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Research Article/Araştırma Makalesi

Quality and microbial inactivation of powdered *Irvingia gabonensis* using moringa and different storage materials

Moringa ve farklı depolama malzemeleri kullanarak toz Irvingia gabonensis'in kalitesi ve mikrobiyal inaktivasyonu

Musliu Olushola SUNMONU[1], Adeshina FADEYIBI[2*], Olawale Saheed OLABANJO[3]

[1]Department of Food Engineering, Faculty of Engineering and Technology, University of Ilorin, P.M.B. 1515 Ilorin, Kwara State, Nigeria
[2]Department of Food and Agricultural Engineering, Faculty of Engineering and Technology, Kwara State University, Malete, P.M.B. 1530 Ilorin, Kwara State, Nigeria
[3]Department of Agricultural and Biosystems Engineering, Faculty of Engineering and Technology, University of Ilorin, P.M.B. 1515 Ilorin, Kwara State, Nigeria.

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Address for Correspondence:
Adeshina FADEYIBI
e-mail:
adeshina.fadeyibi@kwasu.edu.ng

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ABSTRACT

A biological approach can be used to maintain the quality of food products for an extended storage life. In this research, the effects moringa parts (B), botanical concentration (C) and, storage material (S) on the quality and microbial inactivation were investigated for storage of powdered *Irvingia gabonensis*. The products were mixed with different parts of the powdered B (leaf, seed and bark) to form varying C (10− 20ppm); and then stored in different S (calabash, sisal and jute sacks) for 3 months. The proximate and microbial compositions of the stored products were determined using standard methods. Results show that the proximate, total coliform, viable and fungi counts decreased with C ($p < 0.05$). Also, the effect was more pronounced in the product stored in the jute sack treated with the 20ppm powdered moringa leaf. This can therefore be used for storing powdered *Irvingia gabonensis*.

Key Words: Botanical concentration, *Irvingia gabonensis,* Quality, Powdered moringa parts, Storage materials

ÖZ

Daha uzun bir depolama ömrü için gıda ürünlerinin kalitesini korumak için biyolojik bir yaklaşım kullanılabilir. Bu araştırmada, toz haline getirilmiş Irvingia gabonensis'in depolanması için moringa kısımları (B), botanik konsantrasyon (C) ve depolama malzemesinin (S) kalite ve mikrobiyal inaktivasyon üzerindeki etkileri araştırılmıştır. Ürünler, değişen C (10 - 20 ppm) oluşturmak için toz haline getirilmiş B'nin (yaprak, tohum ve kabuk) farklı parçalarıyla karıştırıldı; ve daha sonra 3 ay boyunca farklı S (su kabağı, sisal ve jüt çuvalları) içinde saklanır. Depolanan ürünlerin yakın ve mikrobiyal bileşimleri standart yöntemler kullanılarak belirlendi. Sonuçlar, C ile yakın, toplam koliform, canlı ve mantar sayımlarının azaldığını göstermektedir ($p < 0.05$). Ayrıca, 20 ppm toz moringa yaprağı ile muamele edilmiş jüt çuvalda depolanan üründe etki daha belirgindi. Bu nedenle bu, toz haline getirilmiş Irvingia gabonensis'in depolanması için kullanılabilir.

Anahtar Kelimeler: Botanik konsantrasyon, Irvingia gabonensis, Kalite, Toz moringa parçaları, Depolama malzemeleri

Introduction

Moringa oleifera plant is the most widely cultivated specie of the genus *Moringa* (Fuglie, 2001). It is known as drumstick tree from the appearance of long, slender and triangular seed pods (Fahey, 2005; Mishra et al., 2012). The tree is slender and with drooping branches that grow to approximately 10 m in height. In cultivation, it is often cutback annually to 1-2 m and can re-grow, so the pods and leaves remain within arm's reach (Fuglie, 2001). *The tree* is rich in iron, potassium, calcium, zinc, magnesium, and are rich in useful vitamins approximately four times the amount found in carrot (Fahey, 2005). Almost every part of the *Moringa oleifera* is of benefit, no part of the plant is useless as both humans and animals have one thing or the other to gain from the plant (Armha et al., 2019). For example, the foliage is eaten green as salad, in vegetable curries, as pickles and for seasoning. The seeds yield 38-40% of non-drying oil, known as Ben oil, and is used in arts for lubricating machines and other delicate machinery. The oil is edible and can be used to manufacture perfumes. The roots can be shredded and used as a condiment but contains a potentially fatal nerve paralyzing agent called spirochim (Armha et al., 2019).

The storage and processing of the *Irvingia gabonensis* is usually a challenge due to its short shelf-life resulting from the high amount of moisture present in the fresh product. Also, the plant requires its natural habitat to thrive, and is seasonal (Armha et al., 2019). This makes its scarce especially during certain period. Thus, the postharvest preservation of the product is essential to ensure its availability for a later use (Fadeyibi et al.,2020). The powder can be used to make delicious meals as well as to preserve and store food for an extended storage life (Armha et al., 2019; Fuglie, 2001). As a way of preservation, the product can be dried to remove the excess moisture that can cause deterioration and then ground into powder. The powdered *irvingia gabonensis* can be guaranteed to last longer in the shelf and can be available whenever needed. There is therefore the need to transform the product into powder to actualize this.

Application of different parts of *moringa olifera* plant to the storability of most agricultural products have been reported. For instance, Adegbehingbe et al. (2017) studied the effect of fermentation on the nutrient and anti-nutrient contents of *Irvingia gabonensis* seed and reported that fermentation enhances the nutritional value of the seed. Although, Chuku (2017) reported the ability of powdered moringa leaf to extend the shelf-life of *Irvingia gabonensis*, the effects of the botanical concentration and storage materials on the quality attributes of the product have not been reported. There is therefore the need to address these deficit knowledge gaps by investigating the essential and commercial values of the product above its physiological storage condition. This research was carried out to determine the effects of moringa parts, botanical concentration and storage materials on the nutritional and microbial quality attributes of the *Irvingia gabonensis,* such as the proximate values, bacteria and fungi loads over a given storage period above its physiological storage condition.

Materials and Methods

Materials and sample preparation

A 5 kg of freshly harvested *Irvingia gabonensis* seed was purchased from Ipata market in Ilorin, Kwara State. The kernels were manually cleaned to remove impurity like chaffs and stones. The cleaned kernels were transported to the Plant Biology Department of the University of Ilorin, Ilorin, Nigeria, for experimentation. The product was dried and ground into powder; and the moisture content maintained at 24.5% (wb). A fresh Moringa *plant part (leaf, seed and bark)* was harvested from a matured Moringa plant in the University of Ilorin farm for this research. The plant parts were washed and rinse in distilled water; and dried at ambient temperature for 7 days to 12.8% (wb) (Chuku 2017). The powdered samples of the moringa plant parts were prepared by grounding the dried products using a blender, and then sieved to obtain finer materials of approximately 200 µm particle size.

Storage procedure and experimental design

A Completely Randomized Design (CRD) was used to investigate the degree of associated error with respect to the experimental variables namely, the moringa plant parts, storage materials and the concentration of the botanicals. The powdered moringa parts were mixed thoroughly together with the powdered *Irvingia gabonensis* to give a varying concentration of the botanicals as 10 ppm, 15 ppm and 20 ppm. These were then stored in three different storage mediums, namely calabash, sisal sack and jute sack, for a period of 3 months.

Determination of nutritional and microbial quality parameters of the seed

The moisture, crude fat, ash, protein, crude fiber and carbohydrate contents of the samples of the treated *Irvingia gabonensis* were determined, at 1 month storage interval, using the chemical analytical procedure reported by AOAC (2000). The total coliform counts, total viable counts and fungi count were also determined using the Pour Plate method of determining microbial qualities (Fadeyibi et al.,2017; Fadeyibi et al.,2020).

Statistical analysis

Data obtained from the experiments were subjected to statistical analysis of variance using SPSS ver. 20.0 for the measured parameters; and Duncan's New Multiple Range Test (DNMRT) was used to find the difference in means of botanical type, storage type, botanical concentration and their interactions over the range of the botanical concentration and type storage material used.

Results and Discussion

Effect of storage parameters on proximate composition

The effect moisture content on the proximate composition of the stored powdered *Irvingia gabonensis* are shown in Figures 1 – 3. The effect of the moisture content of the product on the botanical concentration were not the same for all the samples. We observed that the moisture content of the product treated with moringa leaf decreased with the botanical concentration (Figure 2). However, this increases for the product treated with the moringa seed and bark, as shown in Figures 1 and 3. This behavior may be associated with the presence of cracks and holes in the storage materials, which could serve as points of moisture migration to the surrounding during storage (Karim et al., 2005). This agrees with the findings of Noorka and da Silva (2012) who reported a significant moisture lost during the storage of wheat using a plastic container. The amount of moisture in the product stored using the powdered moringa seed was higher than those from the powdered leaf and bark of the plant. The hygroscopic nature of the seed might be responsible for this observed difference (Chuku, 2017). The higher the botanical concentration, the better the moisture retained by the *Irvingia gabonensis* in storage.

The fat content of the product in the jute sack increases with an increase in the botanical concentration when treated with the powdered moringa seed, as shown in Figure 1. However, this decreases with the botanical concentration when treated with the powdered moringa leaf and bark, as shown in Figures 2 and 3. A decrease in the fat content was generally observed across other storage materials with an increase in the botanical concentration. This supports the findings of Onojah et al. (2018), who reported a decrease in the fat content of *Irvingia gabonensis* with an increase in the substrate concentration. Also, the storage effects of both the calabash and the sisal sack are quite similar on the fat content of the stored product, while the jute sack shows a distinct effect. The product treated with the 15-ppm botanical concentration shows significant decrease in the fat content compared to that of 10-ppm and 20-ppm. This corroborates the findings of Omobowale et al. (2015) who reported a general decrease in the oil content of stored maize across a concrete and galvanized steel silo. The percentage fat content of the control sample indicates that there is an increase in the fat content (21.1%) compare to all the treated samples at $p< 0.05$ (Omobowale et al., 2015).

A decrease in crude fibre and protein contents was observed in the samples stored in the sisal sack and treated with the powdered moringa seed and leaf, as shown in Figure 1. The samples stored in jute sack and calabash however increase with an increase in the botanical concentration. The crude fibre and protein contents in the samples stored in sisal, jute sack and calabash remain constant when moringa bark was used as the substrate, as shown in Figure 3. This supports the findings of Ekpe et al. (2007), who reported a decrease in crude fibre and amino acid profile of *Irvingia gabonensis* seed. An increase in the crude protein content of the stored product was observed with an increase in the botanical concentration. This contradicts the findings of Ilesanmi and Gungula (2016) who reported a decrease in the crude protein content in cowpea with an increase in the substrate concentration. The crude protein content of the product stored in the sisal sack and jute sack had similar effect, while the protein content of the products in the calabash was the highest (6.14%). The percentage the crude protein content in the control sample shows a decrease in crude protein 4.2% with an increase in the botanical concentration.

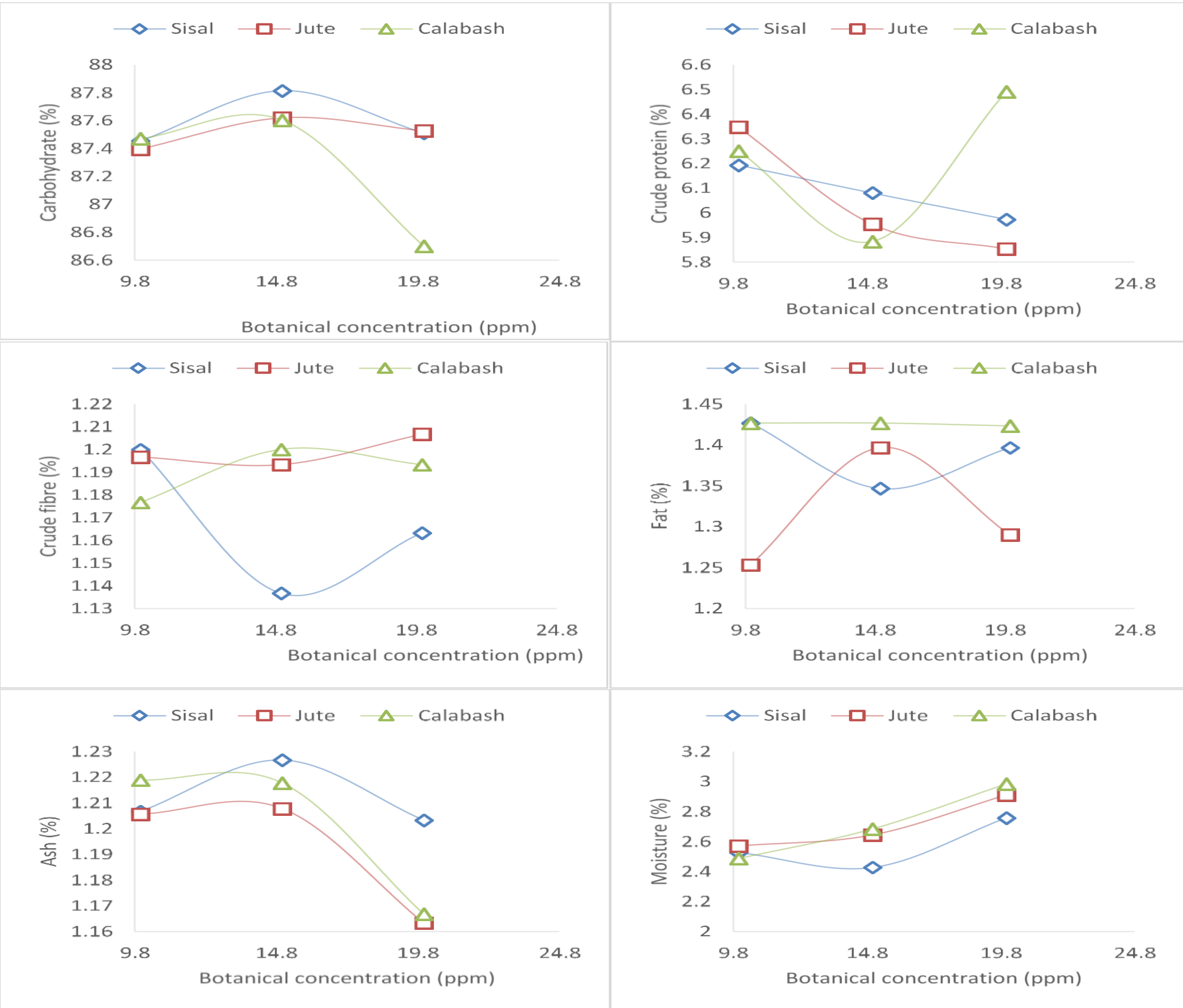

Figure 1. Effects of storage material and powdered moringa seed on proximate values of *irvingia gabonensis*
Şekil 1. Depolama malzemesi ve toz haline getirilmiş moringa tohumunun irvingia gabonensis'in yaklaşık değerleri üzerindeki etkileri

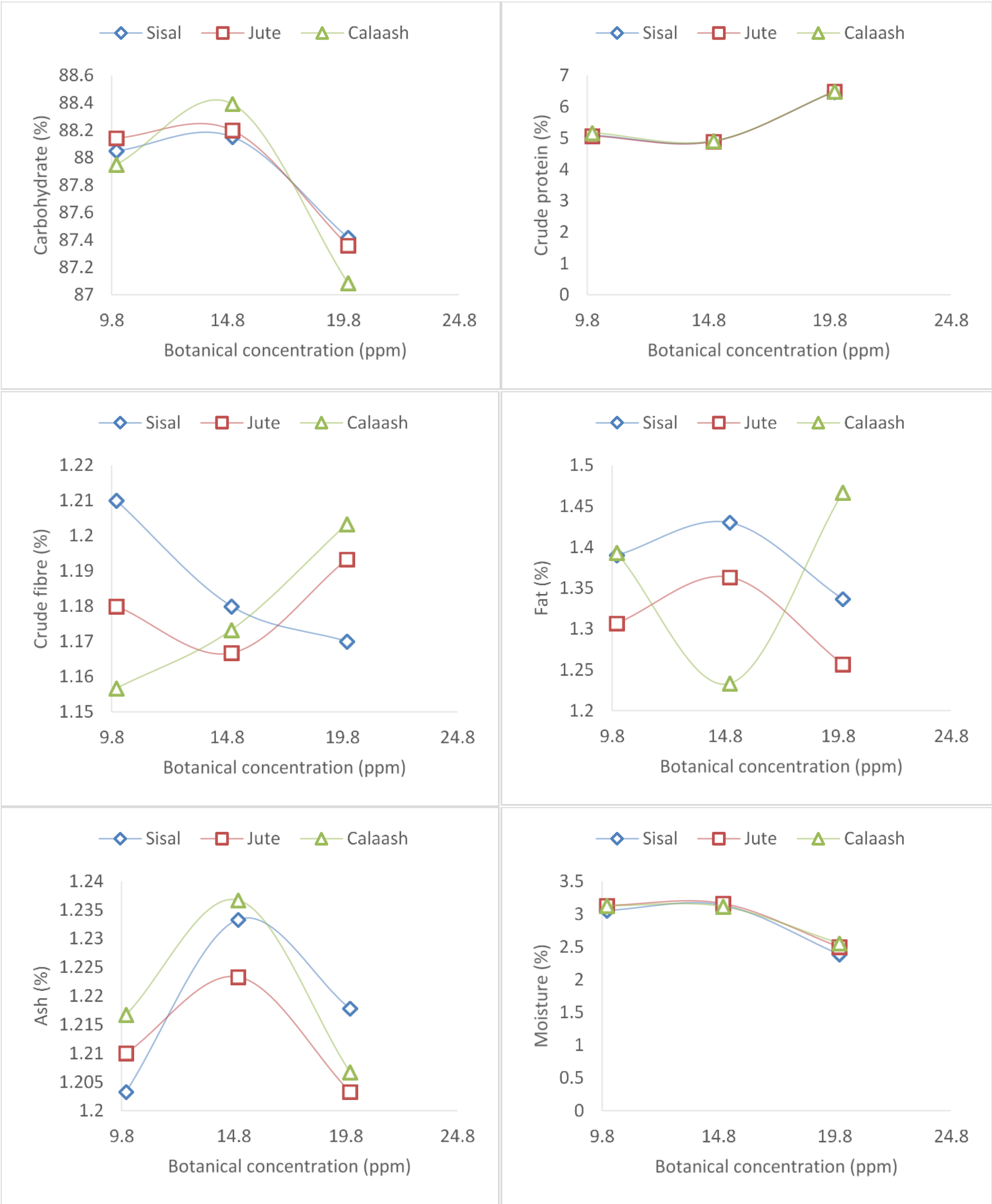

Figure 2. Effect of packaging material and powdered moriga leaf on proximate value of *Irvingia gabonensis*
Şekil 2. Paketleme malzemesi ve toz halindeki moriga yaprağının Irvingia gabonensis'in yaklaşık değeri üzerindeki etkisi

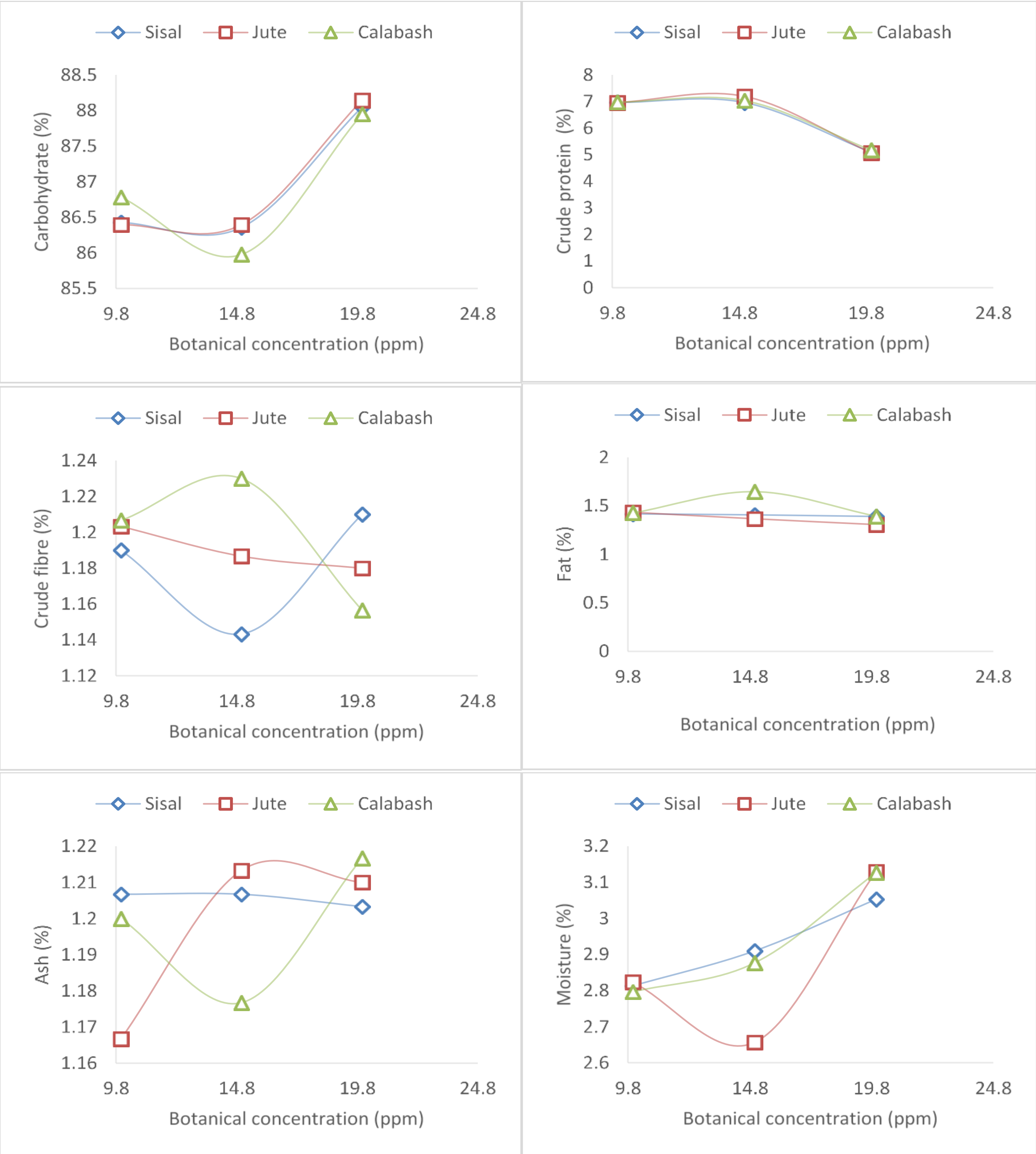

Figure 3. Effect of packaging material and powdered moriga bark on proximate value of *Irvingia gabonensis*
Şekil 3. Paketleme malzemesi ve toz halinde moriga kabuğunun Irvingia gabonensis'in yaklaşık değeri üzerindeki etkisi

A general decrease in the carbohydrate content was observed for all the samples treated with the powdered moringa seed and leaf, as was shown in Figures 1 and 2. But, the carbohydrate content of the sample treated with the powdered moringa bark increases with an increase in the botanical concentration, as was shown in Figure 3. The jute sack retained a higher carbohydrate content (86.48%) compared to the calabash (86.17%) and sisal sack (86.35%). The research results of Chuku (2017), who reported an increase in the carbohydrate using different concentrations of moringa leaf, scent leaf and bitter leaf support the present investigation. This also supports the findings of Osunde and Orhevba (2009) who reported an increase in carbohydrate content of yam stored in barns beyond the normal storage period. In another related investigation, Chuku (2017) reported that the carbohydrate content of *Irvingia gabonensis* seed, blended with powdered moringa leaf, stem and bark, significantly increases with an increase in the storage period. The ash content increases for the product packaged inside the jute and sisal sacks but decreased for the calabash material. Result revealed a significant difference at $p < 0.05$ of 0.08% in the ash content and a decrease in value of 0.02% due to the treatments applied (Aanyu, Ondhoro, Aanyu, & Ondhoro, 2016). This slightly agrees with the findings of Ogunsina et al. (2012) and Ekpe et al. (2007) who reported a significant difference in the ash content at $p < 0.05$ on the processed and fresh seeds. The percentage ash content of the control sample was found to be 3.49% at the end of the storage period. It can be said that the storage parameters increase the ash content of the stored *Irvingia gabonensis*.

Results of the analysis of variance of the individual effect of the storage parameters on the proximate composition of the stored *Irvingia gabonensis* powder are shown in Table 1. The results show that moisture content of the stored product in the calabash was significantly higher compared to that stored in sisal sack provided that all other factors remain constant. It can be deduced that *Irvingia gabonensis* powder stored in calabash retain moisture than the ones stored in sisal sack and jute sack. It is possible that the food powder absorbed moisture from the surrounding damped air since it is hygroscopic. Similar finding was recorded by Alabadan (2006) who reported that wooden materials (wooden silo) has a better moisture retention ability than jute and sisal sacks for maize storage.

Table 1. Multiple Comparison of the Proximate and Microbial Compositions of the stored products
Tablo 1. Depolanan ürünlerin Yakın ve Mikrobiyal Bileşimlerinin Çoklu Karşılaştırması

Variables	L	MC	Ash	Fat	CF	CP	CHO	TVC	TCC	FC
Botanical Type (B)	1	3.72^{c}	1.20^{a}	1.51^{c}	1.37^{a}	5.30^{a}	86.9^{c}	4.36^{a}	3.03^{a}	1.45^{a}
	2	3.27^{a}	1.23^{b}	1.45^{b}	1.52^{c}	6.24^{b}	86.3^{b}	4.81^{b}	3.31^{b}	1.49^{a}
	3	3.60^{b}	1.29^{c}	1.37^{a}	1.46^{b}	6.55^{c}	85.8^{a}	4.82^{b}	3.38^{b}	1.42^{a}
Storage Type (S)	1	3.55^{b}	1.23^{a}	1.44^{a}	1.46^{b}	6.15^{b}	86.2^{a}	4.94^{b}	3.39^{b}	1.36^{a}
	2	3.51^{a}	1.24^{b}	1.44^{a}	1.41^{a}	5.96^{a}	86.5^{c}	4.59^{a}	3.31^{b}	1.49^{b}
	3	3.52^{a}	1.25^{c}	1.45^{b}	1.48^{c}	5.98^{a}	86.4^{b}	4.46^{a}	3.02^{a}	1.50^{b}
Concentration (C)	1	3.44^{a}	1.24^{ab}	1.45^{b}	1.44^{b}	6.04^{b}	86.4^{b}	4.54^{a}	3.11^{a}	1.46^{a}
	2	3.50^{b}	1.24^{b}	1.41^{a}	1.48^{c}	6.07^{c}	86.3^{a}	4.65^{ab}	3.22^{ab}	1.45^{a}
	3	3.64^{c}	1.23^{a}	1.47^{c}	1.43^{a}	5.97^{a}	86.3^{a}	4.80^{b}	3.38^{b}	1.45^{a}

Means with the same letters are not significantly different at $p< 0.05$; Means with different letters are significantly different at $p < 0.05$; TVC = Total Viable counts ($\times10^5$ cfu/g), TCC = Total Coliform Counts ($\times10^5$ cfu/g), FC = Fungal Counts ($\times10^3$ cfu/g), L = level; MC = moisture content (%); Ash content (%); Fat content (%); CF = Crude fibre (%); CP = Crude Protein (%), CHO = Carbohydrate (%)

Effect of Storage Parameters on the Microbial Composition of the Stored Products

The influence of the storage period, botanical type, storage type and botanical concentration on the total viable count (TVC), total coliform count (TCC) and fungi count (FC) of the stored *Irvingia gabonensis* powder is shown in Figure 4. A significant decrease in the TVC, TCC and FC was observed with an increase in the botanical concentration. Accordingly, Rabi et al. (2017), who reported a decrease in microbial composition of fermented African locust bean when powdered ginger was added as preservative corroborate the finding of the current investigation. The TVC decreased from 8.4×10^5cfu/g to 3.9×10^5cfu/g, the TCC decreased from 6.2×10^5cfu/g to 2.9×10^5cfu/g and the FC decreased from $4.4\text{x}10^3$ cfu/g to 1.2×10^3 cfu/g. However, all the samples did not contain the FC throughout the duration of storage. This supports the findings Arekemase et al. (2015), Ibeabuchi et al., and Wogu and Iyayi (2011) in their separate investigations.

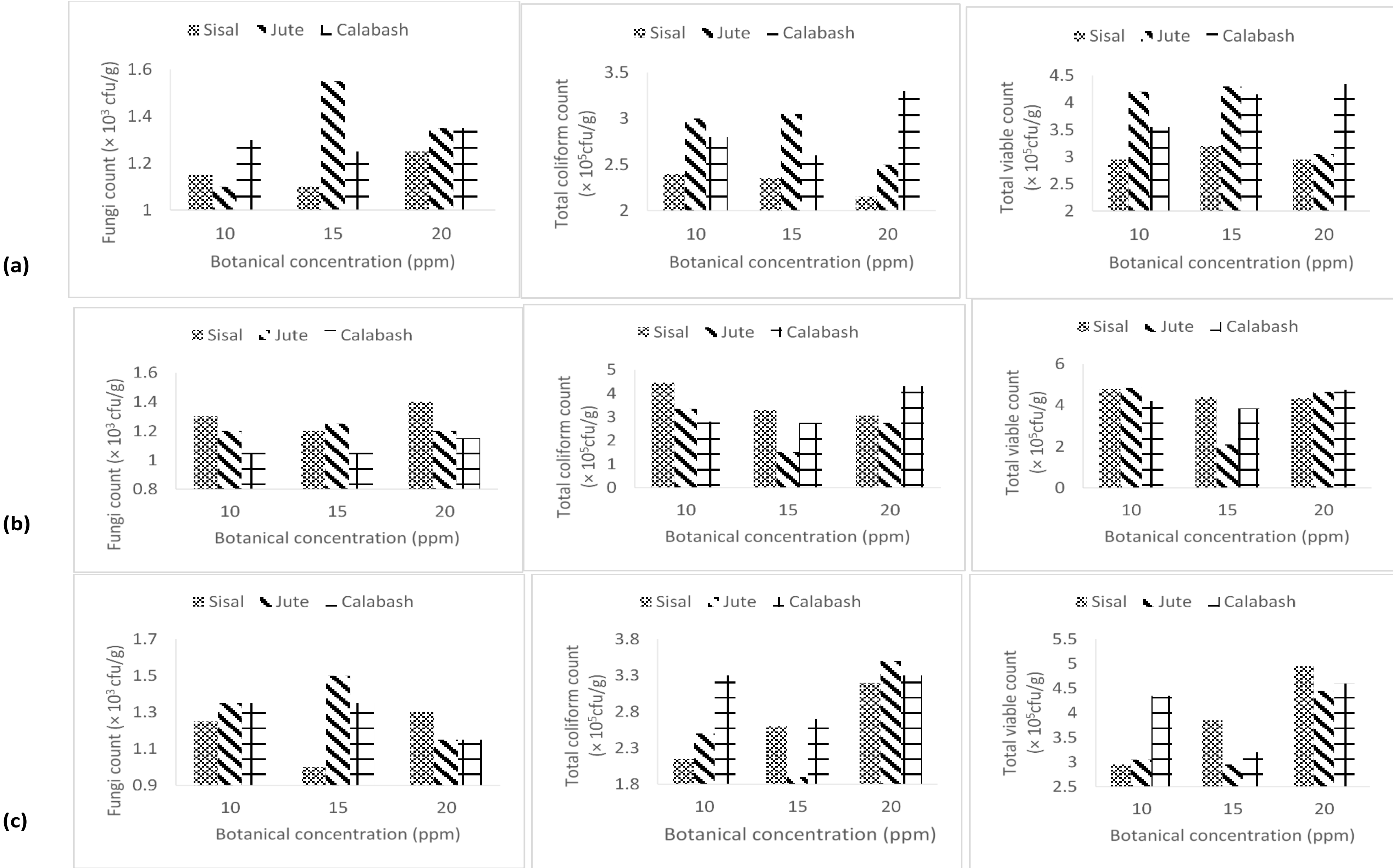

Figure 4. Effect of packaging material and powdered moringa on microbial inactivation of *Irvingia gabonensis* (a) bark (b) leaf (c) seed

Şekil 4. Paketleme malzemesi ve toz moringanın Irvingia gabonensis (a) kabuk (b) yaprak (c) tohumunun mikrobiyal inaktivasyonuna etkisi

A multiple comparison effects of storage parameters on the microbial compositions of stored *Irvingia gabonensis* powder were done using NDMRT as was shown in Table 1. This indicates that the mean values of the TVC, TCC and FC of the stored product in the various storage materials used were significantly different ($p< 0.05$). The TVC and TCC of the stored product in the calabash were significantly higher compared to the those stored in sisal sack and jute sack provided all other factors remain constant. A similar finding was reported by Farinde, Adeniran, and Abiose (2014), who stated an increase in TVC of fermented locust bean when stored in the calabash. The *Irvingia gabonensis* powder stored in the calabash recorded the lowest fungal count of $1.3x10^3$ cfu/g while the one stored in jute sack recorded the highest count ($1.5x10^3$ cfu/g). This finding is also similar to the work of Adegbehingbe et al. (2017) who reported an increase of fungal count of solid substrate in *Irvingia gabonensis* powder in storage. The addition of the botanical concentration into the samples of the products might partly be responsible for the decrease in the values of the TVC, TCC and FC with an increase in the storage period. The research effort of Rabi et al. (2017) who reported a decrease in the microbial composition of fermented African locust bean as a result of the powdered ginger applied has also given credence to the current investigation. This show that the storage period and the botanical used had a greater influence on the microbial counts of the stored *Irvingia gabonensis* powder.

Furthermore, *Irvingia gabonensis* powder treated with 20-ppm of botanical has higher TVC and TCC at $p< 0.05$. A similar result has been reported by Arekemase et al. (2015) in their work on the microbial spoilage and acting of preservative on mango seed powder. However, stored *Irvingia gabonensis* powder treated with 10-ppm of botanical recorded the lowest TVC and TCC the FC. There was no significant difference on FC at different concentration levels ($p< 0.05$). This supports the work of Chuku (2017), who reported that the application of the powdered moringa parts can great inhibit the microbial activity in the grounded *Irvingia gabonensis* powder.

Conclusions

The effect of storage material, botanical concentration and moringa plant parts on the proximate compositions and microbial inactivation of the powdered *Irvingia gabonensis* were studied. The results show a general decrease in the moisture content, fat, ash and crude protein contents with an increase in the botanical concentration. The type of moringa part used also affected this trend, with the powdered moringa leaf influencing storage stability of the product the most. The sample stored in the calabash and treated with the 10-ppm powdered moringa leaf was found to be effective for retaining proximate composition. The microbial composition of the stored product showed that total viable counts, total coliform counts, fungi counts decreases with the botanical concentration. The product stored in a jute sack and treated with the 20-ppm powdered moringa leaf was found to be effective for microbial inactivation.

Conflict of Interest: The authors declare no conflict of interest.

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