Effect of *Musa acuminata* and *Tectona grandis* Leaves as Packaging Materials on Shelf Life of Local Nigerian Corn Jell-o

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Abstract: *Objective*: This study investigated the effect of *Musa acuminata* and *Tectona grandis* leaves as packaging materials on the shelf life of local Nigerian corn jell-o.

Methods: Fungi were isolated from corn jell-o wrapped separately with leaves of *M. acuminata* and *T. grandis*, polyethylene bags and aluminium foil at the interval for 7 days. The proximate analyses were carried out on all packaging materials used to store the corn jell-o at the interval for 7 days.

Results: The isolated fungi included *Aspergillus flavus*, *Aspergillus niger*, *Candida* spp. and *Trichoderma harzianum*. The proximate analyses showed that the leaves of *M. acuminata* and *T. grandis* have good preservative potential after 7 days as packaging materials for corn jell-o. The carbohydrates, crude fat and fiber contents of *T. grandis* were 13.91%, 1.64% and 0.93%, respectively, which were higher than the contents in *M. acuminata* while the protein, moisture and ash contents of *M. acuminata* were 3.92%, 79.37%, and 0.92%, respectively and showed more considerable contents than *T. grandis*.

Conclusion: The study was able to attest to the uses of *M. acuminata* and *T. grandis* locally for the preservation of food products.

Keywords: Corn jell-o, *Musa acuminata,* proximate composition, *Tectona grandis*.

INTRODUCTION

Zea mays L., commonly known as maize or corn belongs to the Poaceae or grass family and is one of the most important cereal crops in the world. *Zea mays* are consumed directly by humans as a staple food in many parts of the world, it is an ingredient of animal feed and raw material of several industrial products [1]. Various food technologies are used for processing industrially produced *Zea mays* flours and corn meals in different parts of the world to obtain precooked refined maize flour, dehydrated nixtamalized flour, fermented maize flours, and other maize products [1]. In Nigeria, maize can be processed to different food products based on the locality. For example, in the northern part of the country, maize is processed into a local bolus meal known as 'tuwo', in the southern part, Yoruba people refer to the maize product as 'ogi' and Igbo people call the product 'akamu'. Maize is also processed into a dessert product called 'eko' in Yorubaland, 'akasan' in Benin land, 'komu' in Hausaland and 'agidi' in Igboland. The maize product 'eko' is also commonly known as corn jell-o, a gelatinized food product, made from fermented maize paste or flour [2].

The production of corn jell-o from maize is quite laborious and these activities require hygienic environment conditions that will not encourage the incursion of contaminants. The corn jell-o is subject to physical, chemical and biological deterioration, with its acceptance rarely exceeding three days because of rapid deterioration [3,4]. The rapid deterioration of corn jell-o in storage result in repetition of the cumbersome and time-consuming production cycles in order to keep the product available [3-5]. There was an established folkloric assertion that leaves of some plant species enhance the shelf life stability of corn jell-o. It is common knowledge in south-western Nigeria that plants' leaves are used to wrap food products aimed at extending their shelf life, among such plant species are *Bauhinia reticulatum* DC., *Canna indica* L., *Cola acuminata* (P. Beauv.) Schott & Endl., *Cola nitida* (Vent.) Schott & Endl., *Colocasia esculenta* (L.) Schott, *Megaphrynium macrostachyum* (K. Schum.) Milne-Redh., *Musa acuminata* Colla, *Musa x paradisiaca* L., *Tectona grandis* L. f., *Thaumatococcus daniellii* (Benn.) Benth. and *Theobroma cacao* L. leaves [6]. The rural communities in southwestern Nigeria wrap food products such as corn jell-o with plants' leaves as a strategy to extend their shelf life. Therefore, the aim of this study was to investigate the effect of *M. acuminata* and *T. grandis* leaves as packaging materials on the shelf life of corn jell-o.

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Figure 1: Prepared corn jell-o in different packaging materials: **a**: *Musa acuminata*, **b**: low-density polyethylene bags, **c**: *Tectona grandis*, **d**: aluminium foil and **e**: plastic container.

MATERIALS AND METHODS

Materials

The maize was obtained from a local market in Bariga, Lagos State. The leaves of the selected plants were sourced from different farms within south-western parts of Nigeria and the polyethylene bags and plastic containers were obtained from a local store in Surulere, Lagos State.

Methods

Preparation of Corn Jell-o from Fermented Maize Flour

The maize was soaked in sterilized water for two days and the water was drained out and the maize rinsed thoroughly with cold water. The maize was processed in a blender until it was smooth. The puree from the soaked maize was later sieved with a muslin cloth in a sterile environment and poured through with water which separated the chaff. The sieved mixture was allowed to settle for one hour before removing excess water. The mixture was left for two days for tartness to occur and the water was changed after every twelve hours. The mixture was later swirled in boiling water with a turning stick and put aside to solidify. This was cut into shape and wrapped with healthy leaves of *T. grandis* and *M. acuminata*, low-density polyethylene bags, plastic container and aluminium foil (Figure **1**). The experiment was conducted in an aseptic environment at the Department of Botany, University of Lagos, Nigeria from December 2016 to June 2017.

Preparation of Agar Plates

The Potato Dextrose Agar (Lab M) used for the isolation of fungi from corn jell-o was prepared based on the specification of the manufacturer and this followed standard mycological laboratory procedures.

Isolation of Fungi from Corn Jell-o

The portion on the corn jell-o showing growth of fungi after removing the leaves was teased and placed on potato dextrose agar (PDA) that has solidified in petri dishes. The dishes were then incubated at room temperature for a period of 48 hours. The developing fungal colonies were sub-cultured aseptically into fresh PDA dish until pure cultures of the isolates were obtained [7].

Identification of Fungal Isolates

The isolates were identified by comparing their morphology with fungi descriptions of Talbot [8] and Watanabe [9].

Proximate Analysis of Corn Jell-o

Estimation of Carbohydrate Content

The method of Adekunle and Oluwo [10] was used to determine the carbohydrate content in the samples.

Estimation of Protein Content

The protein content of the samples was determined following Adekunle and Oluwo [10] and Nwinyi and Chinedu [11] as a guide with slight modification. Twenty grams of the samples were weighed into a filter paper and space into a Kjeldahl flask, then 10 tablets of Na_2SO_4 with 1g of $CuSO_4$ were added. Twenty millilitre of concentrated H_2SO_4 was added and then condensed in a fume cupboard until the solution becomes colourless. It was cooled overnight and transferred into a 500 ml flat bottom flask with 200 ml of water. This was then cooled with the aid of packs of the ice block. Approximately 60 to 70 ml of 40% of NaOH were poured into the conical flask which was utilized as the receiver with 50 ml of 4% boric acid using 3 days of screened methyl red indicator. The ammonia gas was then distilled into the receiver until the whole gas evaporates. Titration was done in the receiver with 0.1 M NH_2SO_4 until the solution became colourless.

$$\text{Percentage protein} = \frac{A_s - A_b \times 0.01401 \times \text{N acid} (6.25)}{\text{Original weight of sample used}} \times 100$$

Where A_s = Volume (ml) of acid required to titrate sample; A_b = Volume (ml) of acid required to titrate blank; N acid = normality of acid

Determination of Moisture Content

This method followed the method of Nwinyi and Chinedu [11], which is based on moisture evaporation.

$$\text{Moisture content (g / 100 g)} = \frac{\text{Loss in weight } (W_2 - W_3)\text{ (g)}}{\text{Original weight of sample g } (W_2 - W_1)} \times 100$$

Where W_1= initial weight of empty crucible, W_2= weight of crucible + food before drying,

W_3 = final weight of crucible + food after drying.

% Total solid (dry matter) (%) = 100- moisture (%)

Determination of Ash Content

The ash represents the inorganic component (minerals) of the sample after all moisture has been removed as well as the organic material. The method of Nwinyi and Chinedu [11] was adopted. This is a destructive approach based on the decomposition of all organic matter such that the mineral elements may be lost in the process.

$$\text{Ash content} = \frac{\text{Weight of ash (g)}}{\text{Weight of original sample used}} \times 100$$

$$\frac{\text{Loss in weight } (W_3 - W_1)\text{ (g)}}{W_2 - W_1} \times 100$$

Where W_1 = weight of empty crucible, W_2 = weight of crucible + food before drying and or ashing, W_3 = weight of crucible + ash.

Determination of Crude Fibre

The bulk of roughages in food is referred to as fibre and is estimated as crude fibre. The estimation of crude fibres in the samples adopted the method of Nwinyi and Chinedu [11].

$$\text{Calculation} = \text{Weight of fibre} =$$

$$(C_2 - C_3)\, y\,\% \text{ Fibre} = \frac{C_2 - C_3}{\text{Weight of Original Sample}}$$

C_2: Weight of the sample before oven-drying

C_3: Weight of the sample after oven-drying

Determination of Fat Content

The method employed was the soxhlet extraction technique as described by Nwinyi and Chinedu [11].

Statistical Analysis

The data obtained from this study was analysed using Statistical Package for the Social Sciences (SPSS) version 20.0.

RESULTS

Plant Identity

The *M. acuminata* and *T. grandis* plant were identified with voucher no: LUH 5908 and LUH 6873 deposited in the Lagos University Herbarium, Lagos, Nigeria.

Fungal Isolates

The isolated fungi is Aspergillus niger, Trichoderma harzianum, Penicillium digitatum and Candida spp (Figure **2**).

Proximate Composition of Corn Jell-o

The carbohydrate, crude fat, protein, moisture and ash compositions of the stored corn jell-o packaged differently with *T. grandis*, *M. acuminata*, a polyethylene bag, plastic container and aluminium foil is depicted in Table **1**. Corn jell-o packaged with aluminium foil (13.59±0.82%) had the highest carbohydrate content composition among packaging materials after 7 days, *M. acuminata* (3.92±0.34%) had the highest protein content composition, *T. grandis* had highest crude fat (1.64±0.04%) and fibre

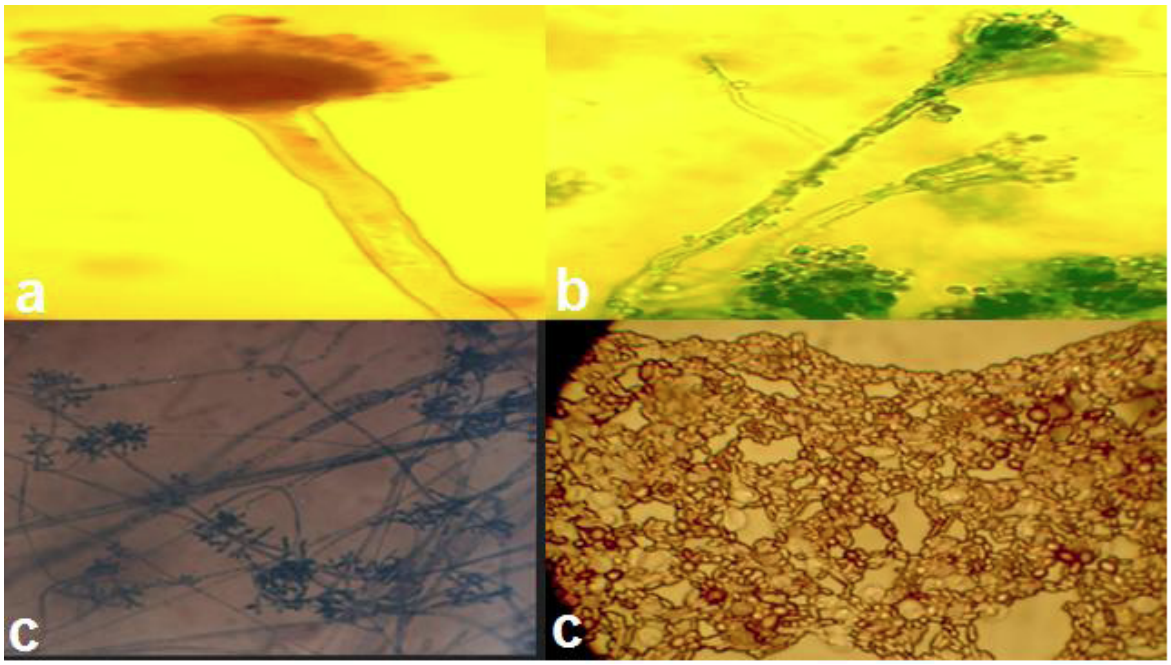

Figure 2: Photomicrograph of test isolates: a: *Aspergillus niger*, b: *Penicillium digitatum*, c: *Tricoderma harzianum*, and d: *Candida* sp.

Table 1: Proximate Analysis of Corn Jell-o Wrapped with *T. grandis, M. acuminata,* Nylon, Plastic and Aluminium Foil

Day 0	**Packaging material**	**CHO (%)**	**Protein (%)**	**Crude fat (%)**	**Moisture (%)**	**Ash (%)**	**Crude fibre (%)**
	T. grandis	11.51±0.03	2.58±0.35	1.73±0.35	82.18±0.33	1.02±0.43	0.98±0.03
	M. acuminata	11.39±0.04	2.72±0.17	1.45±0.71	82.57±0.39	1.09±0.23	0.78±0.43
	Polyethylene bag	10.48±0.91	2.27±0.55	0.96±0.50	84.20±0.88	1.13±0.34	0.96±0.05
	Plastic container	10.71±0.65	2.18±0.22	1.11±0.05	83.87±0.79	1.15±0.28	0.98±0.02
	Aluminium foil	11.24±0.62	2.08±0.55	1.18±0.25	83.49±0.43	1.08±0.43	0.93±0.43
Day 3	**Packaging material**	**CHO (%)**	**Protein (%)**	**Crude fat (%)**	**Moisture (%)**	**Ash (%)**	**Crude fibre (%)**
	T. grandis	12.64±0.02	2.60±0.47	1.71±0.87	81.15±0.22	0.96±0.99	0.94±0.05
	M. acuminata	12.47±0.28	2.86±0.68	1.44±0.40	81.52±0.31	0.95±0.42	0.76±0.23
	Polyethylene bag	11.53±0.045	2.31±0.47	0.93±0.88	83.18±0.88	1.08±0.34	0.97±0.34
	Plastic container	11.82±0.03	2.20±0.71	1.09±0.13	83.14±0.74	1.12±0.45	0.63±0.32
	Aluminium foil	12.36±0.28	2.11±0.40	1.15±0.33	82.45±0.32	0.97±0.22	0.96±0.54
Day 5	**Packaging material**	**CHO (%)**	**Protein (%)**	**Crude fat (%)**	**Moisture (%)**	**Ash (%)**	**Crude fibre (%)**
	T. grandis	13.07±0.04	2.72±0.51	1.67±0.55	80.69±0.09	0.93±0.43	0.92±0.43
	M. acuminata	12.55±0.47	2.89±0.29	1.42±0.16	81.39±0.65	1.05±0.23	0.70±0.71
	Polyethylene bag	12.39±0.34	2.32±0.08	0.91±0.09	82.47±0.45	1.07±0.35	0.84±0.82
	Plastic container	12.56±0.43	2.36±0.29	1.07±0.40	82.25±0.56	1.09±0.60	0.67±0.05
	Aluminium foil	13.48±0.37	2.14±0.50	1.13±0.34	81.54±0.44	0.92±0.16	0.79±0.23
Day 7	**Packaging material**	**CHO (%)**	**Protein (%)**	**Crude fat (%)**	**Moisture (%)**	**Ash (%)**	**Crude fibre (%)**
	T. grandis	13.91±0.57	3.65±0.29	1.64±0.04	78.98±0.71	0.89±0.27	0.93±0.34
	M. acuminata	13.69±0.39	3.92±0.34	1.39±0.05	79.37±0.20	0.98±0.05	0.65±0.34
	Polyethylene bag	12.61±0.28	3.36±0.57	0.88±0.32	81.38±0.41	0.96±0.23	0.81±0.45
	Plastic container	12.95±0.18	3.27±0.43	1.03±0.32	80.91±0.05	1.04±0.34	0.80±0.43
	Aluminium foil	13.59±0.82	3.15±0.95	1.11±0.53	80.48±0.43	0.83±0.23	0.84±0.34

(0.93±0.34%) compositions, plastic container had the highest moisture (81.38±0.41%) and ash (1.04±0.34%) contents after 7 days of storage showed in Table **1**.

DISCUSSION

This work established that *T. grandis* and *M. acuminata* had a better retention capacity of the nutritional composition of stored Nigerians' corn jell-o compared to the test polyethylene bags and aluminium foil. The spoiling of food indicates deterioration of food to the degree that its edibility status reduces and consumption quality becomes a suspect. The spoilage brings about a decrease in nutritional values, texture, and flavour [12]. This study established the presence of *Aspergillus niger*, *Trichoderma harzianum*, *Penicillium digitatum* and *Candida* spp. in stored corn jell-o after seven days of storage; the presence of these fungi is an indicative of the spoilage activities of these fungi. Several reports have laid credence to the presence of these fungi in fermented food, such as Fagbohun and Lawal [13] acknowledged the presence of *Aspergillus niger* in sundried soybean. Ajima *et al*. [14] and Adebayo *et al*. [15] reported the presence of *Penicillium* spp. in corn jell-o. Akinyele and Akinkunmi [16], Adebayo *et al*. [15] and Udoh *et al*. [17] confirmed the presence of the isolated fungi in food produce.

This study revealed the increase in carbohydrate contents as depicted in all the packaging materials as the days of storage increased. *T. grandis* and *M. acuminata* leaves had the highest content of 11.51±0.03% and 11.39±0.04% respectively at day 0 with 13.91±0.57% and 13.69±0.39 at day 7 for *T. grandis* and *M. acuminata* respectively and the reduction applies to other packaging materials as illustrated in Table **1**. The decrease in sugar content is probably due to an enzymatic reaction that occurred with the usage of the sugar content of the corn jell-o by fungi contributing to the spoilage of corn jell-o. These findings corroborate earlier works by Bello and Henry [18] and Kabou *et al*. [19] who showed a decrease in sugar content of *Chrysophyllum africanum* A. DC. and "usu" (an indigenous meat analogue) produced from mushroom (*Lentinus tuber-regium*) and melon seed (*Citrullus colocynthis* (L.) Schrad.). The results of this study also showed that the pores in the leaves encouraged microbial attack that contributed to the reduction in carbohydrate content of the test samples [20].

The protein content was found to be increasing as the day of storage increased as depicted in Table **1**. The *T. grandis* and *M. acuminata* leaves had the highest content of 2.58±0.35% and 2.72±0.17% respectively at day 0 and with 3.65±0.29% and 3.92±0.34 at day 7 for *T. grandis* and *M. acuminata* respectively. The increase in the protein content demonstrated by the leaves of *T. grandis* and *M. acuminata* is comparable to other packaging materials. These findings were attributed to the larger surface area of the leaves which ultimately encourage rapid fungal growth. The increase in protein content can be ascribed to the proteolytic enzymes produced by the fungi which allowed the fungi structure and spore to contribute to the increase of the protein content of corn jell-o. These results confirm findings by Fagbohun and Oluwaniyi [21] who reported an increase of protein content of stored *Oryza sativa* L.

The fat content decreased with time of storage as showed in Table **1**. The fat content of *T. grandis* and *M. acuminata* leaves had the highest content of 1.73±0.35% and 1.45±0.35% respectively at day 0 and with 1.64±0.04% and 1.39±0.05% at day 7 for respectively. The decline in fat content corroborates earlier findings by Fagbohun and Oluwaniyi [21] who argued that the reduction in fat value during storage is probably due to the presence of lipolytic enzymes in fungi which may be responsible for breaking down free fatty acids of the test sample. The reduction in moisture content of corn jell-o could be attributed to the fact that the fungi responsible for spoilage utilize the moisture content of corn jell-o for their survival and growth [22]. The current study showed that moisture content of polyethylene bag and the plastic container had the highest content of 84.20±0.88% and 83.87±0.79% respectively at day 0 and with 81.38±0.41% and 80.91±0.05 at day 7 for polyethylene bag and plastic container respectively (Table **1**).

The decline in ash content of corn jell-o has to do with the loss of inorganic matter as the days of storage increased [18]. Table **1** showed that the ash content of polyethylene bag at day 0 was 1.13±0.34% and at day 7 was 0.96±0.23%, and plastic container at day 0 and 7 had an ash content of 1.15±0.28% and 1.04±0.34%, respectively. These results showed considerable loss compared with the ones obtained from the leaves' packaging. The fibre content showed an increase in corn jell-o stored in plastic container (day 0: 0.98±0.02%, day 7: 0.80±0.43%) compared with stored corn jell-o wrapped with leaves of *T. grandis* (day 0: 0.98±0.03%, day 7: 0.93±0.34%) and *M. acuminata* (day 0: 0.78±0.43%, day 7: 0.65±0.34%). The considerable loss in fibre content indicates the enzymatic action of fungi on the corn jell-o during

storage and this assertion is supported by the work of Fagbohun and Oluwaniyi [21]. Bello and Henry [18] observed that the decline in fibre content is an indication of the utilization of the cellulose and lignin of the test samples by the fungi responsible for the spoilage.

This study established that the leaves of *T. grandis* and *M. acuminata* can preserve the corn jell-o more than three days of edibility that have been mentioned by several vendors of the commodity across the markets within the south-western region of Nigeria. The proximate composition of the test corn jell-o fares well with most maize from some markets analyzed for proximate composition [4,5]. The enhancement of shelf life of corn jell-o by other packaging materials as indicated in this study shows that they can preserve more than the leaves of selected plants but the use of these packaging materials have been queried based on the toxicological impact on humans when the food wrapped with the materials are consumed. Bassioni *et al*. [23] reported the probability of leaching of aluminium into food cooked with aluminium foils and the negative impacts of polyethylene packaging materials on the environment have been documented [24] hence the use of the selected plants' leaves as natural packaging materials seem to come to fore because of the documented fact that they have been regarded as safe [6].

CONCLUSION

This study was able to establish the proximate composition of different packaging materials. The use of *T. grandis* and *M. acuminata* leaves has been established as food wrapper and generally regarded as safe. The preservation of corn jell-o by other packaging materials apart from the plant leaves indicated in this study showed that they can preserve more than the leaves of selected plants but the use of these packaging materials have been queried based on the toxicological impact on humans when the food wrapped with the materials were consumed. The concern about the side effect of plastic containers, polyethylene bags and aluminium foil as packaging materials raised the need and support for the use of plant wrappers as packaging material. This study was able to validate the use of *T. grandis* and *M. acuminata* leaves by the natives in Nigeria for the preservation of corn jell-o. This study established that the leaves contributed towards the retention of the proximate composition present in the tested corn jell-o. This study will provide a template for a further analysis of the preservative properties of the test leaves.

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COMPETING OF INTEREST

The authors declare that they have no competing interest.

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