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Effect of Moisture Content on the Mechanical Properties of Dika (*Irvingia gabonensis*) Fruit and Nut

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Authors' contributions

Author OOA designed the work, wrote the manuscript and interpreted the work. Author BAO carried out the experiment. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

Aims: The effect of varying moisture content on the mechanical properties of Dika (*Irvingia gabonensis*) fruits and nuts was carried out. Some of the mechanical properties investigated were deformation at peak, energy at peak, deformation at break, energy to break, force at peak, force at break and Young's modulus.
Study Design: Dika nut and dika fruit samples were each separated into six different portions named F, E, D, C, B and A, analysis carried out were in duplicate
Place and Duration of Study: Federal University of Technology, Akure, Nigeria, where preliminary analyses were carried out and Federal Institute of Industrial research, Oshodi (FIIRO), Lagos Nigeria where the mechanical properties were analyzed using Testrometric AX type DBBMTCL – 2500Kg Equipment. The research was carried out between March and September, 2012.
Methodology: Each sample was oven dried until required moisture content (5%, 8%, 11%, 14%, 17% and 20% d.b. respectively) were attained the samples were separated into six portions and oven dried until required moisture content (5%, 8%, 11%, 14%, 17% and 20% d.b. respectively were attained). Each sample of the treated dika nuts and fruits was placed between the compression plates of the testing equipment. The samples were compressed at a constant deformation rate of 40.00mm min^{-1}. The procedure was repeated for the all the samples. The data logger attached to the machine recorded the parameters.

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Results: There was no significant (p=0.05) difference on the effect of moisture (8 % to 20 % d.b) on the force at peak of dika fruit except at moisture content (5% d.b). The effect of moisture on deformation at peak, energy at peak, deformation at break, energy to break, force at break and Young's modulus were significantly (p = 0.05) different at 8% and 5% b.d while there was no significant (p = 0.05) difference at moisture content 11% to 20%. The effect of moisture on the dika nut mechanical properties also showed similar behavior as that of dika fruit. Lower moisture (5% and 8% d.b.) significantly (p=0.05) affected the mechanical properties while higher moisture (11% to 20 % d.b) did not significantly affect the properties

Conclusion: As the moisture content reduces, the better the mechanical properties of dika nut and fruit, hence, improvement in their postharvest handlings.

Keywords: Moisture content; mechanical properties; young's modulus; deformation; dika nut.

1. INTRODUCTION

Dika (Irvingia gabonensis) is a commercial and indigenous fruit tree of West and Central Africa, which has been identified as the most important tree for domestication [1,2]. It is popularly called bush mango in Nigeria. The kernels are used as condiment and are highly valued for their soup thickening properties [3]. The kernel is widely used for food, as a pharmaceutical binder and in the manufacture of soap and cosmetics [2]. The kernel contains about 8.9% protein, 19.7% carbohydrate, 62.8% lipids, 5.3% dietary fibre and 3.2% ash by weight [4]. Powdered dika kernel is commonly cooked with vegetables into *ogbono* soup, a valuable local delicacy in Nigeria, Ghana, and Gabon [5]. The Dika fruit is a drupe with a thin epicarp, a yellow, soft and fleshy mesocarp which is fibrous in nature and a stony endocarp (nut) encasing a soft dicotyledonous kernel locally called *ogbono* in Nigeria.

The mechanical properties data of fruits are important in the design of various handling, packing, storage and transportation systems [6]. It has been observed that one of the most important export problem is quality decrease of fruits in postharvest operations. Knowledge of the mechanical properties such as failure stress and strain as well as modulus of elasticity under the static loading is required to understand how external forces applied of food materials increases their susceptibility to deterioration during storage [7]).

This work therefore seeks to determine the effect of varying moisture contents on the mechanical properties of *Dika (Irvingia gabonensis) fruit and nut.*

2. MATERIALS AND METHODS

2.1 Materials

The materials used include freshly harvested dika fruits purchased from Oja-Oba market at Akure, Ondo State, Nigeria. Digital Vernier Caliper, (Cappera precision, China), Sartorius 1600 electronic digital Weighing balance, Testrometric AX Type DBBMTCL – 2500 KG (Rochdale, England) obtained from Federal Institute of Industrial Research, Oshodi, (FIIRO) Lagos.

2.2 Sample Preparation

Unit mass of each sample used for the analysis were obtained by weighing each sample on an electronic digital weighing balance. The moisture content of the samples were varied (20, 17, 14, 11, 8 and 5% dry basis) by varying the drying time in an electric oven, periodically checking the moisture content until the required moisture content was obtained.

2.3 Determination of Mechanical Properties

Mechanical properties (force at break, energy to break, deformation at break, energy to yield, stress at yield, stress at break, stress at peak, deformation at peak, force at peak, Young's modulus) were determined using Testrometric AX Type DBBMTCL 2500kg (Rochdale, England). Testing conditions for the Instron Machine were loading range, 0.500N and cross head speed, 5 – 40 mm min^{-1}

Each sample of the treated dika nuts and fruits was placed between the compression plates of the testing equipment. The sample was compressed at a constant deformation rate of 40.00mm min^{-1}. The procedure was repeated for the all the samples. The data logger attached to the machine recorded the parameters. Data were subjected to statistical analysis using SPSS 16.0

3. RESULTS AND DISCUSSION

The effect of moisture content (5 to 20% db) on the deformation at peak, energy at break, deformation at break and energy to break of dika fruit was shown in Fig. 1**.** There were significant different on the effect of moisture on deformation at peak at all level, but with 17% and 11% moisture that were not significantly different. Deformation at break showed the same behavior with deformation at break. For energy to peak, the effect of moisture is also significantly (p=0.05) different at all level except 20% and 14% moisture, 11% and 8% moisture that were not significantly (p=0.05) different. However, Fig. 1 showed that the energy to peak is highest at 5% moisture. Energy to break also showed significant (p=0.05) different on the effect of moisture on it. Fig. 1 also showed that it is highest at 5% moisture. Table 1 showed that there were significant (p=0.05) differences on the effect of moisture on it at all moisture levels except that the pairs of 17 % and 14%, 11% and 8%, were not significantly (p=0.05) different. The behavior of the properties at 5 % might be as a result of caking of the surface as moisture reduces which makes deformation to reduce as moisture level increases while the opposite is the case for energy. Energy to peak increases as moisture reduces. These behaviours were as a result of caking at the surfaces as moisture reduces, similar to the work of Raji et al.,2011 [8]. This same behavior was recorded on the effect of moisture on the deformation at peak, energy to peak, deformation at break and energy to break of dika nut as shown in Fig. 2. The effects were more pronounced in dika nut than in dika fruits, probably because the fleshy part has been removed and it remains only the nut which naturally was harder than the fruits.

Fig. 3 and 4 showed the effect of varying moisture contents on the force at peak and breaking force. Force at peak and breaking force increases with decreasing moisture content. Caking due to reduced moisture level could also result in the peak force and breaking force extremely high at the lowest moisture level. The peak force and breaking force is generally higher for the dika nut than for the dika fruit. This was as a result of hard nature of nut compared to fruit. the energy to break of dika fruit was generally higher than of dika nut. This is because moisture is trapped within the flesh of the fruits hence higher energy to break. Dika nut with lower energy trapped has lower energy to break. The energy to peak and energy to break followed a reverse order, increasing with decreasing moisture content for both the dika fruit and dika nut. This is in agreement with the work by Raji et al., 2011 [8].

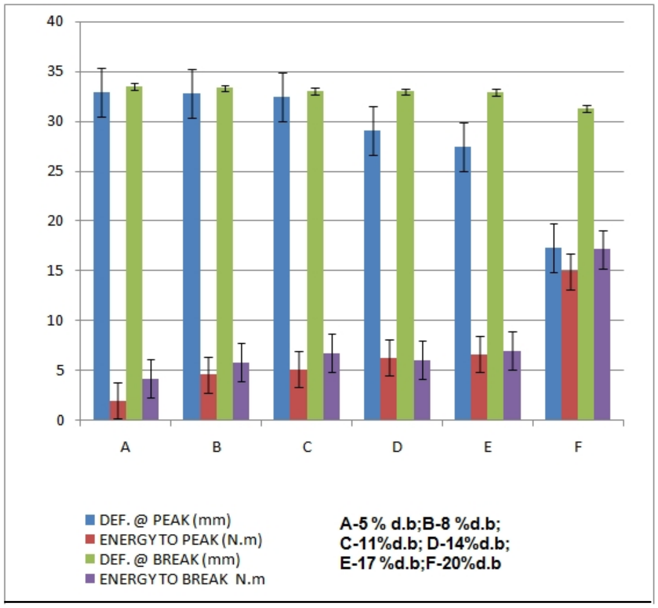

Fig. 1. Effect of moisture content on deformation at peak, energy at peak, deformation at break and energy at break of dika fruit

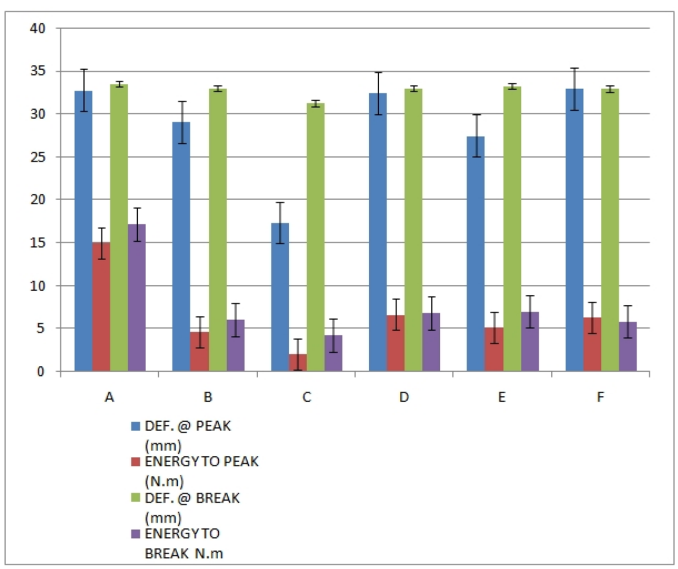

Fig. 2. Effect of moisture content on deformation at peak, energy at peak, deformation at break and energy at break of dika nut

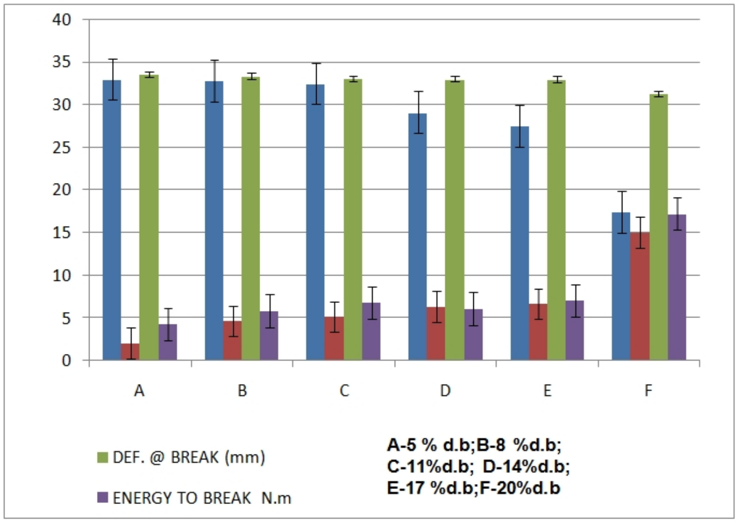

Fig. 3. Effect of moisture content on force at peak and force at break of dika fruit

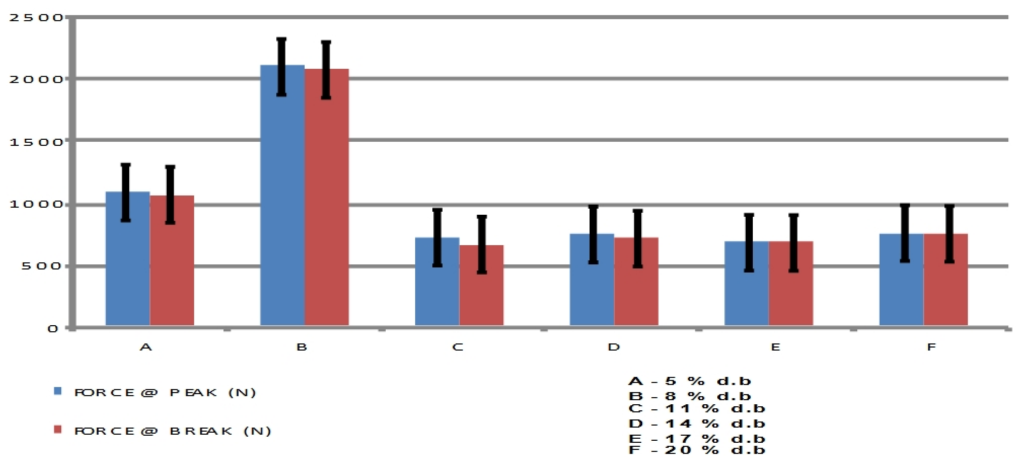

Fig. 4. Effect of moisture content on force at peak and force at break of dika nut

The effect of varying moisture content on the Young's modulus was shown in Fig. 5 and 6. Young's modulus is often used by engineers as an index of product firmness [6]. The nut generally was more firm than the fruit at all moisture levels except at 5% moisture level. It has been observed that toughness and hardness are important quality attributes use for fruit quality assessment [9]. It can therefore be deduced from at 5% moisture content, the firmness of the fruit is good, and hence, it showed a good quality parameter over fruits at higher moisture levels.

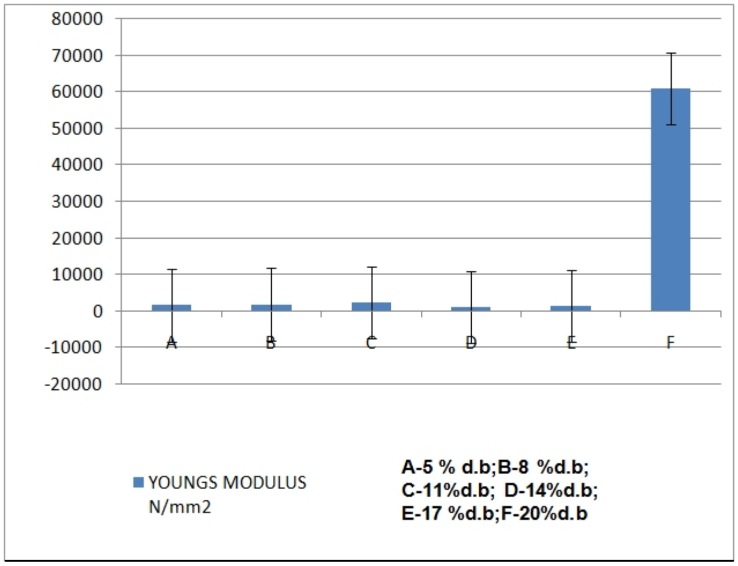

Fig. 5. Effect of moisture content on Young's Modulus of dika fruit.

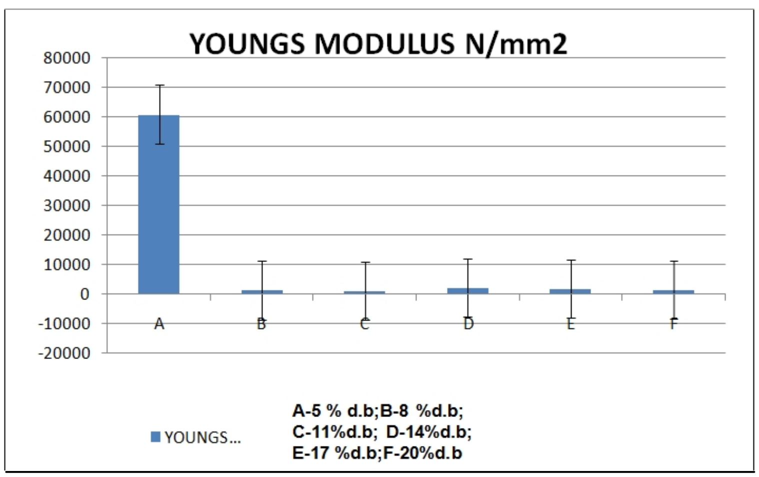

Fig. 6. Effect of moisture content on Young's Modulus of dika nut

4. CONCLUSION

This work has shown that reducing the moisture content of dika fruit and dika nut improves its quality especially those that has to do with post-harvest operations like handling, processing, grading and packaging. Reducing the moisture content of both the dika nut and the dika fruit to 5% will reduce mechanical injury that could affect the post-harvest operations of dika nut and dika fruit. In addition, dika nuts are better handled than dika fruits when post-harvest operations are considered since dika nut showed more resistance to mechanical injury than dika fruits. This is because he Young's Modulus is highest when the moisture content has been reduced to 5% for dika nut, on the other hand the Young's Modulus is highest at 20% for dika fruit when it is still fresh.

COMPETING INTERESTS

Authors declare that there are no competing interests.

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APPENDIX

Appendix I: Testrometric machine with sample

Appendix II: Fresh samples of dika fruits and nuts

Appendix III: Samples of dika fruits after treatment

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