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Effects of cooking oils and packaging media on quality of meat floss

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Abstract

Meat floss (MF) is one of the popular ready-to-eat meat products among the elites of northern Nigeria, which is fast extending to some other parts of the country because of its long shelf-life at room temperature. Nonetheless, there is little documentation on the keeping quality during storage when MF is prepared from different cooking oil and packaged in different materials. In this study, meat floss was produced from raw beef (3kg) by cooking, cooling, shredding and deep frying. The deep frying was done in three cooking oils (groundnut oil - GO, soya oil - SO and palm oil - PO) and the products were packed in three materials (acrylic bottle - P_1, polyethylene - P_2 and polyamide - P_3). The frying was done using 1 litre each oil to 500 g of shredded meat, continued until golden brown colour was reached at about 20 minutes. The iodine number of each of the three oil types, and the crude protein and moisture contents of the raw meat and freshly prepared meat floss were determined. At 7, 14 and 21 days of storage the meat floss types were assessed for microbial growth and Thiobarbituric Acid Reactive Substances (TBARS). The study was a 3 x 3 factorial experiment fitted into completely randomized design replicated three times. The GO had highest iodine number (38.83) and PO had the least (28.00). The protein content of MF (43.93%) was higher than that of raw meat (21.79%). The MFSO was richest in crude protein (44.54%) but MFPO had highest moisture content (14.33%). The microbial load (1.49 $log10^{-2}$cfu/cm^2) and TBARS (0.82mg MDA/kg) of fresh MFSO was highest. The microbial load decreased with storage, with highest values obtained in MFSO on 0, 7 and 14 days. However on day 21, the three MF types had similar lowest microbial load. The polyamide pack had the highest microbial load throughout the storage period. Conversely, the TBARS of MF prepared from the three oils and stored in the three materials increased with storage for 21 days, with highest values obtained in MFSO and in polyamide. Nonetheless, all values obtained for microbial load and TBARS during storage did not exceed the threshold values for spoilage of stored meat products. It can be inferred from the study that though meat floss produced from palm oil and packed in acrylic bottle stored best, any of the three oils and any of the three packaging media retained the keeping quality of beef meat floss for 21 days at room temperature.

Keywords: Cooking oils, lipid oxidation, meat floss, microbial growth, packaging media

Introduction

Meat is an excellent source of many essential nutrients and makes an important contribution to a balanced diet (Presswood, 2012). Its high nutrients make it prone to spoilage that can be prevented by value addition (Anna *et al*., 2005). This involves processing and preservation of meat so as to prolong its shelf-life and improve the acceptability (Eyas Ahmed *et al*., 2007).

Dehydration is one of the oldest forms of meat preservation. Dehydration of meat can be achieved through many processes, which include deep frying. Palatability of fried food is related to unique sensory characteristics, including flavour, texture and appearance (Saguy and Dana, 2003). The uniqueness in the sensory characteristics is produced as a result of degradation of certain lipids in frying fats or

oils which generate the characteristic flavour of fried foods (Pokorny, 1999). Therefore, the type of oil used for frying has significant influence on the quality and shelf-life of fried food because frying oils are absorbed by cooked food and so become part of the food (Mihaela *et al*., 2010).

Food spoilage is a metabolic process that causes foods to be undesirable or unacceptable for human consumption due to changes in sensory characteristics (Doyle, 2007). Oxidation is the major cause of spoilage in lipid-containing foods. Deleterious changes in foods caused by lipid oxidation include loss of flavour or development of off-flavours, loss of colour, nutrient value and the accumulation of compounds, which may be detrimental to the health of consumers (***Wasowicz, 2004)***. Furthermore, microbial contamination and subsequent growth also reduce the shelf-life of foods and increase the risk of food borne illness (Kerry *et al.,* 2006).

Extension of the storage period of food with retention of quality is very important in the food industry. Most researches have been centered on quality changes occurring in meat and meat products during storage in response to different packaging conditions. However, few studies have looked into the effect of packaging materials on the keeping quality of the product during storage. Hence, this study was designed to evaluate the keeping quality during storage of meat floss produced from three frying oil types and packed in three different packaging media.

Materials and methods

Experimental design

The study was a 3 x 3 factorial arrangement fitted into a completely randomized design. The cooked meat samples were allotted randomly to the three oil types (groundnut oil - GO, soya oil – SO and palm oil – PO) and the resulting meat floss products were stored in three different packaging materials: Acrylic bottles, Polyethylene and Polyamide. Each treatment was replicated three times**.** The three oil types were purchased from a standard supermarket. The palm oil was thermally bleached before using it for meat floss production. This was achieved by heating the oil to a temperature of 120 ºC (using a kitchen thermometer) and maintaining this temperature until the oil became almost white in colour.

Collection and Preparation of meat sample

The meat used for this study was the semi-tendinosus of a matured bull. This was purchased in a commercial abattoir and transported to the laboratory within one hour of postmortem to avoid the onset of rigor mortis of the muscles. All visible dirt, fats, connective tissues and ligaments were trimmed off the meat and washed with cool clean water. They were cut into chunks with average weight of 100 g each. Thirty chunks were randomly selected to have three kg of fresh meat for each oil type. The moisture and crude protein contents of the raw meat were 78.07±0.75% and 21.79±0.85% respectively (n=3).

Production of meat floss

The steps involved in production of the meat floss were spice mixture preparation (cooking and shredding recipes), meat preparation, cooking, shredding, frying and de-oiling following Kassim (2013). All the steps were carried out in the Meat Science Laboratory, Department of Animal Science, University of Ibadan, Nigeria. The compositions of the two recipes are given in Table 1. The spices were separately enveloped and oven-dried at 60 °C for three hours. Garlic was cut into small pieces and air-dried at room temperature (28 °C). The spices were singly milled in a table top grinder (model BLST MG PN. 133093-002) and sieved through a 1.0 mm diameter mesh to remove the coarse particles. The onion was weighed wet, thinly sliced and added during cooking and shredding at a ratio of

120 g of onion to 100 g of dried recipe powder.

The meat chunks were cooked in a pot on an electric hot plate (Pifco Japan Model number ECP 2002) with water added at the ratio of 1.5 litres to 1.0 kg of meat and the cooking recipe added at a ratio of 1 g to 100 g of meat. The cooking was done at an internal temperature of 72 °C until the broth completely dried on the meat. The meat samples were removed from the pot and spread on a tray to equilibrate to room temperature.

Table 1: Composition (g/100g) of cooking and shredding recipes used for meat floss production

Ingredients /seasoning	Scientific/*Botanical names	Quantity (g/100g)
	Cooking Recipe	
Salt	Sodium Chloride	10.00
Maggi (Knorrs®)	Maggi	15.00
Thyme	*Thymus vulgaris* L.	12.50
Curry	*Murraya koenigii* (L.) Spreng.	12.50
Onions	*Allium cepa* L. var. *cepa*	50.00
Total		100.00
	Shredding Recipe	
Red Pepper	*Piper nigrum* L.	35.00
Maggi (Knorr®)	Maggi	30.00
African Nut Meg	*Monodora myristica* (Gaertn.) Dunal	2.50
Ginger	*Zingiber officinale* Rosc.	4.00
Garlic	*Allium sativum* L.	3.00
Cloves	*Syzygium aromaticum* (L.) Merr. et L.M. Perry	2.50
Curry powder	*Murraya koenigii* L.	3.50
Thyme leaves	*Thymus vulgaris* L.	2.50
Salt	Sodium Chloride	5.00
Onions	*Allium cepa* L. var. *cepa*	12.00
Total		100.00

Source: Kassim (2013)

* All botanical names according to Rehm and Espig (1991)

The cooled meat samples were randomly allocated to oil types. Each was shredded by pounding with a local mortar and pestle with shredding recipe added a little at a time in the ratio 1 g to 20 g of meat. The shredded meat was deep-fried in each oil type (pre-heated to 180°C) in the ratio of 1 litre to 500 g of meat. The meat was fryied at 70 strokes per minute for about 20 minutes until it turned golden brown in colour. The product was emptied into a colander and pressure applied to drain out excess oil and obtain a dry spongy product (meat floss). Upon cooling the meat floss types were separated into strands and immediately packed into nine each of the three packaging materials and left at room temperature. At 7, 14 and 21 days of storage of the meat floss three packs (replicates) were randomly selected from each package types and used for the various analyses.

Parameters measured

The parameters measured were iodine values of the different vegetable oils (using Wji's method), the moisture and crude protein contents of the raw beef and the beef meat floss, all according to AOAC (1990). Other parameters measured for 7, 14 and 21 days of storage of the beef meat floss were microbial growth by total plate counts (TPC) and lipid oxidation by determining the Thiobarbituric Acid Reactive Substances (TBARS).

Microbial growth analysis

Meat floss samples (10 g) were homogenised with 90 mL of 0.1% (W/V) peptone water for 1 minute at room temperature using a blender with plate 5

mm (model 242 Nakai, Japan). Appropriate serial dilutions were prepared in 0.1% (W/V) peptone water solution. 1 mL of homogenate of each sample was spread on petri plates using a pour plate technique. This was then incubated at 35 ºC for 48 hours. Colonies that appeared at the end of the incubation period were counted and the data was expressed as logarithms of the colonies forming unit (log $_{10}$CFU/g) sample. All analyses were done following the procedures described by Seydim *et al*. (2006) and all analyses were carried out in triplicates.

Thiobarbituric Acid Reactive Substances Test

The distillation method developed by Tarladgis *et al*. (1964) was used with some modifications Torres and Okani (1997). Ten (10) g of sample and 50 ml of distilled water were put in a beaker and homogenized for two minutes. The homogenate was transferred to a Kjeldahl flask. Subsequently, 47.5 mL of distilled water, 2.5 mL of HCl (4 mol/L), some anti-foaming drops, some glass beads, and 2 mL sulfanilamide solution (0.5% in 20% HCl solution) were added. The mixture was then distilled under intensive heating until 50 mL of distillate was collected in an Ernlemeyer flask. The flask was agitated. Five (5) ml aliquot was then withdrawn and transferred to test tubes to which 5 mL of 2-TBA solution (0.02 mol/L) were further added. The test tubes were closed and heated in a water bath at 96 °C for 35 min. After cooling, absorbance at 532 nm was read using an UV-vis spectrophotometer (CE1020 model, Cecil – UK). The results were expressed as mg malonaldehyde (MDA)/kg of products.

Statistical analysis

Data collected were analysed using Analysis of Variance (ANOVA) and significant means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

Results

Iodine, moisture and protein contents

The iodine values of groundnut oil (38.83%) and soya oil (36.17%) were not significantly different, but were significantly ($P<0.05$) higher than 28.00% obtained for palm oil (Table 2).

The moisture content of MFPO (14.33%) was significantly ($P<0.05$) higher than the moisture contents of MFGO (11.38%) and MFSO (11.75%). However, there were no significant differences ($P>0.05$) in the crude protein contents of MF products from the three oil types (Table 3).

Table 2: Iodine values of groundnut, soya and palm oils used to produce beef meat floss (Values are mean±SD)

	Oil types		
Parameters	Groundnut oil	Soya oil	Palm oil
Iodine values	38.83±0.76^{a}	36.17±0.76^{a}	28.00±1.00^{b}

^{a,b,c} Means along the row with different superscripts are significantly different ($P<0.05$)

Table 3: Some Chemical Characteristics (m oisture and protein contents) and keeping qualities (Microbial counts and TBARS and) of freshly prepared meat floss from different oil types (Values are mean±SD; n=3)

Parameters	Meat floss types		
	MFGO	MFSO	MFPO
Chemical Characteristics			
Moisture contents%	11.38± 0.38^{b}	11.75± 0.49^{b}	14.33± 0.41^{a}
Crude protein %	43.82± 0.51	44.54± 0.56	43.44± 0.29
Keeping Qualities			
Microbial Counts (TPC) (log10^{-2} cfu/g/cm^{2})	1.18±0.36^{b}	1.49±0.18^{a}	1.27±0.41^{b}
TBARS (mgMDA/kg)	0.42±0.25^{b}	0.82±0.06^{a}	0.46±0.30^{b}

^{a,b,c} Means in the same row with different letter superscripts are significantly different ($P<0.05$)

Note: MFGO= Meat floss from Groundnut Oil; MFSO = Meat floss from Soya Oil
MFPO = Meat floss from Palm Oil; TBARS = Thiobarbituric Acid Reactive Substances

Microbial Growth and TBARS Test

Freshly Prepared Meat Floss

The microbial load of MFSO (1.49 $log10^{-2}$ cfu/g/cm^2) was significantly ($P<0.05$) higher than 1.18 $log10^{-2}$ cfu/g/cm^2 and 1.27 $log10^{-2}$ cfu/g/cm^2 recorded for MFGO and MFPO respectively (Table 3). Also, the result showed that TBARS of MFSO (0.82 mgMDA/kg) was significantly ($P<0.05$) higher than 0.42 mgMDA/kg and 0.46 mg/100g obtained for MFGO and MFPO respectively (Table 3).

Meat floss stored for 7 days

In acrylic bottle and polyethelene packs MFPO had significantly lowest microbial counts while MFGO and MFSO were not significantly (Table 4) different. However in polyamide, the three MF are significantly different in microbial count with MFGO the least (1.47±0.31 $log10^{-2}$ cfu/g/cm^2) and MFSO the highest (2.14±0.75 $log10^{-2}$ cfu/g/cm^2) (Table 4). Generally, mean microbial count was lowest in MFPO and highest in MFSO, whereas among the packaging materials the mean microbial count was lowest in polyethylene and highest in the acrylic bottle.

The packs were significantly ($P<0.05$) different with regards to TBARS (Table 4). Across the three packs, the TBARS was lowest in MFPO, which was significant ($P<0.05$) in polyethylene and polyamide. The TBARS in MFSO was significantly highest with an overall average of 1.14 mgMDA/kg (Table 4). The TBARS was least in acrylic bottle (0.90 mgMDA/kg) followed by polyamide and highest (0.11 mgMDA/kg) in polyethylene.

Meat floss stored for 14 days

The microbial load ranged from 0.84 $log10^{-2}$ cfu/g/cm^2 in MFGO (packed in acrylic bottle) to 1.52 $log10^{-2}$ cfu/g/cm^2 in MFSO (packed in polyamide) (Table 5). The microbial load was highest in MFSO across the three packs but lowest in MFGO packed in acrylic and polyethylene materials. However in polyamide, the MFPO had the lowest microbial load. The microbial load was similar in acrylic bottle and polyethylene but significantly highest in the polyamide (Table 5). The TBARS was significantly lowest in MFSO irrespective of pack used (Table 5). The packs were significantly ($P<0.05$) different with regards to TBARS. Across the meat floss types TBARS was significantly lower in acrylic bottle with an overall average of 1.06 mgMDA/kg and highest in the polyethylene with an overall average of 1.43 mgMDA/kg.

Meat floss stored for 21 days

The microbial count ranged from 0.84 $log10^{-2}$ cfu/g/cm^2 in all MF types packed in acrylic bottle and polyethylene to 1.06 $log10^{-2}$ cfu/g/cm^2 in MFSO packed in polyamide (Table 6). The MF types were not significantly different in their microbial load in acrylic and polyethylene packs, but in polyamide the MFSO (1.06 $log10^{-2}$ cfu/g/cm^2) was significantly higher than MFGO and MFPO (Table 6). In all the MF types the microbial load in polyamide with an overall average of 1.00 $log10^{-2}$ cfu/g/cm^2 was significantly higher than in acrylic bottle and polyethylene.

The TBARS ranged from 1.21 mgMDA/kg in MFPO stored in acrylic bottle and polyethylene to 2.52 mgMDA/kg in MFSO stored in polyamide (Table 6). Irrespective of pack, the TBARS was significantly highest in MFSO with an overall average of 1.81 mgMDA/kg and significantly lowest in MFPO with anoverall average of 1.29 mgMDA/kg. Across all the MF types the TBARS in polyamide (1.82 mgMDA/kg) was significantly higher than acrylic bottle and polyethylene that both had an overall average of 1.33 mgMDA/kg (Table 6).

Table 4: Some keeping qualities (Microbial counts and TBARS) of beef meat floss produced from different oil types and stored in different packages for 7 days. Values are mean±SD (n=3)

Packaging materials	Meat floss types			Packaging Mean
	MFGO	MFSO	MFPO	
	***Microbial counts ($log10^{-2}$ cfu/g/cm^2)**			
Acrylic bottle (P_1	$1.73±0.59^{ax}$	$1.70±0.39^{ay}$	$1.15±0.50^{by}$	**1.53**
Polyethylene (P_2)	$1.35±0.50^{ay}$	$1.49±0.18^{ay}$	$1.06±0.42^{by}$	**1.30**
Polyamide (P_3)	$1.47±0.31^{cx}$	$2.14±0.75^{ax}$	$1.61±0.46^{bx}$	**1.40**
Floss Type Mean	**1.52**	**1.78**	**1.27**	
	TBARS (mgMDA/kg)			
Acrylic bottle (P_1	$0.98±0.07^{ay}$	$0.91±0.14^{az}$	$0.82±0.02^{ay}$	**0.90**
Polyethylene (P_2)	$1.05±0.17^{bx}$	$1.39±0.31^{ax}$	$0.89±0.10^{cy}$	**1.11**
Polyamide (P_3)	$1.07±0.21^{bx}$	$1.13±0.10^{ay}$	$1.02±0.13^{bx}$	**1.07**
Floss Type Mean	**1.03**	**1.14**	**0.91**	

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)
^{x,y,z,} Means in the same column with different superscripts are significantly different (P<0.05)
***** Microbial counts are square root $(x+0.5)^{½}$ transformed data. De-transform using (x^2-0.5).
Note: MFGO = Meat floss from Groundnut Oil; MFSO = Meat floss from Soya Oil
MFPO = Meat floss from Palm Oil; TBARS = Thiobarbituric Acid Reactive Substances

Keeping qualities across durations of storage

In MFGO and MFSO the microbial load increased up to 7 days and continued to decrease to 21 days. However, in MFPO the microbial load remained similar up to 7 days from when it decreased up to 21 days (Figure 1). The three MF types were similar in their microbial load on 21 days. In all the MF types, the TBARS increased from fresh up to 21 days with MFSO having the highest followed by MFGO that is just slightly higher than MFPO (Figure 1). In all the packs the microbial load decreased from 7 days to 21 days. On 14 and 21 days the microbial load was higher in polyamide than in acrylic bottle and polyethylene that are similar in the load (Figure 2).

Table 6: Some keeping qualities (Microbial counts and TBARS) of beef meat floss produced from different oil types and stored in different packages for 21 days (Values are mean±SD n=3)

Packaging materials	Meat floss types			Packaging Mean
	MFGO	MFSO	MFPO	
	***Microbial counts ($log10^{-2}$ cfu/g/cm^2)**			
Acryllic bottle (P_1	$0.84±0.26^{ay}$	$0.84±0.26^{ay}$	$0.84±0.26^{ay}$	**0.84**
Polyethylene (P_2)	$0.84±0.26^{ay}$	$0.84±0.26^{ay}$	$0.84±0.26^{ay}$	**0.84**
Polyamide (P_3)	$0.97±0.29^{bx}$	$1.06±0.42^{ax}$	$0.97±0.29^{bx}$	**1.00**
Floss Type Mean	**0.88**	**0.91**	**0.88**	
	TBARS (mgMDA/kg)			
Acryllic bottle (P_1	$1.34±0.21^{ay}$	$1.44±0.29^{ay}$	$1.21±0.06^{by}$	**1.33**
Polyethylene (P_2)	$1.32±0.13^{by}$	$1.47±0.30^{ay}$	$1.21±0.06^{cy}$	**1.33**
Polyamide (P_3)	$1.51±0.08^{bx}$	$2.52±0.29^{ax}$	$1.44±0.32^{cx}$	**1.82**
Floss Type Mean	**1.39**	**1.81**	**1.29**	

^{a,b,c} Means in the same row with different superscripts are significantly different (P<0.05)
^{x,y,z,} Means in the same column with different superscripts are significantly different (P<0.05)
***** Microbial counts are square root $(x+0.5)^{½}$ transformed data. De-transform using (x^2-0.5).
Note: MFGO= Meat floss from Groundnut Oil; MFSO = Meat floss from Soya Oil
MFPO = Meat floss from Palm Oil; TBARS = Thiobarbituric Acid Reactive Substances

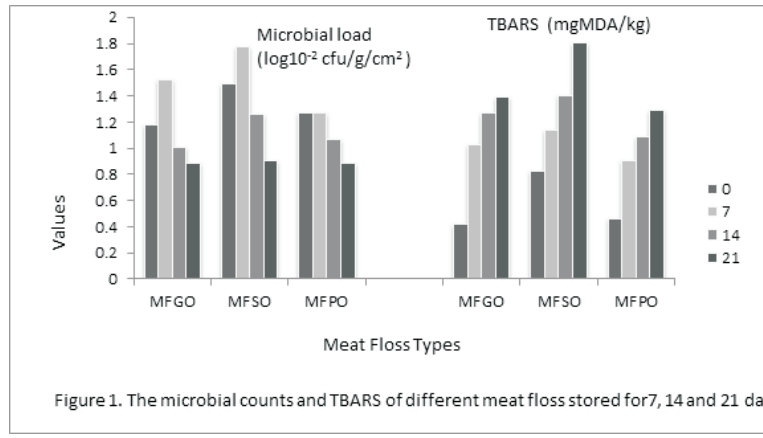

Figure 1. The microbial counts and TBARS of different meat floss stored for7, 14 and 21 day

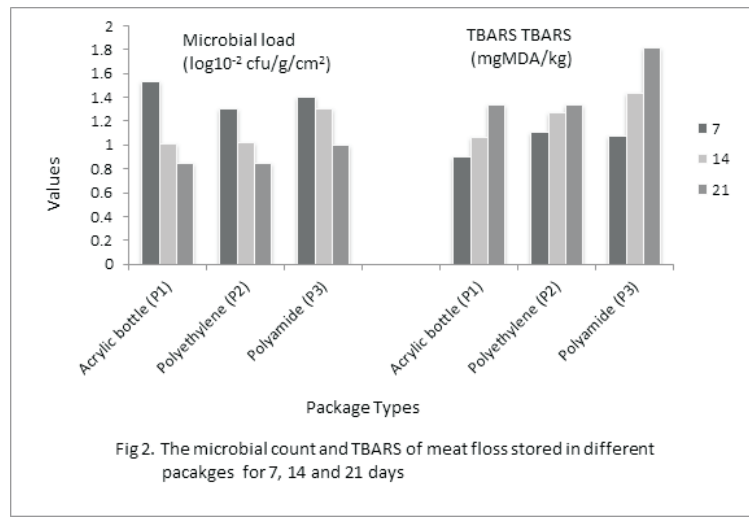

Fig 2. The microbial count and TBARS of meat floss stored in different pacakges for 7, 14 and 21 days

Discussion

Iodine value or number, which is a measure of the degree of unsaturation of oil, is the weight of iodine absorbed by 100 g of the oil expressed in percentage. The higher the iodine number, the higher the degree of unsaturation which implies that such oil contains more of polyunsaturated fatty acids with double bonds that are reactive (Morrissey *et al.,* 1998). The iodine values obtained for the three oils used in this study indicated that palm oil had a lowest degree of unsaturation compared to either groundnut oil or soya oil.

Generally, shelf-life of the product is defined as the period of time between packaging of a product and its end use when the product properties remain acceptable to the product user (Lorenzo and Gómez, 2012). Esmer *et al.* (2011) reported that microbial growth, lipid oxidation and colour change are important factors for the shelf life and consumer acceptance of meat. The microbial load at the shelf-life point has been reported to depend on initial microbial levels and the extent of growth, which is often affected by the type of product and how it is stored (Borch *et al.,* 1996). Although the high temperature involved in deep frying and the low moisture contents of the meat floss showed that the products had been sufficiently dried to minimize or eliminate microbial growth, the microbes were present in the freshly prepared products. The microorganisms recorded in the freshly prepared meat floss may be

thermophyllic, which might have resisted the high heat treatment of the products. Such microbes could also arise from the environment because the environment may not be void of microbes, which can get into products from the air during cooling. All these corroborate the report by Saad *et al*. (2011) that processed meats can be contaminated with microorganisms from different sources such as processing, cooking and even the environment.

The high microbial load of meat floss produced using soya oil can be attributed to the presence of high nutrient content (crude protein) of the product. The product from soya oil had highest protein content and second in moisture contents among products from the three oils. This high protein coupled with the slightly high moisture contents may indicate that the product from soya oil had abundant available nutrients and favourable environment for microbial growth as compared to products from other oils. The study also revealed that there was increase in the microbial loads of all the products, irrespective of the packaging media, up to day 7 before it declined. The later decline in microbial load during storage may be attributed to the antimicrobial attributes of some of the spices used as flavouring agents. For instance, cloves and thyme contain phenolic compounds which have antimicrobial properties (AbdEl-Hamied *et al*., 2009). It may be assumed that the phenolic compounds were released during storage and in the process retarded the growth and proliferation of the microbes. Generally, the reduced microbial load obtained in this study agrees with the report by Oke *et al*. (2009) that plant extracts constitute a natural source of antimicrobial mixtures or pure compounds. These are used as natural agents to prevent the growth of food borne bacteria and moulds in food system as well as resulting in extension of the shelf life of processed foods (Oke *et al.*, 2009).

The oxidation of lipids is a major quality deteriorative process and it is one of the most important changes that occur during food storage and production (Rosmini *et al.,* 1996). Lipid oxidation leads to change in colour, aroma, flavour, texture and the nutritive value of the animal food products (Fernandez *et al*., 1997). Monitoring of lipid oxidation during meat processing or storage is important due to increased demand for pre-cooked convenient meat products (Raharjo *et al*., 1992). The TBARS test is the most widely used test for measuring/quantifying the extent of lipid oxidation in foods, especially meat and meat products (Gomes *et al*., 2003). The TBARS test determines in a sample the amount of malondialdehyde (MDA), a major secondary by-product of lipid oxidation (Jo and Ahn, 1998). In the present study, TBARS increased in all products; however the rate of increase in each of the products were different. This might be due to difference in the fatty acids composition of oils used which will also result in different TBARS. This agrees with the report of Ramırez *et al*. (2004) that TBARS recorded in products will depend on the type of fat or oil used in frying such product. This is because frying involves an exchange of fatty acids between the fat in the meat and the fat or oil used, causing an alteration of the fatty acid profiles of the meat, and tending to make the fat composition of meat similar to that of the frying fat or oil (Sanchez-Muniz *et al.,* 1992).

The result obtained in this study showed that the rate of lipid oxidation in the product were high for the meat floss produced using soya and groundnut oils as they recorded highest TBARS values. The low susceptibility of meat floss from bleached palm oil to lipid oxidation could be traced to the high content of vitamin E (tocopherol) which is a natural antioxidant present in palm oil (Zagre and Tarini, 2001). This

compound is assumed to be taken up by meat floss during frying. Cuesta and Sanchez-Muniz (2001) and Ramırez *et al.* (2004) reported that some minority compounds, such as carotenes, phytosterols and α- tocopherol, present in vegetable oils are taken up by meat during frying. This may account for the stability of meat floss produced from palm oil (Sundram *et al*., 2002).

Out of the three meat products, meat floss from soya oil recorded the highest TBARS value. The relatively low TBARS in meat floss from groundnut oil, despite its high unsaturated fatty acids, may be due to the fact that the unsaturated fat found in groundnut oil is more of monounsaturated fatty acids (MUFA) that are less reactive than polyunsaturated fatty acids (PUFA) that are more reactive. Buckley *et al.* (1995) and Morrissey *et al.* (1998) reported that PUFA is more susceptible to oxidative damage than MUFA, and that meat products with high degree of unsaturation are more susceptible to lipid oxidation. Again, the susceptibility of meat floss from soya oil to lipid oxidation could also be attributed to the fact that soya oil contains a high proportion (7-10%) of oxidation-prone linoleic acid, a fatty acid which makes it less stable and sensitive to oxidation (USDA, 2004). This result also agrees with the report of **Ghita** *et al.* (2010) that different oils have different rate of lipid oxidation because of difference in their degree of saturation and that oil high in polyenoic such as linoleic acid are much more sensitive to lipid oxidation.

It was observed generally that the rate of lipid oxidation increased as the day of storage increased, which corroborates the report of Singh *et al*. (2011) that TBARS increases as the number of days of storage increases. Nonetheless, the rate of lipid oxidation is slow in this study, which could be attributed to some antioxidants that may be present in some of the spices or oil used (Zagre and Tarini, 2001). Esmat and Ferial (2010) also reported slow rate of lipid oxidation during storage of meat steaks when various antioxidants were used.

The role of food packaging in the food industry is being increasingly recognized as it has multiple functions and is very important in terms of increasing product shelf life by retarding food quality degradation and ensuring food safety (Zakrys *et al*., 2009, Gómez and Lorenzo, 2012). Factors such as dehydration, lipid oxidation, discoloration and loss of aroma must be considered when packaging processed meat products (Mondry, 1996). Changes in TBARS content of the meat floss were significantly affected by different packaging materials. The high TBARS value obtained for products in polyamide packaging medium might be due to entry of air, as the material may not be as air tight as assumed for polyethylene and acrylic bottle. Therefore, the product stored in polyamide is prone to damage because oxygen received from the air will aid high rate of lipid oxidation, thereby increasing the TBARS value. Ahn *et al*. (1992) reported oxygen to be the most common and essential component for the progress of lipid oxidation. However, the TBARS value obtained for all the products during storage does not exceed the threshold value of 3 mgMDA/kg, at which rancidity is observed in stored meat products as reported by Wong *et al*. (1995).

The high microbial load of the products in polyamide may be attributed to the fact that the medium is prone to easy damage, which makes it permeable to oxygen, light and moisture. These factors will aid the growth of aerobic microbes and make them to proliferate rapidly. Since, as a result of packaging, the product may contain some anaerobic microbes, the proliferation of aerobic microbes in the medium will have increased the microbial load. However in

polyethylene and acrylic bottle, which are assumed to be air tight, only anaerobic microbes will prevail, hence low TPC. Nevertheless, the microbial load of all the products in the different packaging media did not exceed the levels of 6–7 log CFU cm^{-2} which is the critical level for spoilage of meat (Insausti *et al.,* 2001).

Conclusion

The results of this study indicated that the shelf-life of meat floss can be affected by different production oil and packaging media. All the products stored best in acrylic bottle than other packaging media except in the case of meat floss produced from palm oil whose TBARS levels both in acrylic bottles and polyethylene were almost similar. Meat floss produced from palm oil was most stable, and packaging in acrylic bottles was the most effective in reducing microbial spoilage and maintaining lipid stability during storage. However, all results obtained at 21 days of storage of the products, irrespective of the oil and packaging media used, indicated that the products did not exceed the critical level for spoilage of meat.

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Erratum

The paper titled ***"Effects of cooking oils and packaging media on quality of meat floss" by Olayemi, R. K and Omojola, A. B.*** previously published in Volume 44 Issue 2 of Nigerian Society for Animal Production Journal has been withdrawn due to technical error and republished in Volume 47 Issue 3 as ***"Effects of cooking oils and packaging media on quality of meat floss" by Kassim, O. R. and Omojola, A. B.***