasted and fried cashew nut samples were stored using seven different packaging materials (tin, plastic, foil paper, nylon, bottle, foil-in-plastic and foil-in-tin) at ambient temperature of 28 ± 2 °C for the period of four weeks. The microorganisms isolated at various stages of storage included, *Bacillus subtilis, Bacillus brevis, Micrococcus luteus, Stapholococcus epidermis, Aspergellius niger, Rhizopus stolonifer and Mucor mucedo*. Roasted as well as fried samples stored in tin, bottle, and foil-in-tin packages were observed to contain lower microbial load compared with the samples stored in nylon, foil paper, and plastic containers. The protein and crude fat contents of the fried samples were found to be significantly higher at $P<0.5$ than those of the roasted samples. Result of the sensory evaluation shows that there was a significant difference between the freshly roasted and freshly fried samples at $P<0.5$ in terms of colour, taste and texture. On the other hand there was no significant difference among the stored roasted as well as among stored fried samples at $P<0.5$.
Key words: Roasted, fried, cashew nut, microorganisms, samples.

INTRODUCTION

Cashew plant (*Anacardnium accidentale*) though a native of tropical American grows in all tropical countries including Nigeria (Opeke, 1987). The cashew tree is a native of Brazil and the lower Amazons. The cashew has been introduced and is a valuable cash crop in America, West Indies, Madagascar, India and Malaysia (Frankel, 1991). The major producing countries of cashew are Tanzania, India, Mozambique Sri Lanka, Kenya, Madagascar, Thailand, Malaysia, Nigeria, Malawi and Angola. World bank data estimates that 97 % of production is from wild trees and only 3 % is from established plantation (Rosengarten, 1984). In Nigeria about 5000-7000 tonnes are produced annually mainly as an export crop (Aremu *et. al*., 2006). Africa is the third largest global source of cashew nut and produces about 100,000 tonnes per year (Spore, 1997). According to Fetuga *et. al*. (1974), only about 60 – 65 % of the total cashew production in Africa is utilized while the rest are discarded. The cashew nut is the main commercial product of the cashew plant. It is a kidney shaped hard shelled nut borne on a swollen receptacle known as the cashew apple is the real cashew fruit (Rankeen, 1988). The kidney shaped nut is the real cashew fruit. The kidney shape nut has within itself, a whole kernel and this delicate kernel is covered by a testa membrane and a thick outer shell which effectively protects the tasty kernel from the ravages of nature. Cashew kernels are consumed as food since they are extremely nutritious; contain high level of proteins and fats, rich in iron, vitamin B and C (Purseglove, 1968). Opeke, 1987 reported that the kernel has 80-82 % of its fat in the form of unsaturated fatty acids, hence, its consumption could not support the development of fatty liver. The kernels constitute a valuable export product for confectionery and dessert purposes (Jaffe and Morton, 1995).

Presently, there are only a few cashew nut processing factories in Nigeria. This means that greater percentage of the nuts produced in the country are not processed rather exported in their raw form pr wasted. There is need therefore to study the processing of cashew nut in a country like ours in order to encourage would be processor.

Cashew nut processing involves the extraction of the tasty kernel from the shell, roasting and packaging. Roasting improves the flavour of the cashew kernel. Two methods of roasting are usually employed namely: The so called "Wet roasting" usually performed in a hot frying fat and a "dry" process which involves roasting in dry oven. Reports have shown that the quality of fried food has direct relationship with quality of the oil used for the frying. The need for appropriate packaging of "wet" and "dry" roasted cashew nut cannot be over emphasized

as good packaging would mean increased storage life. Roasted cashew nut can be consumed either directly, or used as a raw material. In whichever form, the excess has to be preserved for future use. The greater value of this product is lost to spoilage after a period of time due to improper handling and storage conditions and this result in great loss of product and investment. Roasted cashew nut is vulnerable to deterioration over time and this result from improper packaging to adverse storage conditions. The rate of this spoilage is dependent on moisture content of stored nuts; relative humidity of storage environment; permeability of packaging material; ambient temperature and insect infestation. Based on these effects, roasted cashew nuts deteriorate by mould growth, rancidity and insect attack (Nomisma, 1990).

The objective of this experiment is to determine the microbial quality, and proximate composition of "wet" and "dry" roasted cashew nuts stored in different packaging materials (tin, bottle, nylon, plastic, foil-in-tin and foil in plastic.

MATERIAL AND METHODS.

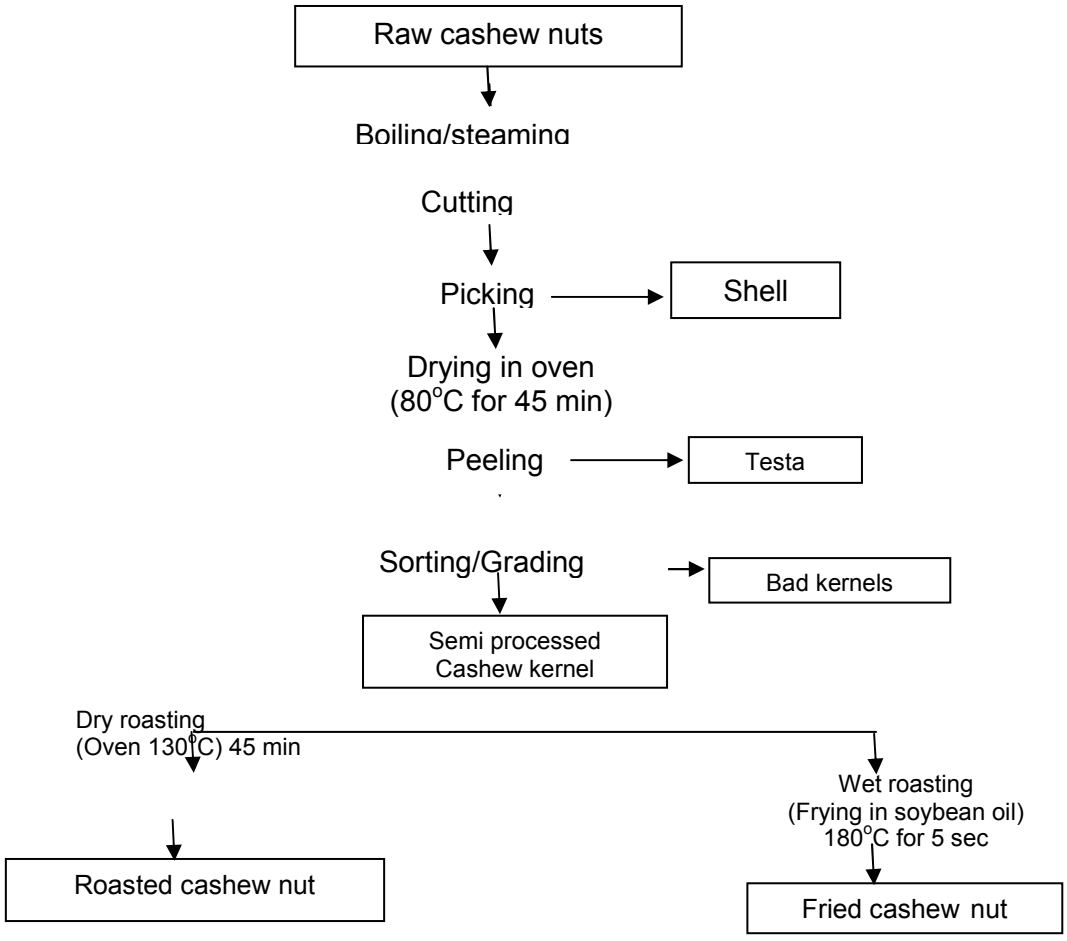
Sources of materials:

Raw cashew nuts and processing equipment such as cutting machine, oven and fryer were obtained from Jof Ideal Family Farms Limited Owo, Ondo State. Packaging materials (tin, bottle, nylon, plastic, foil paper packages were purchased from Ose market at Onitsha, Anambra state. The chemicals and laboratory equipment were obtained from Microbiology, Food science and Technology, Akure.

Processing of Cashew Nut Samples.

The method of Nomisma (1990) was adopted as illustrated in figure 1 below about 2 kg of the semi processed kernel was roasted in a dry heat oven at 130 °C for 45 minutes while another 2 kg was fried in soya bean oil at 180 °C for 5seconds. The samples were allowed to cool, then 250g of roasted and fried samples each were packed in tins, bottle, nylon, foil, plastic, foil in-tin, and foil-in-plastic containers respectively. The samples were labelled and stored at ambient temperature of 25 ± 2 °C for four weeks.

Fig 1: Flow diagram of cashew nut processing



Source: Nomisma (1990)

Proximate and mineral composition of the samples.

The proximate and mineral compositions were determined on fresh and stored samples. The standard method of AOAC (1990) was adopted.

Microbiological analysis of cashew nut samples

The pour plate method as described by Olutiola et al., (1991) and Uzuegbu, (2000), were used to determine the total viable count and mould count while the identification of the isolates was done according to Cowan (1974).

Sensory evaluation of samples

Sensory parameters such as colour, texture and taste were accessed both for the fresh samples and stored samples. Coded samples were presented to twenty member semi trained panellists who were drawn f rom staff and students of Federal University of Technology Akure. The samples were scored using a nine point hedonic scale where 9 indicated "like extremely" and 1 "dislike extremely"

Statistical analysis

All data obtained were statistically analyzed using the analysis of variance and the means separated by Ducan Multiple range tests according to steel and Torre, (1981).

RESULT AND DISCUSSION

The result in this experiment shows that the total bacteria and mould counts are below the recommended limit of less than 10^5 cfu/g for ready to eat foods by the international commission on microbiology specifications for foods (AIIBP, 1992). Five bacterial and three fungal species were isolated and identified as *Bacillus subtilis, Bacillus brevis, Staphylococcus epidermis, Micrococcus luteus, Aspergellus niger, Rhizopus stolonifer Mucor mucedo* . Figures 2 and 3 show changes in bacterial plate counts in roasted and fried sample respectively stored using different packaging materials. For the roasted samples, plate count was highest in the sample stored in foil for four weeks (A_4F) with bacterial plate count of 18 X 10^2 cfu/g. The roasted sample stored in tin had the least bacterial count of 4 X10^2 cfu/g. Also roasted samples stored in foil-in-tin and bottle had bacterial plate counts of 6 X 10^2 cfu/g. (Figures 4 and 5). The fried samples stored in tin, bottle and foil- in- tin compared with nylon, plastic and foil. Similarly the fungal counts in both roasted and fried samples were higher in foil and plastic but lower in tin, bottle and foil in tin packages.

The proximate and mineral compositions of the cashew samples are shown on table 3 and 4 respectively. The moisture mean value of both the roasted and fried samples ranged between 1.61 ± 0.01 - 4.44 ± 0.04 % and were low when compared to moisture content of most legumes usually between 7.0 and 11.0 % as reported by Arkroyed and Doughty (1964). However, this result is in close agreement with those reported by Aremu *et. al*., (2006), Ige *et al*., (1984) and Fagbemi and Oshodi (1991) for fluted pumpkins seed of 5.0 and 5.50 %, respectively. Significant difference existed between the roasted and fried samples. For instance, the protein content of roasted samples ranged from 15.30 ± 00.17 % for freshly roasted to 15.42 ± 0.10 % for roasted samples stored for four weeks while the protein content of the fried samples ranged from 17.22 ± 0.02 % for freshly fried samples to 17.23 ± 0.12 % of the fried samples stored for weeks The crude protein of the 15.20 ± 0.06 - 17.40 ± 0.22 % is low comparable to protein rich foods such as soybeans, cowpeas, pigeon peas, melon, pumpkin and gourd seeds ranging between 23.1-33.0 % (Olaofe *et. al*., 1994) and jack bean 30.8 % (Anonymous, 1972). It can be seen from this study that the roasted and fried cashew nut samples can supply more than 70 % of the recommended daily intake of protein for children (23.0-36.0g) (NRC, 1989). The crude fibre content of the cashew nut samples 0.82 ± 0.00 – 1.42 % was very low compared to legumes with mean values ranging between 5-6% (Aremu *et. al*., 2006).

Table 4 presents the mineral content (mg/100 g) of the cashew nut samples. The most abundant of the minerals was potassium, phosphorus, magnesium and calcium,. The least abundant were zinc, copper, iron, sodium. These results were in close agreement with the observation of Olaofe and Sanni (1988) and Aremu *et al*. (2006). Magnesium has been reported to be involved in maintaining the electrical potential in leave and activation of some enzyme systems. (Ferro *et. al*., 1987). The

calcium content is in agreement .with Aremu *et. al*., (2006). Calcium is responsible for bone formation in conjunction with phosphorous, magnesium, manganese, vitamin A, C and D; chlorine and protein (Akinhanmi *et.al*., 2008). Phosphorous and calcium occur together in the body to maintain body blood. Low Ca/ p ratio facilitates calcinations of calcium in the bone (Nieman *et. al*., 1992). The ratio of sodium to potassium (Na/k) in the body is a great concern for prevention of high blood pressure. Na/k ratio <1 is recommended (Nieman *et. al*., 1992). The Na/k ratio in this study (0.2-0.3) is an indication that consumption of the roasted and fried cashew nuts would probably reduce high blood pressure.

The mineral composition of the freshly roasted samples varied significantly from the freshly fried samples at P< 0.05. On the other hand, there was no significant difference among the mineral composition of the stored roasted and fried samples. This suggests that neither the packaging materials nor the period of storage has significant effect on the mineral composition of the sample.

Mean sensory scores for both freshly scores for the samples stored in different packaging materials for four weeks are shown on table 1 and 2. Freshly fried samples were rated higher than the freshly roasted samples the three attributes of colour, taste, texture and the f-test shows that significant difference exists between the two samples at 95 % confident level. For the stored samples, roasted samples stored in the tin and bottle were rated higher for texture and taste while fried samples stored in nylon and foil had the lowest scores of 2.15 for texture. This implies that tin and bottle retained the crisp texture of the nuts. For colour assessment, fried samples were rated higher than roasted samples in all cases.

CONCLUSION

Result obtained from the experiment show that frying (wet roasted) should be employed when the cashew kernels are meant for immediate consumption while dry roasting is recommended when the kernels are meant to last over a period of time. Tin and bottle packages are recommended in all cases.

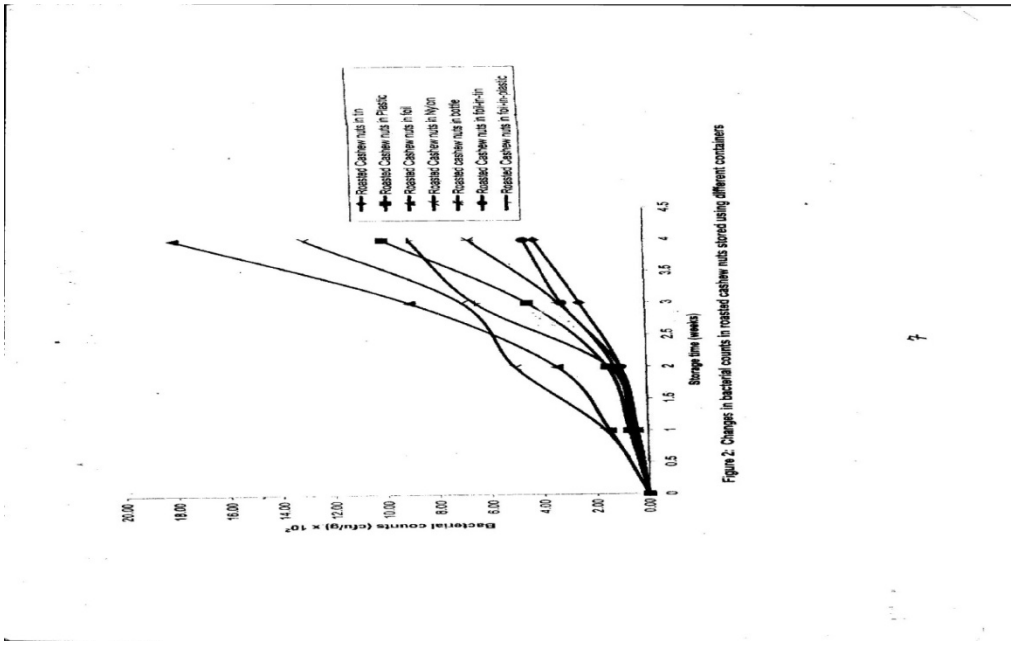


Figure 2: Changes in bacterial counts in roasted cashew nuts stored using different containers

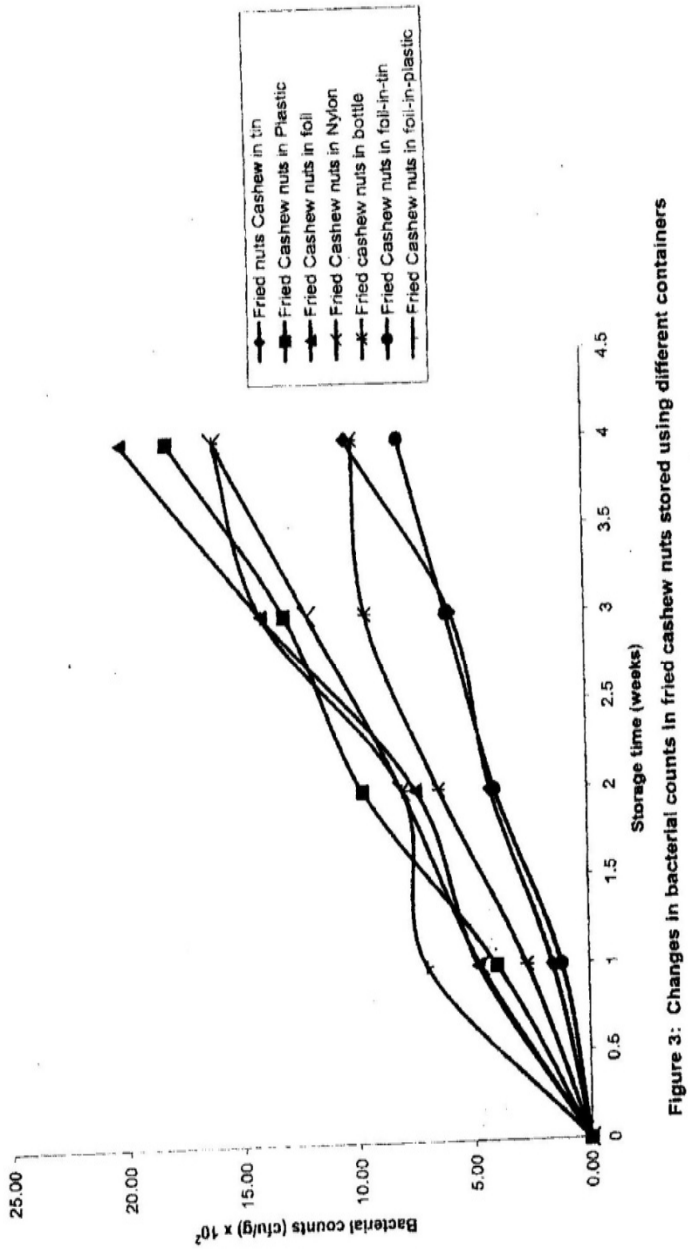


Figure 3: Changes in bacterial counts in fried cashew nuts stored using different containers

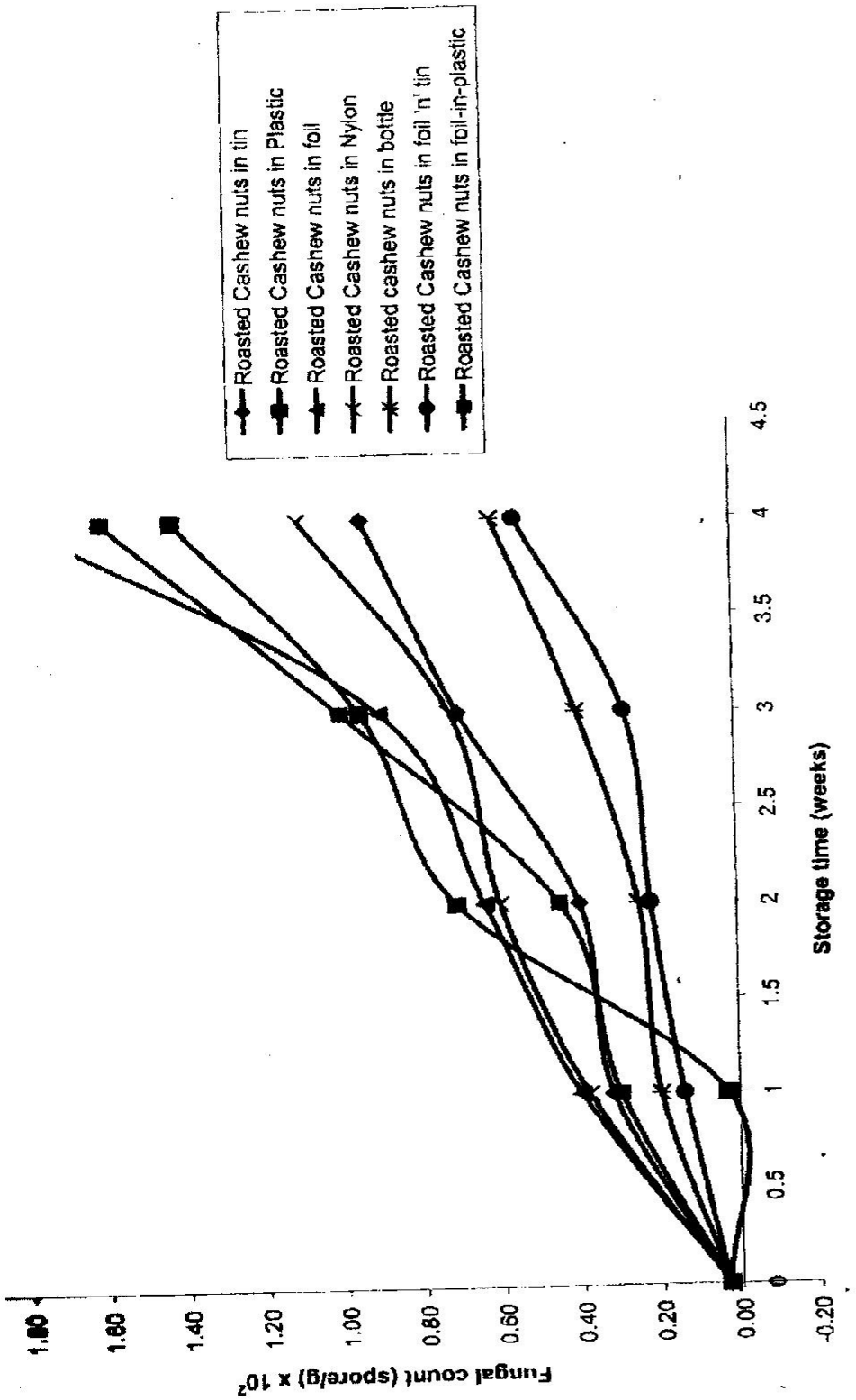


Figure 4: Changes in fungal counts in roasted cashew nuts stored using different containers

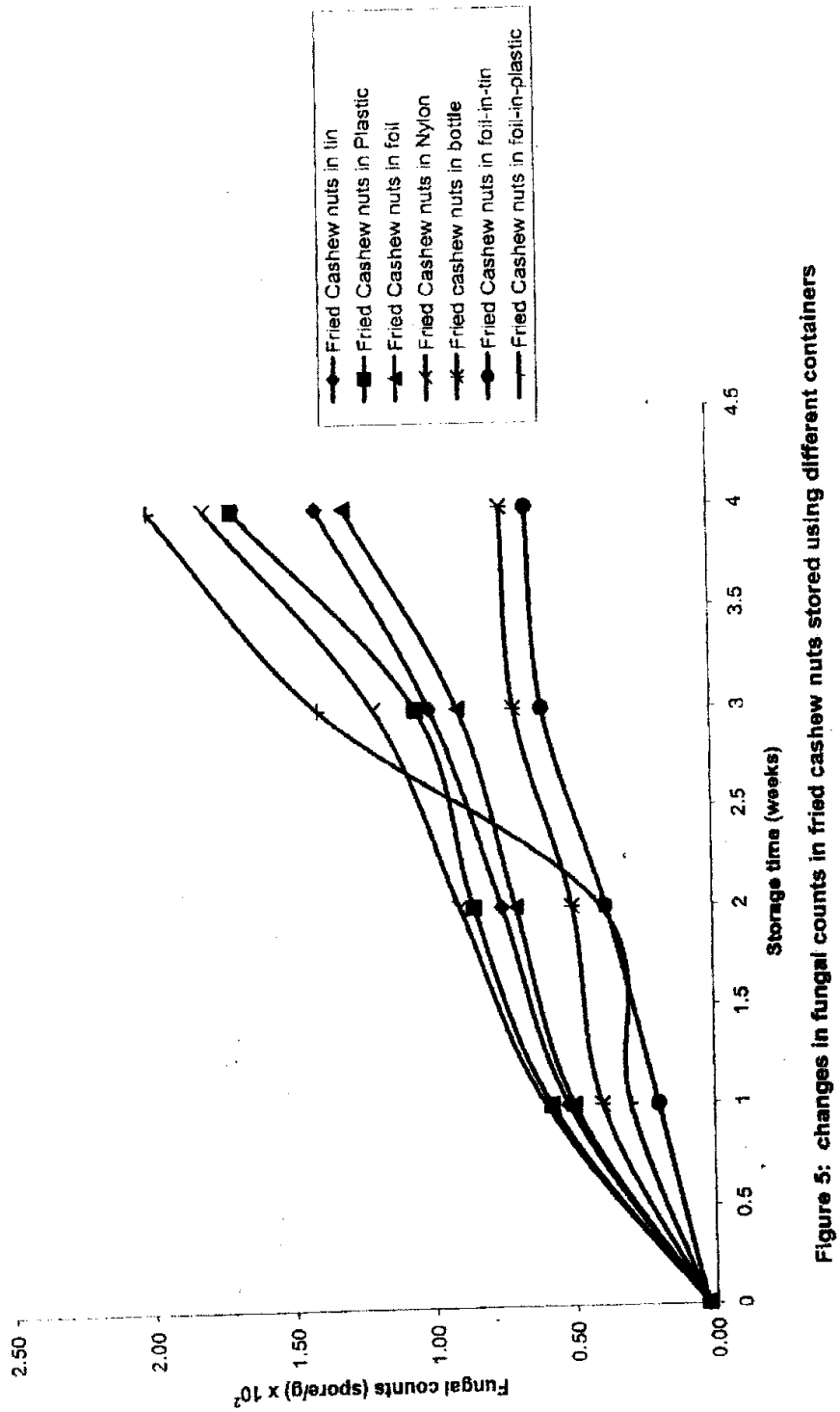


Figure 5: changes in fungal counts in fried cashew nuts stored using different containers

TABLE 1: Mean sensory score of freshly processed cashew samples

Samples	colour	taste	texture
Roasted samples (R)	7.7^{a}	7.0^{a}	8.5^{a}
Fried sample (F)	9.0^{b}	8.5^{b}	7.0^{b}

Note: Values in the same column with the same superscripts are not significantly different, while those with different superscripts are significantly different at $p< 0.05$

Table 2: mean sensory of stored cashew nut samples (four weeks)

Sample	Colour	Taste	Texture
R_4T	7.65^{a}	6.80^{d}	7.10^{e}
R_4P	7.00^{a}	4.00^{a}	3.25^{b}
R_4F	7.10^{a}	4.35^{a}	3.40^{c}
R_4N	7.00^{a}	5.10^{bc}	3.85^{c}
R_4B	7.05^{a}	5.10^{bc}	6.85^{e}
R_4FP	7.20^{a}	5.50^{c}	4.35^{d}
R_4FT	7.60^{a}	5.50^{c}	6.60^{a}
F_4T	8.50^{b}	5.80^{c}	2.75^{a}
F_4P	9.00^{b}	4.80^{b}	2.15^{a}
F_4F	9.00^{b}	5.00^{b}	2.35^{b}
F_4N	8.20^{b}	4.50^{a}	2.15^{a}
F_4B	8.00^{b}	5.75^{c}	3.80^{c}
F_4FP	8.10^{b}	4.60^{b}	4.00^{c}
F_4FT	8.60^{b}	5.60^{c}	4.80

Note: Values in the same column with the same superscripts are not significantly different, while those with different superscripts are significantly different at $p< 0.05$

Key

R- Freshly roasted sample
F- Freshly fried sample
R_4T- Roasted sample stored in tin (four weeks)
R_4P- Roasted sample stored in plastic (four weeks)
R_4F- Roasted sample stored in Foil (four weeks)
R_4N- Roasted sample stored in nylon (four weeks)
F_4FT- Fried sample stored in foil-in-tin (four weeks)
R_4FP- Roasted sample stored in foil -in-plastic (four weeks)
R_4FT- Roasted sample stored in foil-in-tin (four weeks)
F4FP-Fried sample stored in foil -in-plastic (four weeks)
F_4T- Fried sample stored in tin (four weeks)
F_4P- Fried sample stored in plastic (four weeks)
F_4F- Fried sample stored in Foil (four weeks)
F4N- Fried sample stored in nylon (four weeks)
F_4B- Fried sample stored in bottle (four weeks)
R_4B- Roasted sample stored in bottle (four weeks)

Table 3: Mean value for proximate composition of freshly processed stored cashew nut samples (g)

Sample	protein	Moisture	Lipid	Fibre	Ash	Carbohydrate
R	15.42 ± 0.33^{a}	1.61 ± 0.01^{a}	46.13 ± 0.60^{a}	0.82 ± 0.04^{a}	3.62 ± 0.23^{a}	32.40 ± 0.01^{c}
F	17.26 ± 0.27^{b}	4.01 ± 0.11^{d}	49.42 ± 0.16^{b}	1.39 ± 0.08^{b}	3.19 ± 0.20^{a}	26.12 ± 0.38^{b}
R4T	15.30 ± 0.17^{a}	1.68 ± 0.04^{b}	46.05 ± 0.53^{a}	0.80 ± 0.09^{a}	3.46 ± 0.15^{a}	32.71 ± 0.08^{c}
R4P	15.20 ± 0.20^{a}	1.71 ± 0.07^{b}	46.02 ± 0.10^{a}	0.83 ± 0.04^{a}	3.46 ± 0.02^{a}	32.78 ± 0.04^{c}
R4F	15.20 ± 0.06^{a}	1.74 ± 0.01^{c}	46.03 ± 0.12^{a}	0.85 ± 0.20^{a}	3.48 ± 0.32^{a}	32.67 ± 0.20^{c}
R4N	15.30 ± 0.22^{a}	1.69 ± 0.05^{b}	46.10 ± 0.05^{a}	0.90 ± 0.06^{a}	3.46 ± 0.14^{a}	32.55 ± 0.02^{c}
R4B	15.30 ± 0.04^{a}	1.66 ± 0.32^{b}	46.20 ± 0.03^{a}	0.82 ± 0.00^{a}	3.40 ± 0.22^{a}	32.62 ± 0.22^{c}
R4FP	15.29 ± 0.21^{a}	1.80 ± 0.04^{c}	46.02 ± 0.06^{a}	0.80 ± 0.05^{a}	3.33 ± 0.25^{a}	32.76 ± 0.40^{c}
R4FT	15.30 ± 0.17^{a}	1.62 ± 0.06^{a}	45.95 ± 0.12^{a}	0.84 ± 0.03^{a}	$3\ 42 \pm 0.06^{a}$	32.87 ± 0.02^{c}
F4T	17.22 ± 0.02^{b}	4.12 ± 0.11^{d}	48.20 ± 0.12^{b}	1.30 ± 0.05^{b}	3.18 ± 0.04^{a}	25.98 ± 0.06^{b}
F4P	17.24 ± 0.20^{b}	4.00 ± 0.03^{d}	48.02 ± 0.24^{b}	1.40 ± 0.32^{b}	3.24 ± 0.00^{a}	26.10 ± 0.24^{b}
F4F	17.18 ± 0.00^{b}	4.24 ± 0.32^{d}	48.50 ± 0.00^{b}	1.35 ± 0.22^{b}	3.08 ± 0.20^{a}	25.65 ± 0.12^{b}
F4N	17.32 ± 0.32^{b}	4.44 ± 0.04^{d}	48.00 ± 0.24^{b}	1.42 ± 0.33^{b}	3.45 ± 0.06^{a}	25.37 ± 0.11^{b}
F4B	17.20 ± 0.40^{b}	4.02 ± 0.24^{d}	48.62 ± 0.32^{b}	1.28 ± 0.04^{b}	3.20 ± 0.00^{a}	23.88 ± 0.05^{a}
F4FP	17.40 ± 0.22^{b}	4.16 ± 0.34^{d}	48.65 ± 0.28^{b}	1.30 ± 0.22^{b}	3.18 ± 0.11^{a}	25.31 ± 0.24^{b}
F4FT	17.23 ± 0.45^{b}	4.00 ± 0.20^{d}	48.22 ± 0.05^{b}	1.39 ± 0.08^{b}	3.20 ± 0.31^{a}	25.96 ± 0.04^{b}

Note: Values in the same column with the same superscripts are not significantly different, while those with different superscripts are significantly different at $p< 0.05$

Key

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F_4F- Fried sample stored in Foil (four weeks)
F_4N- Fried sample stored in nylon (four weeks)
F_4B- Fried sample stored in bottle (four weeks)
F_4FP- Fried sample stored in foil-in-plastic (four weeks)
F_4FT- Fried sample stored in foil-in-tin (four weeks)

Table: 4 Mean value for Mineral composition of freshly roasted and stored cashew nut samples (mg)

Sample	Calcium	Iron	Magnesium	Manganese	Phosphorus	Potassium	Sodium	Zinc	Copper
R	42.0 ± 0.58 [a]	6.10 ± 0.32[a]	258 ± 0.20[a]	0.8 ± 0.46[a]	433 ± 0.16[a]	542 ± 0.15[a]	16.8 ± 0.40[a]	4.7 ± 0.05[a]	2.5 ± 0.03[a]
F	46.0 ± 0.30 [b]	5.80 ± 0.22[b]	260 ± 0.05[a]	1.2 ± 0.06[b]	490 ± 0.02[b]	575 ± 0.04[b]	17.2 ± 0.24[a]	5.7 ± 0.15[b]	2.2 ± 0.12[a]
R_4T	41.0 ± 0.20[a]	6.05 ± 0.12[a]	250 ± 0.25[a]	0.8 ± 0.22[a]	430 ± 0.28[a]	542 ± 0.15[a]	16.5 ± 0.15[a]	4.7.± 0.22[a]	2.3 ± 0.05[a]
R_4P	41.5 ± 0.45[a]	6.00 ± 1.15[a]	251 ± 1.73[a]	0.8 ± 0.02[a]	433 ± 0.00[a]	541 ± 0.00[a]	16.2 ± 056[a]	4.6 ± 0.35[a]	2.7 ± 0.02[a]
R_4F	41.8 ± 0.15[a]	6.20 ± 0.05[a]	254 ± 0.15[a]	0.8 ± 0.02 [a]	426 ± 0.25[a]	541 ± 0.20[a]	16.0 ± 0.08[a]	4.7 ± 0.03[a]	2.4 ± 0.04[a]
R_4N	42.0 ± 0.12[a]	6.00 ± 0.28[a]	254 ± 0.35[a]	0.8 ± 0.12[a]	426 ± 0.24[a]	541 ± 0.10[a]	16.7 ± 0.50[a]	4.7 ± 0.17[a]	2.5 ± 0.02[a]
R_4B	41.9 ± 0.15[a]	6.08± 0.22[a]	255 ± 0.25[a]	0.8 ± 0.03[a]	425 ± 0.28[a]	541 ± 0.00[a]	16.2 ± 0.00[a]	4.7 ± 0.02[a]	2.4 ± 0.10[a]
R_4FP	42.0 ± 0.00[a]	6.04± 0.01[a]	254 ± 0.08[a]	0.8 ±0.08[a]	426 ± 0.23[a]	540 ± 0.28[b]	16.0 ± 0.04[a]	4.6 ± 0.24[a]	2.5 ± 0.00[a]
R_4FT	41.6 ± 0.06[a]	6.05± 0.20[a]	255 ± 0.03[a]	0.8 ± 0.06[a]	426 ± 0.08[a]	540 ± 0.28[b]	16.0 ± 0.25[a]	4.7 ± 0.20[a]	2.7 ± 0.00[a]
F_4T	45.2 ± 0.35[b]	5.92 ± 0.13[b]	260 ± 0.16[a]	1.2 ± 0.04[b]	490 ± 0.15[b]	570 ± 0.00[b]	17.0 ± 0.15[a]	5.6 ± 0.12[b]	2.2 ± 0.29[a]
F_4P	45.6 ± 0.23[b]	6.05 ± 0.00[b]	261 ± 0.15[a]	1.2 ± 0.10[b]	485 ± 0.25[b]	574 ± 0.05[b]	17.0 ± 0.16[a]	5.6 ± 0.04[b]	2.2 ± 0.24[a]
F_4F	45.8 ± 0.24[b]	6.02 ± 0.12[b]	259 ± 0.00[a]	1.2 ± 0.06[b]	481 ± 0.04[b]	575 ± 0.23[b]	16.7 ± 0.33[a]	5.5 ± 0.24[b]	2.1 ± 0.22[a]
F_4N	45.4 ± 0.23[b]	6.05 ± 0.30[b]	255 ± 0.15[a]	1.2 ± 0.03[b]	480 ± 0.00[b]	573 ± 0.06[b]	16.9 ± 0.58[a]	5.5 ± 0.29[b]	2.2 ± 0.12[a]
F_4B	45.6 ± 0.02[b]	5.8 0 ± 0.22[b]	255 ± 0.60[a]	1.2 ± 0.10[b]	485 ± 0.38[b]	575 ± 0.00[b]	16.0 ± 0.14[a]	5.6 ± 0.06[b]	2.1 ± 0.14[a]
F_4FP	44.8 ± 0.31[b]	5.91 ± 0.06[b]	258 ± 0.24[a]	1.2 ± 0.05[b]	475 ± 0.12[b]	570 ± 0.00[b]	16.5 ± 0.24[a]	5.5 ± 0.06[b]	2.1 ± 0.20[a]
F_4FT	45.8 ± 0.35[b]	6.01 ± 0.06[b]	259 ± 0.00[a]	1.2 ± 0.02[b]	489 ± 0.90[b]	574 ± 0.25[b]	17.0 ± 0.28[a]	5.6 ± 0.10[b]	2.2 ± 0.00[a]

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F_4FP- Fried sample stored in foil-in-plastic (four weeks)
F_4FT- Fried sample stored in foil-in-tin (four weeks)

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