Preliminary Investigations On Some Mechanical Properties Of Selected Plastic Packaging Materials For Gari Packaging In Nigeria

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Abstract: Preliminary investigations on the Comparative Tensile Strength (CTS) and Percentage Elongations (PE) of some selected plastic materials used for gari packaging and storage was carried out. With the initial CTS and PE determined, 500g each of freshly produced gari were packaged in a 20 x 40cm polyester, polypropylene and hessian bags respectively. The CTS and PE were determined on monthly basis for 6 months at three replicates each. The results show that the polyester, polypropylene and hessian bags had initial CTS of 0.98, 3.19, 3.68 and PE of 57.0%, 17.0%, and 14.0% respectively. The CTS of all the packaging materials decreased with increase in storage duration. PE decreased by 75% and 53% for polyester and polypropylene bags, while it increased by 7% in hessian bags. CTS and PE of packaging bags were significantly lower ($p<0.05$) than their initial values. The CTS of polypropylene and hessian bags were lower than their threshold values of 1.49 and 1.2N/mm indicating their unsuitability for long term storage of gari, while for polyester bag it is still within the threshold value. However, further work should be carried out to ascertain the probability of the effects of the composition of gari on the effects of these mechanical properties.

Keywords: Gari, packaging, storage, hessian, polyester, polypropylene

1. INTRODUCTION

The role of packaging in the food industry and imperativeness to the consumer include protection, containment, transportation, preservation and advertisement [1] [2] [3]. Packaging makes food more convenient and gives the food greater safety assurance from microorganisms, biological and chemical changes such that the packaged foods can have a longer shelf life. As a result packaging became an indispensable element in the food manufacturing process. In order to meet huge demand of the food industry, there was remarkable growth in the development of food packaging in the past decades. Now more than 30 different plastics are being used as packaging materials [1]. Also different types of additives such as antioxidants, stabilizers, lubricants, anti-static and anti-blocking agents have been developed to improve the performance either during processing and fabrication or in use of these polymeric packaging materials. Nevertheless concern about the wholesomeness and safety of foods has increased dramatically recently. Most concern usually focuses on harmful substances from packaging to foodstuff additives both those added intentionally to the foods and those ending up in the food from the packaging material or processing equipment [4]. In the area of packaging material plasticiser migration from food contact materials into food had raised many concerns in recent times [5]. Food packaging is seen as a vital link in the overall chain of food production, processing, marketing and consumption.

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Food packaging is an integral part of the processing and preservation of these staple foods and can also minimize many of the potential spoilage changes, imparting improved keeping quality and increased shelf-life to the processed and packaged food [6]. Transparent plastic films are being increasingly adopted in the packaging of a variety of foods. Low-density polyethylene commonly called polythene is the best known. The adoption of this film in several developing nations for packaging has significantly improved the display of ready to eat food from aesthetic and hygienic point of view. They are used to package both solid and liquid foods. They are particularly useful for dry products such as gari, sugar, coffee and cocoa powder as the items remain dry for a long time if properly sealed [7]. There are several plastics and films adoptable for food packaging. It has been reported that these includes regenerated cellulose (cellophane), cellulose acetate, polymid (nylon), rubber-hydrochloride (pliofilm), polyester resin, polyethylene resin, polypropylene resin, polystyrene resin, polyvinlidene chloride and polyvinylchloride [8] [9]. The knowledge of the mechanical and physical properties of plastic packaging films is important in its selection and suitability for the packaging of various products. The physical properties include density, flammability, water absorption, while the mechanical properties include the tensile strength, coefficient of friction, Rockwell-hardness etc. Earlier works [10] [11] [12] have highlighted factors that influence the choice of food packaging materials such as geometric properties (shape and size), chemical property (pH), physical properties (colour, aero and hydrodynamic properties) and thermal properties of the food material. Other factors known to influence the choice of packaging material of food products include permeability characteristic, mechanical strength, light transmission and temperature change [9]. Thus the degree of permeability of the packages to water vapour, gases and volatile odor compounds is pertinent in packaging consideration. Products with low equilibrium relative humidity tend to absorb moisture particularly in high humidity atmospheres and this can cause significant textural distortion. Also, packaging material should be able to withstand change in temperature which is likely to be encountered without any loss in performance or appearance. Therefore the rate of change of temperature and the type of heat may influence the choice of packaging material [13]. Gari is a granulated, white or yellowish product produced from fresh cassava tubers. The processing steps of gari production from cassava include harvesting, peeling, washing, grating, fermentation, dewatering, sieving, frying/garification, cooling and packaging. It is a dehydrated, storage cupboard, staple food, consumed raw or cooked. Gari easily absorbs moisture from the air due to its hygroscopic nature and should be packed in airtight moisture proof bags. When properly packaged and stored in a dry environment, gari will store for up to 6 months [14]. Gari produced in Nigeria are usually sold from open containers, polyethylene sheets or mats using small measures. Due to the problem that exists in the packaging of products emanating from cassava roots, the use of polyethylene materials has been suggested [7]. Previous work has been carried out on the effects of some packaging materials, storage methods and storage duration on the proximate, biochemical and microbiological properties of gari in storage [15] [16]. There are however limited information on the effects of gari on these packaging materials in storage. Therefore the main objective of this work is to carry out preliminary investigations on the effects of packaged gari on some mechanical properties of the packaging materials in storage.

2 MATERIALS AND METHODS

2.1 The Determination of the initial Comparative Tensile Strength and Percentage Elongation of selected packaging materials

The comparative tensile strengths of the polyester, polypropylene and hessian bags were determined using the standard procedure SP 0012-1: 2005 adapted from BS 903-A1:1995 used to compare the tensile strength of sheets of materials, such as plastics, films, paper and card or metal foils. The comparative tensile strength of the materials was determined using a Monsanto (tensiometer KRA-100T) in the Mechanical Engineering department of Ladoke Akintola University of Technology Ogbomoso, Nigeria. A gauge length of 65mm and width of 8mm was chosen as the test piece of the polyester, polypropylene and hessian bags. The grips on the Monsanto (tensiometer KRA-100T) were fixed and the test piece inserted with the spring beam suitable for the particular test. The test piece was loaded until the mercury in the glass tube reached zero point. The test piece was loaded uniformly, taking readings of load and extension until the mercury reading was constant. At this point maximum load was achieved and the test pieces come apart. The total length and the width of the smallest portion of the test piece were measured using a steel rule for each of the test piece. The experiments were carried out in three replicates.

Calculations:

The comparative tensile strength (σ) and percent elongation (ϵ) were determined for each of the test piece using the following equations: -

$$\sigma = \frac{F}{w} \quad (1)$$

$$\epsilon = \frac{l}{lo} \quad (2)$$

Where,

F = Maximum load (N)
w = Width (mm)
l = Final length (mm)
l_o = Original length (mm)

2.2 Experimental set up

Freshly harvested cassava was processed into gari. The processing steps for producing gari from cassava include harvesting, peeling, washing, grating, fermentation, dewatering, sieving, roasting, cooling and packaging. Two hundred grams (200g) of the freshly produced gari were packaged in a 20 x 40cm polyester, polypropylene and hessian bags. The packaged gari were stored for six months. The comparative tensile strength and percent elongation of the packaging materials were evaluated on monthly basis to determine the effect of packaged gari and storage duration on the comparative tensile strength and percent elongation of the bags.

3 RESULTS AND DISCUSSION

The comparative tensile strength and percent elongations of packaging materials used for the packaging and storage of gari determined on monthly basis are as presented in Table 1 for the polyester, polypropylene and hessian bags respectively. The result showed that comparative tensile strength and percent elongations of the packaging materials decreased as the storage duration increased. The analysis of variance showed that the storage duration had significant effects ($p<0.05$) on the comparative tensile strength (Table 2) and percent elongations (Table 3) of all the packaging materials. The comparison means is as shown in Table 4 and Table 5. The comparative tensile strength of polyester and polypropylene bags decreased to the third month of storage and then it remained stable with no significant difference to the end of the six months of storage (Table 4). It however varied to the end of storage in hessian bag to the end of storage. The percent elongations are significantly different all through to the end of storage, but there are no significant differences in the second and third months for all the packaging materials (Table 5). In general the strain is observed to increase as the stress increases for all the packaging bags at all the storage conditions.

Table 1: The monthly comparative tensile strength and percent elongation of packaging materials

Month	*ETS*	*EE*	*PTS*	*PE*	*HTS*	*HE*
0	0.98	57.0	3.19	17.0	3.68	14.0
1	0.59	12.0	0.35	6.0	0.25	10.0
2	0.60	10.0	0.60	8.0	0.62	9.0
3	0.36	10.0	0.37	8.0	0.50	9.0
4	0.33	7.0	0.36	7.0	0.44	8.0
5	0.34	9.0	0.39	9.0	0.47	8.0
6	0.36	14.0	0.37	8.0	0.44	7.0

Where;

ETS = Comparative tensile strength of polyester bag

EE = Percent elongation of polyester bag

PTS = Comparative tensile strength of polypropylene bag

PE = Percent elongation of polypropylene bag

HTS = Comparative tensile strength of hessian bag

HE = Percent elongation of hessian bag

Table 2: The ANOVA for comparative tensile strength of the selected packaging materials

Materials	Sum of squares	Df	Mean sum	F	Sig.
Polyester	1.025	6	0.171	35.913	0.000
Polypropylene	20.058	6	3.343	690.292	0.000
Hessian	26.988	6	4.498	671.341	0.000

Table 3: The ANOVA for percent elongation of the selected packaging materials

Materials	Sum of squares	Df	Mean sum	F	Sig.
Polyester	5688.00	6	948.0	717.405	0.000
Polypropylene	240.00	6	40.0	58.947	0.000
Hessian	93.303	6	15.55	61.383	0.000

Table 4: The mean[1,2] effect of storage duration on the comparative tensile strength of selected packaging materials

Duration (month)	Polyester	Polypropylene	Hessian
0	0.98^{a}	3.19^{c}	3.68^{d}
1	0.59^{b}	0.35^{a}	0.25^{a}
2	0.60^{b}	0.60^{b}	0.62^{c}
3	0.36^{c}	0.37^{a}	0.50^{c}
4	0.33^{c}	0.36^{a}	0.44^{b}
5	0.34^{c}	0.39^{a}	0.47^{c}
6	0.36^{c}	0.37^{a}	0.44^{b}

[1] Means of three replicate [2]Means with the same letters for a particular measurement are not significantly different ($p \leq 0.05$)

Table 5: The mean[1,2] effect of storage duration on the percent elongation of selected packaging materials

Duration (month)	Polyester	Polypropylene	Hessian
0	57.0^{e}	17.0^{d}	14.0^{e}
1	12.0^{c}	6.0^{a}	10.0^{d}
2	10.0^{bc}	8.0^{bc}	9.0^{c}
3	10.0^{bc}	8.0^{bc}	9.0^{c}
4	7.0^{a}	7.0^{ab}	8.0^{bc}
5	9.0^{b}	9.0^{c}	8.1^{b}
6	14.0^{d}	8.0^{bc}	7.0^{a}

[1] Means of three replicate [2]Means with the same letters for a particular measurement are not significantly different ($p \leq 0.05$)

The baseline a value of 100µm thickness of the selected packaging films is such that certain factors that can cause food deterioration during storage are inhibited [3] [17]. For instance mechanical forces of vibration, compression or abrasion would be taken into account by the highlighted mechanical strength of the films. Contamination by microorganisms, insect or pest would partly be addressed by the tensile strength while climatic factors that cause physical and or chemical changes such as ultraviolet light are addressed by the light transmitting property of the packages [4] [17]. For instance the contaminant due to the tensile strength will not be able to penetrate into the gari unless there is deformity such as pinholes or wetted where there is higher pressure outside than inside the packages containing the gari. The comparative tensile strength and percentage elongation of polyester bags was observed to decrease sharply to about 40 and 79% respectively of its initial values in the first month of storage. The results showed that the comparative tensile strength and percentage elongation of polyester bag decreases as the storage period increase; it decreased from the initial values of 0.98 N/mm to 0.36 N/mm and 57 to 14% after six months of storage which represents 63% and 75% respectively of their initial values. These decreases were due to the changes in the relative humidity and temperatures of the storage condition, composition of gari as well as the duration of the storage period. The decrease in the comparative tensile strength of the hessian and polypropylene bags were below the threshold values of 1.49 N/mm and 1.2N/mm indicating their unsuitability for long term storage at the storage condition evaluated, while for polyester bag it is still within the threshold value of 0.30 N/mm.

4.0 CONCLUSION

The comparative tensile strength and percent elongation are affected by storage duration. Comparative tensile strength of hessian and polypropylene bags are not retained for six month making these materials unsuitable for long term storage. Polyester bags retained its tensile strength throughout the test period and so the most suitable for gari packaging in terms of the retained property. However further analysis should be carried out to ascertain the effects of the chemical components of gari on the mechanical properties of these packaging materials.

References

[1]. British Plastics Federation – BPF (2005). Plastic packaging. Retrieved on February 2, 2006, from http:// www.bpf.co.uk.

[2]. Schmidheiny, S.; Chase, R. and De Simoine, L. (1997). Signals of change: business progress towards sustainable development, the world business council for sustainable development.

[3]. Oyelade, O. J. (2005). Moisture sorption phenomena and their effects on film packaging of cassava, (Manihot esculenta, crantz), yam (Discorea rotundata, Poir) and maize (Zea mays, Linn) flour. Unpublished Ph.D Thesis. Department of Agric Engineering, University of Ibadan, Nigeria.

[4]. Norman, N. P and Joseph, H. H. (1998). Food Science. 5th edition. Springer, New York.

[5]. Oi-Wah, L. and Siu-Kay, W. (2000). Contamination in food from packaging material. Journal of Chromatography, 882: 255–270.

[6]. Tehrany, E.A.; Fournier, F. and Desobry, S. (2005). Simple method to calculate partition coefficient of migrant in food simulant/polymer system. Journal of Food Engineering, (in press).

[7]. Charles, F.; Sanchez, J. and Gontard, N. (2006). Absorption kinetics of oxygen and carbondioxide scavenger as part of active modified atmosphere packaging. Journal of Food Engineering, 72: 1-7.

[8]. Smith, J. P.; Ramaswamy H. S. and Simpson, B. K. (1990). Development in food packaging technology. Pact 2: Storage aspects. Trend in Food Science and Technology, 11: 111-118.

[9]. Smith, J. P.; Hoshino, J. and Abe, Y. (1995). Interactive packaging involving sachet technology. In M.L Rooney (Ed) Active Food Packaging. pp143-173. Blackie Academic and professional.

[10]. Yosida, C. M. P.; Antunes, A. C. B.; Alvear, C. and Antunes, A. J. (2005). An absorption model for the thickness effect in hydrophilic films. International Journal of Food Science and Technology, 40: 41-46.

[11]. Lawson, G.; Bartyman S.; Fitchmes, S. and Woodland, E. D. (2000). MALDI – MS and calorimetric analysis of diisocynate and polyol migrants from model polyurethane adhesives used in Food packaging. Analysts 125 (1): 115-118.

[12]. Sustainable Asset Management (SAM), (1999). Sustainability in the food industry: Future trends and challenges for sustainable business, http://www.samswiss.ch/ e_main_research.html.

[13]. Kim, S. J and Ustunol, Z. (2001). Solubility and moisture sorption isotherms of whey –protein– based edible films as influenced by lipids and plasticizer incorporation. Journal of Agricultural and Food chemistry 49: 4388-4391.

[14]. Chuzel, G. and Zakhia, N. (1991). Adsorption isotherms of gari for estimation of packaged shelf-life. International Journal of Food Science and Technology, 26: 583–593.

[15]. Ogiehor, I.S. and Ikenebomeh, M. J. (2004). Quality characteristics of market garri destined for consumption in ten selected Nigerian states: Baseline for industrialization. Advances in Natural and Applied Sciences Research 2(1): 17-25.

[16]. Adejumo, B.A and A. O. Raji (2012). Microbiological Safety and Sensory Attributes of Gari in Selected Packaging Materials. Academic Research International, 3(3): 153 – 161. ISSN-1: 2223 – 9553; ISSN: 2223 – 9944. www.journals.savap.org.pk

[17]. Lee, D.S.; Jang, J.D. and Hwang, Y. (2002). The effects of using packaging films with Different permeabilities on the quality of Korean fermented red pepper paste International Journal of Food Science and Technology 37: 255-261