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Effect of antioxidant (BHT) inclusion, temperature and packaging on the flavour score and shelf life prediction of soy-melon enriched 'Gari'

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ABSTRACT

Samples of soy-melon enriched 'gari' a protein enriched, fermented and toasted granular cassava product were produced and subjected to Accelerated Storage Stability study to determine the effect of BHT used as an antioxidant, the type of packaging used and the temperature of storage on the shelf life of the product. 200gms of each sample was packaged into: (i) woven sack (Bacco, Nig PLC) (ii) high density polyethylene (HDPE) film. The packaged samples were stored under three (3) different temperatures, viz: 20 ± 2°C , 30 ± 2°C, and 40 ± 2°C. Butylated Hydroxyl Toluene (BHT) at 200ppm level based on 10% fat content was as added as an antioxidant to some while some contains no antioxidant. Samples were brought out at weekly intervals and subjected to sensory evaluation over a period of 32 weeks by 20 member sensory panel of the Federal University of Technology, Akure, Nigerian in order to determine its shelf life. A nine-point hedonic scoring system was used for the evaluation, where 1 = Extremely disliked and 9 = Extremely liked. Results obtained from the replicate evaluations of each set of samples were pooled and statistically analyzed. Other data on the flavor difference scores for each product were subjected to regression analysis based on the critical minimum panel mean score of 5.0 for shelf stability of the samples. The shelf lives for the samples were determined from the slopes (k) using the half life equation [$k_1 = \frac{0.693}{\theta_{1/2}}$ *]. The shelf lives of samples packaged in HDPE were significantly higher than those packaged in woven sack at lower temperatures but samples packaged in HDPE at 40°C reduced faster in flavor score than those in the woven sack after about 29weeks of storage. Sample without BHT started to depreciate in flavor with burnt off flavor after about 16 weeks of storage.*

Keywords: soy-melon enriched 'gari', enrichment, sensory evaluation, shelf life.

INTRODUCTION

Gari is a fermented, dewatered and toasted granules from cassava which is widely consumed all over West Africa and in Brazil where it is known as 'farinha de manioca' (Lancaster *et al*., 1982). Gari is one of the most popular forms in which cassava (*Manihot utilisima*) also known as manioc is consumed in Nigeria and some other parts of West Africa (Ofuya and Akpoti; 1988; Ogiehor,2002; Kordylas, 1990). It is a major component of everyday diet in

Nigeria providing about 11.835kJ/person/day (Osho, 2003). Gari is of poor quality and low protein content hence there is need for continual investigation into cheaper and better ways of enriching the product in order to improve its acceptability in terms of cost and nutritional quality. The crude protein content of locally produced gari could be as low as 1.03% and levels of cyanide are variable (0 – 32mg HCN equivalent Kg^{-1}) depending on the processing method, variety and locality (Oke 1994). Gari has been shown to be a rich source of energy but of poor protein content (1.03%) compared with soy bean (44.08%). It has low levels of Methionine, Tryptophan, Lysine and Phenylalanine (FAO, 1997). Some efforts have been made to improve the nutrient content of cassava products [Oshodi (1985), Collins and Temalilwa (1991), Banjoh and Ikenebomeh (1996), Osho, (2003) and Oluwamukomi et al., (2005).]. Soy-melon enriched gari is another bold response to this. Soy-melon enriched gari is a product to which soy and melon protein flour had been added during the processing of gari.

Gari is still being packaged, transported and stored in woven sacks with attendant fluctuations in climatic conditions and sometimes it is being sold in the market in bowls with exposed surfaces thus increasing its susceptibility to environmental contaminations (Ogiehor and Ikenebomeh, 2006). The price of gari is subjected to seasonal variation being low in the raining season and high in the dry season, with attendant great hardship to poor members of the society since gari is no more the food of the commoner. Gari is becoming more important in export trade hence it is necessary to monitor what happens to gari during long term storage. With the continued interest in the enrichment of gari with local protein sources from oilseeds, it is necessary to study the methods and the effects of the enrichment on storage stability. In the purchase of fresh samples of gari in the market, appearance which encompasses the colour, finess or particle size seems to be the most striking sensory property attracting a consumer of gari in the market, after this is the taste for some people who love their gari to be sour. However, in the case of soy-melon enriched gari, because of the oily nature of its supplement, flavour is very important in assessing the sensory quality of soy-melon enriched gari that has undergone storage. Various types of compounds responsible for objectionable flavor in soybean products have been isolated as including carbonyl compounds, phenolic acids, volatile fatty acids and amines, volatile neutral compounds, alcohols and phosphatidylcholine. The major volatile constituent is hexanal which has a grassy flavor. It comprises 25% of the volatile fraction isolated from milk (Salunkhe et al., 1992, Iwe, 2003). Reports revealed that the oxidation of phosphadidylcholine results in bitternessas a result of conversionof linoleic acid to 9, 12,13-trihydroxyoctadeca-10-enioc acid and 9, 12,13-trihydroxyoctadeca-11-enoic acid (Iwe, 2003). The origin of flavor compounds is largely attributed to linoleic and linolenic acids and their oxidation and degradation give rise to many of the compounds that contribute to the off flavor of processed soy products. The oxidation can occur by autoxidation and lipogynaase catalysis and soybean is very rich in this lipoxygenase enzyme (MacLeod and Ames, 1988). Non volatile compounds responsible for undesirable taste /flavor include lipid derived compounds such as hydroxyperoxides, trihydroxy and other oxygenated fatty acids, oxidized lecithin and fatty acid dimmers; phenolic acids, isoflavones. Phenolic acids are responsible for the astringent taste (MacLeod and Ames, 1988). Due to the cumbersome nature of production process, the need to have the finished products to cities where large buyers live, the importance of garri in dietary intake and the need to meet the increasing international demand, the evaluation of the effect of packaging materials on the overall quality of garri during distribution and at the point of consumption becomes imperative (Ogiehor and Ikenebomeh , 2005). The objectives of this study are therefore to produce soy-melon enriched residue flours from combination of soy and melon flours; produce soy-melon enriched protein enriched gari from cassava; evaluate the changes in flavour quality during storage; determine the effect of temperature, packaging and use of antioxidant (BHT) on the flavor score and use the flavor scores to predict the shelf life of the soy-melon enriched enriched gari.

MATERIALS AND METHODS

Source of Materials:

Cassava roots harvested and used on the same day, were obtained from the research farm of the Federal University of Technology, Akure, Ondo State, Nigeria. Soybean and melon seeds used to produce the protein supplements were purchased from the Oba market, in Akure, Ondo State, Nigeria. They were sorted, cleaned, packed and kept under refrigeration until use.

Sample Preparation:

Soy-melon enriched gari was produced according to the similar methods of Banjoh and Ikenebomeh (1996) and Adeyemi and Balogh (1985). The Cassava tubers were peeled manually with a sharp knife, washed and grated in a locally fabricated mechanical grater. The grater was made of a flat galvanized sheet punctured with holes with a big nail with opening of 0.75cm diameter and fixed round a drum-like plank. This was connected through a belt to a 7 hp driving motor. The washed cassava tuber was held by hand and ran over the rotating drum with extreme care that fingered and palm are not bruised (Agunbiade, 2001). They were then packed into Hessian sack and allowed to ferment for 72 hours after which they were pressed in a mechanical press (Addis Engineering Nig. Ltd, Nigeria) to dewater the mash. The dewatered wet cassava cake was pulverized with hands and sifted on a locally made raffia sieve of mesh (0.3cm x 0.3cm) mounted on a rectangular wooden frame 40cm^2 to remove the fibers. The sifted cassava meal obtained was enriched with full fat soy-melon using 15% supplementation level and taking into consideration the water content of the mash of 65% (Akingbala *et al*, 1993). The white and fluffy cassava meal was then introduced into a wide iron pan (garifyer) supported and being heated over wood fire. It was being continuously stirred using a self insulating manual baffle made of calabash from gourd. This operation fairly distributes the heat to prevent or limit dextrization of gari. The wet meal was introduced into the garifier piecemeal, amidst continuous stirring, until a full manageable batch is subjectively determined as well toasted. The time taken to get the batch roasted to dryness depends on the experience of the processor (Agunbiade, 2001). The toasted soy-melon enriched gari was removed form the iron pot, spread over a large spread of clean surface of HDPE film and allowed to cool. The cooled gari samples were then packaged in HDPE film and kept under refrigerated storage until ready for further analysis.

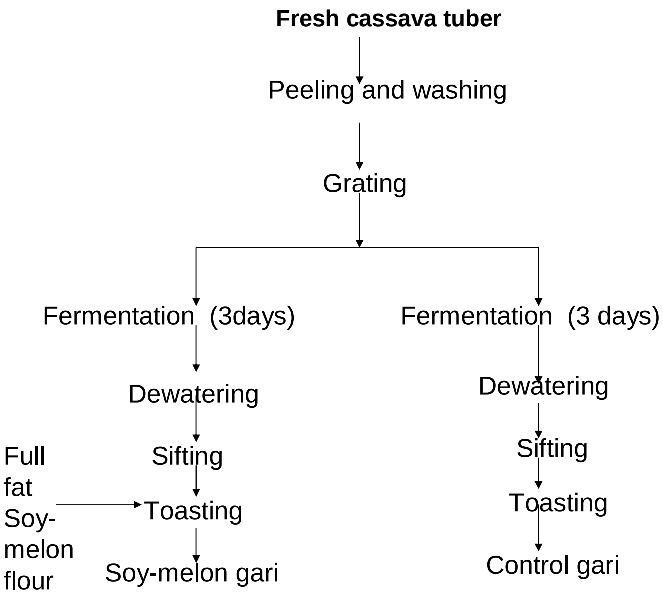

Fig 1: Flow chart of the processing techniques for Control (un-enriched) and Soy-melon enriched gari samples

Sensory Evaluation:

Sensory evaluation of stored soy-melon enriched and control gari

Soy-melon enriched and control gari samples stored at 20, 30 and 40°C were assessed for quality on a nine-point hedonic scale (IFT, 1981) by twenty experienced judges who were used to the consumption of gari. Fifty-gram samples packed and stored in pouches were evaluated for off-flavour at every four weeks interval covering a period of slightly over 32 weeks by a sensory panel consisting of 20 members (Labuza and Schmidl, 1988). Most panel members were undergraduate students and staff members of the Department of Food Science and Technology who were used to the sensory evaluation of gari. Therefore, they were reasonably well trained for sensory tests. They were requested to evaluate differences in overall sensory quality between the control and other samples. A coded control sample was included in each set of samples evaluated in order to check the reliability of each panel member and to provide a base score for each sample series (Kluter et al., 1996). A nine-point flavor scoring system was used for the evaluation. No, slight, moderate, large and extreme differences were represented by scores of 1, 3, 5, 7 and 9, respectively. According to my preliminary test, scores less than 5 represent overall quality comparatively worse than the control gari and scores greater than 5 definitely better than the control gari sample (Hayakawa et al., 1978). In addition to this analysis, all data on the flavor difference scores for each product were subjected to regression analysis. Samples held at 10°C were used as the controls in all flavor evaluations, since the quality of these samples should be almost constant throughout my study. Therefore, the flavor difference scores included the influence of storage time, temperature, packaging, BHT as well as variations due to power outages (Hayakawa et al., 1978). In order to eliminate the influence of power outages, data on the flavor scores of the controls were excluded from the regression analysis since the relative differences in the scores of all other samples should represent the influence of storage time and temperatures. The full fat enriched product was chosen for this study because of its fat content of 13.24% which was the highest in all the samples, and any deterioration during storage will be more pronounced in this sample.

To the full fat soy-melon enriched gari samples was added Butylated Hydroxyl Toluene (BHT) as an antioxidant at 200ppm level based on 10% fat content (Pearson, 1976). 200gms of each sample was packaged into: (i) woven sack (Bacco, Nig PLC) sewn into 15cm X 10 cm size (ii) high density polyethylene (HDPE) film of size 15 x 20cm (50µm [2.15 mils] thickness; water vapour transmission rate: 1.33x 10^{-3}kgmil/m^2/PA) (Labuza et al., 1972). The HDPE pouches were closed by heat sealing taking care that the minimum possible air space remained in the packets and that the packets were leak proof while the mouth of the woven sack was sown properly. The packaged samples were stored under three (3) different temperatures, viz: 20 ± 2°C , 30 ± 2°C, and 40 ± 2°C. A Thermo hydrograph was placed in the storage room to record the temperature and relative humidity of the room atmosphere. Untreated soy-melon enriched gari, without additive, served as control. A control sample was kept in a glass bottle flushed with nitrogen and kept at 20 ± 1°C. Samples were removed monthly and subjected to sensory evaluation. The shelf life of soy-melon enriched and control gari were calculated from the mean panel scores by simple linear regression equation (Hayakawa, *et al*, 1978, Steel and Torrie, 1997). The off flavour estimation through the panel flavour scores is an indication of lipid oxidation leading to the production of hexanal or malonaldehyde and other aldehydes and ketones responsible for off flavour experienced during the storage of soy-melon enriched gari (Iwe, 2003). Appearance of gari which encompasses the colour, finess or particle size seems to be the most striking sensory property attracting a consumer of gari in the market, after this for some people who love their gari to be sour, taste is another important sensory parameter. However, in the case of soy-melon enriched gari, flavour is very important in assessing the sensory quality of soy-melon enriched gari that has undergone storage.

The shelf life of soy-melon enriched gari was calculated from the regression analysis of the sensory scores for the flavor. The shelf lives for the samples at different storage conditions of temperature, packaging and use of antioxidant were determined from the slopes (degradation rate of loss of flavour, k) using the half life equation (1)(Labuza and Kamman, 1983).

$$k_1 = \frac{0.693}{\theta_{1/2}} \qquad 1$$

Statistical Analysis

Means and standard errors of the mean (SEM) of replicate scores were determined and subjected to analysis of variance (ANOVA). Means were separated using The Duncan's New Multiple Range Test (Steel *et al*., 1997). Relevant data were subjected to correlation and regression analyses. All analyses were carried out using Microsoft Excel Office (2003) and the Statistical Package for Social Statistics (SPSS version 10).

RESULTS AND DISCUSSION

Changes in flavour of soy-melon enriched gari under storage

The effects of temperature and packaging, BHT inclusion on the flavour scores of soy-melon enriched gari under storage are presented in Figures 2 &, 3

***(i) Effect of temperature and packaging on the flavour score of soy- melon* gari**

The flavour score decreased with time and temperature of storage ($p < 0.05$). The flavour scores reduced from an average of 7.6 to between 5.8 and 7.2 for the samples at lower temperatures of 20 and 30°C (Figure 2). Those at lower temperatures never reached the critical minimum panel mean score of 5.0 for shelf stability of the samples; but samples kept at 40°C reached the critical mean score of 5 between 16 and 20weeks of storage. This was practically observed as burnt off flavour in the samples in HDPE films which became noticeable between 16-18weeks of storage and became more pronounced after 20 weeks of storage. Soy-melon enriched meal might have provided the protein and lipid necessary for the NEB reaction (Lindsay, 1996). Initial products of NEB may also have been present in toasted gari as a result of heat treatment during the toasting of the soy-melon enriched gari.

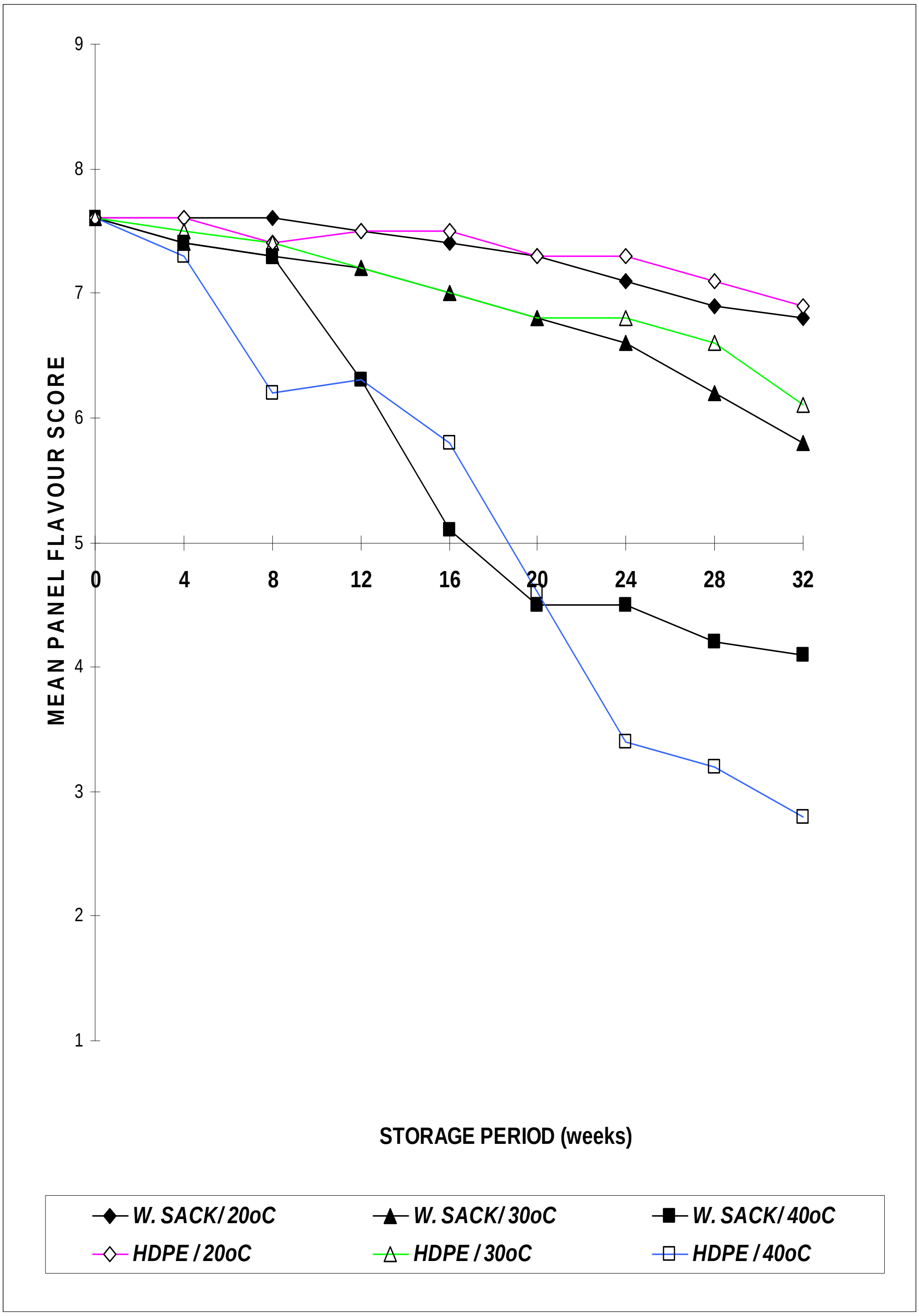

Figure 2: Effect of temperature and packaging on the mean flavour scores of soy-melon enriched gari under storage

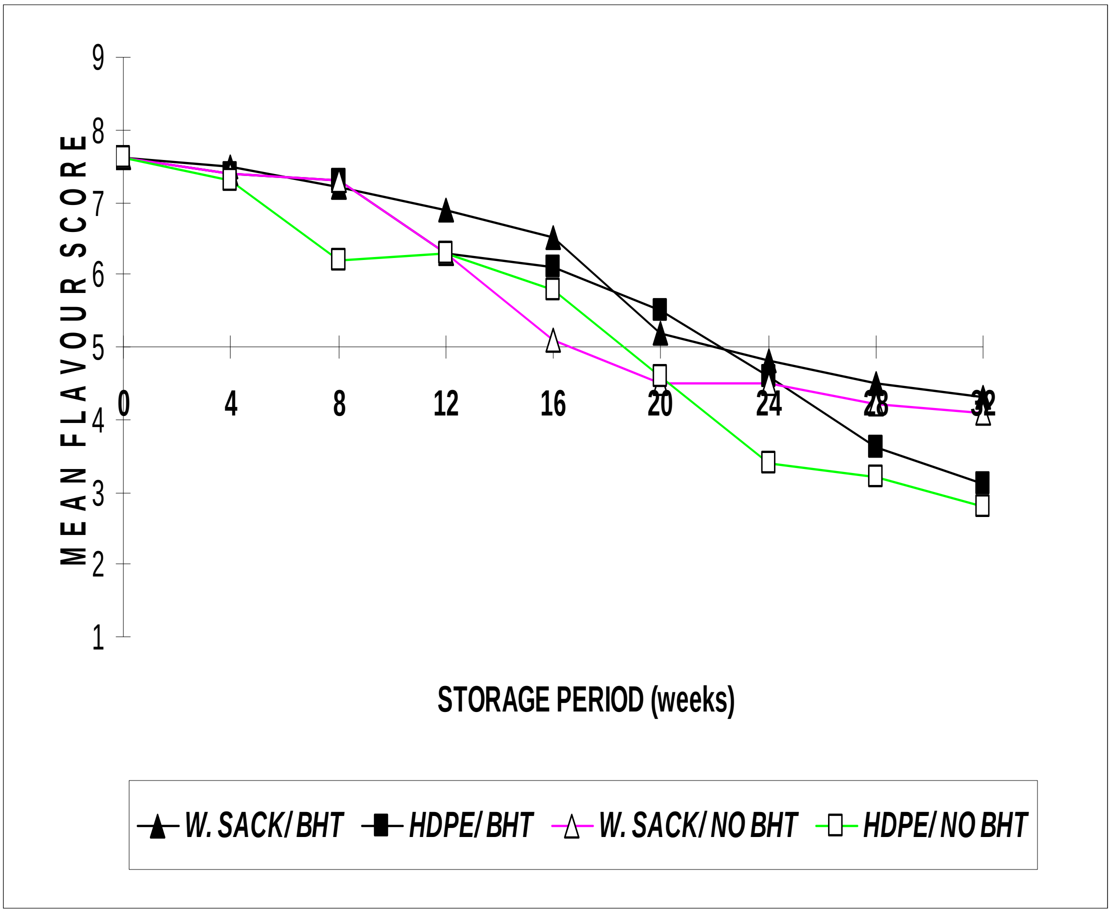

Figure 3: Effect of antioxidant (BHT) inclusion on the mean flavour score of soy-melon enriched gari under storage at 40°C

This might have further led to the progress in NEB during storage. There was no appreciable effect of packaging on the flavour score at the lower temperatures of 20 and 30°C but at high temperature of 40°C there was a significant effect of packaging on the flavour score. Samples packaged in HDPE at 40°C were reduced faster in flavour than those in the woven sack after about 29weeks of storage. This could have been as a result of the direct heating effect on the HDPE at that accelerated temperature of storage and due to permeability of the woven sack which could not retain the product of NEB which could also be responsible for the off-odour. This view was supported by Plahar and Leung (1985) who observed that only relatively little browning occurred for soy-fortified fermented maize meal stored at 25 and 35°C for 130days; but at 60°C sample did not store for more than 10days or 60 days at 45°C.

(ii) Effect of BHT inclusion on the flavour score of soy-melon enriched **gari**

There was no appreciable effect of inclusion of BHT on the flavour score of soy-melon enriched gari at lower temperatures. At the initial period of the study, there was no significant effect of BHT on the samples in the two packaging material, but after about 16 weeks sample without BHT started to depreciate in flavour with burnt off flavour (Figure 3). It was the first to reach the mean critical flavour score of 5 by the 16th week of storage. This was later followed by sample in the HDPE film, while he sample with BHT reached the value by the 22nd week. This means that the effect of BHT on the flavour scores was significant ($P \leq 0.05$). This must have been due to the anti-oxidative or inhibitory effect of BHT on the lipid component thereby limiting or preventing autoxidation which could have led to oxidative rancidity and eventual production of off flavour.

Shelf life prediction using the flavour scores:

The shelf life of soy-melon enriched were calculated from the mean panel scores by simple linear regression equation (Hayakawa *et al.*, 1978; Steel *et al.*, 1997)(Table 1). The off flavour estimation through the panel flavour scores is an indication of lipid oxidation leading to the production of hexanal or malonaldehyde and other aldehydes and ketones responsible for off flavour experienced during the storage of soy-melon enriched gari (Iwe, 2003). The major factor limiting the use of soy products is their off flavor. The presence of a significant amount of polyunsaturated fatty acids and the enzyme lipoxygenase are responsible for the production of off flavour and off aroma compounds at the various stages of processing. In the case of soy-melon enriched gari, flavour is very important in assessing the sensory quality of soy-melon enriched gari that has undergone storage this is due to the fact that the fat content of full fat soy flour used was appreciably high.

(i) Effect of Temperature on shelf life: From Table 1, it could be observed that using flavour score to predict the shelf life of soy-melon enriched gari, the temperature had a significant effect on the shelf life. The shelf life was reduced significantly by increase in temperature ($P < 0.05$). There was a negative correlation between temperature and the flavour score (-0.963). Shelf life of soy-melon enriched gari on the basis of flavor assessment decreased from 101 weeks at 20°C to 21 weeks at 40°C for those packaged in Woven sack and from 133 weeks at 20°C to 17 weeks at 40°C for those packaged in HDPE film. The higher the temperature, the shorter the shelf life.

Table1: Predicted shelf life (weeks) of soy-melon enriched gari based on Regression analysis (Score = k(θ) + c)of the Mean Flavour score during storage

Effects	Storage conditions		Slope=degradation rate of loss of flavour (k)	Intercept	Shelf life (weeks)
EFFECT OF TEMPERATURE & PACKAGING	20°C	W.SACK/20°C	-0.027	7.74	101
		HDPE/20°C	-0.020	7.66	133
	30°C	W.SACK/30°C	-0.052	7.71	52
		HDPE/30°C	-0.043	7.68	62
	40°C	W.SACK/40°C	-0.129	7.73	21
		HDPE/40°C	-0.162	7.83	17
EFFECT OF BHT 0INCLUSION	With BHT	W.sack/40°C	-0.012	7.96	247
		HDPE/40°C)	-0.148	8.09	21
	Without BHT	W.sack/40°C	-0.162	7.83	17
		HDPE/40°C	-0.129	7.73	21

W.SACK = Woven Sack
HDPE= High Density Polyethylene film

(ii) Effect of packaging material on shelf life:
The shelf lives of samples packaged in HDPE at 20 and 30°C were higher than those packaged in woven sack, but at 40°C the shelf life of the sample in HDPE was slightly lower than that of woven sack by just 3 weeks. This was surprising in that one would have expected the sample in woven sack to have a shorter shelf life than that of HDPE. This shows that storing soy-melon enriched gari with HDPE at accelerated temperature above 40°C for more than 32 weeks may not be very advantageous. It produced gari of burnt flavour and bulging packaging film. This might have been due to exposure to light and heat radiation on continuous basis for 32 weeks and the retained evaporated water and air which could not escape outside the packaging film. In order to obtain better shelf life at the high temperature of 40°C and above, it may be necessary to prevent this direct exposure by combining the two packages together by lining the inside of the woven sack with the HDPE film.

(iii) Effect of BHT shelf life:
There was a significant effect of BHT on the shelf life of soy-melon enriched gari during storage ($P < 0.05$). Samples packaged with BHT would keep for 247weeks in woven sack while those without BHT will only keep for weeks. Those in HDPE film at temperature higher than 40°C would only keep for 21 weeks whether there is antioxidant or not.

CONCLUSION

On shelf life determination, the shelf life was reduced significantly by increase in temperature. The higher the temperature, the shorter the shelf life. On the basis of packaging, the shelf life of samples packaged in HDPE at 20 and 30°C were higher than those packaged in woven sack, but at 40°C the shelf life of the sample in HDPE was lower This shows that storing soy-melon enriched gari at accelerated temperature above 40°C may not be advisable. It produced gari of brown colour, burnt flavour and bulging HDPE film; because the extended storage at 40oC changed the integrity of the HDPE film structurally. Besides the effect on moisture permeability/permittivity, gas exchange across the film is affected. This shorter shelf life for sample packaged in HDPE and kept at 40^{o}C must have been due to the effect of the prolonged heating which was felt more in the sample than the other samples. To prevent this direct exposure it may be necessary to combine the two packages by lining the inside of the woven sack with HDPE film. This will go a long way in limiting the rate of moisture absorption, the rate of microbial proliferation, and keeping the system impermeable to air and exposure to heat and light. Enrichment also reduced drastically the shelf life when soy-melon enriched gari was stored at elevated temperature of 40^{o}C. The oil in the full fat soy and melon meal must have been responsible for this. To prevent this, enrichment with defatted supplement should be encouraged wherever it is possible in other to increase the shelf life.

Shelf life prediction by the sensory evaluation methods correlated positively with those of half life and shelf life plot methods used in this study. What this means is that any of these methods that correlated positively with sensory evaluation, could be used to predict the shelf life of soy-melon enriched gari successfully. Soy-melon enriched gari should be stored at temperature lower than 40^{o}C and in a non-humid atmosphere.

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