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Moisture-dependent physical properties of *Moringa oleifera* seed relevant in bulk handling and mechanical processing

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ABSTRACT

Physical properties of *Moringa oleifera* seed and kernel were determined as a function of moisture content. In the moisture ranges of 8.43–31.66% (d.b) (seed) and 6.75–31.5% (d.b) (kernel), the major, intermediate and minor axes of seed increased from 1.19 to 1.32 cm, 1.02 to 1.08 cm and 1.00 to 1.05 cm respectively, while those of kernel were in the range of 0.74–0.79 cm, 0.64–0.71 cm and 0.61–0.65 cm respectively. 1000 seed and kernel weights increased with moisture content and ranged between 0.5–0.6 kg and 0.2–0.38 kg in the above moisture ranges. Particle and bulk densities of seed and kernel increased from 0.88 to 0.98 kg m^{-3} and 0.51 to 0.83 kg m^{-3} respectively and from 0.55 to 0.64 kg m^{-3} and 0.64 to 0.7 kg m^{-3} respectively, as moisture content increased in the above ranges. Porosity of seed and kernel increased from 37.5 to 68%, and from 20 to 74% respectively as moisture content increased. Static and kinetic coefficients of friction varied with structural surface and increased from 0.272 to 0.725 and 0.235 to 0.689 respectively for seed, and from 0.211 to 0.732 and 0.215 to 0.566 respectively for kernel. Angle of repose of seed and kernel increased from 17.1° to 23° and 13.1° to 21.8° respectively in the above moisture content ranges. Regression models that adequately expressed the relationships existing between the physical properties of moringa seed and kernel with moisture content were presented.

1. Introduction

Moringa (*Moringa oleifera* Lam.) also known as horseradish or drumstick (Morton, 1991), is a multipurpose tree crop in the semi-arid region of North Eastern Nigeria. The plant produces fruits in form of lobbed pods (Fig. 1) that contain seeds with kernels having average protein and oil content of 27 and 42%, respectively (Ram, 1994). The seed therefore, serves as a good source of protein and cooking oil. The seed oil which is also known as ben oil finds application as raw material in the cosmetic industry and as lubricant for machineries. It burns without smoke and does not become rancid and sticky. The seed cake remaining after oil extraction can be used as fertilizer or as flocculent in water treatment. When ground into powder, the seed is used for water treatment (Jahn, 1986). The seed and seed oil are used in the treatment of such ailments as arthritis, rheumatism, sexually transmitted diseases, hypertension and boils (Eilert et al., 1981).

To obtain the seeds used in oil extraction, the pods are dried (Fig. 2) and shelled manually. The winged coatings on the seeds are then scraped or washed off and the brown and prism shaped seeds (Fig. 3) are collected. The seeds are further dehulled to obtain the kernels (Fig. 4) by pounding in a mortar using wooden pestle. In the traditional process of oil extraction, the moringa seed kernels are subjected to a series of operations including roasting, grinding, heating the meal in a pan over an open fire or boiling it in a pot containing water. These operations as presently carried out are not only labor intensive and time consuming, but also wasteful. Improved methods of processing the seeds using suitable machines and equipment can be developed if the physical properties are known. The moisture-dependent characteristics of physical properties of agricultural products have effects on the adjustment, performance efficiency and energy consumption of processing machines (Mieszkalski, 1997; Aviara et al., 1999). Therefore, the effect of moisture content on the physical properties of moringa seed is an important consideration in the design of handling and processing equipment.

Several researchers (Aydin, 2003; Santalla and Mascheroni, 2003; Yalcin and Ozarslan, 2004; Aviara et al., 2005a; Wang et al., 2007; Bamgboye and Adejumo, 2009; Shafiee et al., 2009) investigated the moisture dependence of physical properties of oil seeds and nuts (almond nut, high oleic sunflower seed, vetch seed, balanites aegyptiaca nuts, fibered flax seed, roselle seed and dragon head seed, respectively) and reported increase of these properties with moisture content with the exception of bulk density that decreased with increase in moisture content. Aviara et al. (2005b) reported that the physical properties of sheanut all increased with moisture content except the porosity that increased with moisture content up to a point and decreased

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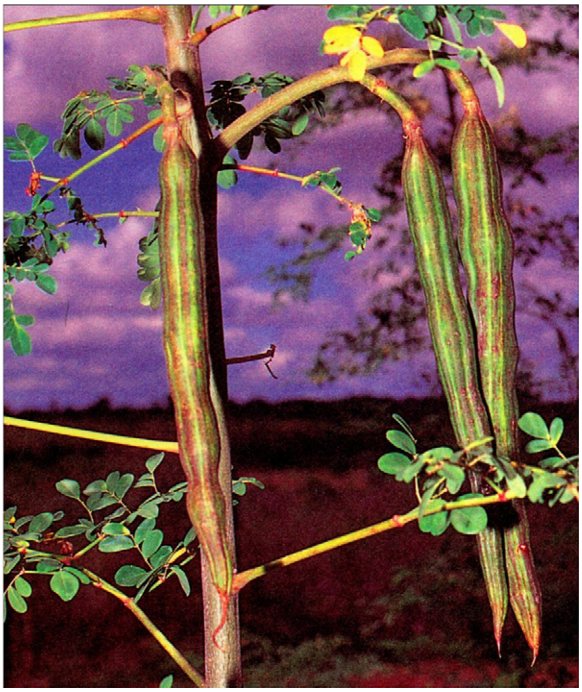

Fig. 1. *Moringa oleifera* tree with lobbed pods.

Fig. 2. Dry *Moringa oleifera* pods ready for mechanical processing.

with further increase in moisture content. The physical properties of beniseed other than bulk density (Tunde-Akintunde and Akintunde, 2007) increased with moisture content. Other investigations (Aviara et al., 1999; Aviara and Haque, 2000; Aydin, 2002; Kaleemullah and Gunasekar, 2002; Konak et al., 2002; Ozarslan, 2002; Abalone et al., 2004; Zewdu and Solomon, 2008; Izli et al., 2009) revealed that the properties of guna seed, guna seed kernel, hazel nut, arecanut kernel, chicken pea seed and rape seed respectively, increased with moisture content except that their true and bulk densities decreased with increase in moisture content. For pumpkin seed (Joshi et al., 1993), karingda seed (Suthar and Das, 1996) and sheanut kernel (Aviara et al., 2000), physical properties other than true density and porosity, increased with moisture content. In soya bean (Deshpande et al., 1993) and neem nut (Visvanathan et al., 1996), the true density, bulk density and porosity decreased with increase in moisture content, while other physical properties increased. Physical properties of gram (Dutta et al., 1988), lentil seeds (Carman, 1996), Okra seed (Sahoo and Srivastava, 2002) and hemp seed (Sacilik et al., 2003) were found to increase with moisture content with the exception of true and bulk densities for gram, bulk density, true density and porosity for hemp and okra seeds and bulk density for lentil seed that respectively decreased with increase in moisture content. No work however appears to have been carried out on the physical properties of moringa seed and their relationship with moisture content.

Fig. 3. *Moringa oleifera* seeds.

Fig. 4. *Moringa oleifera* kernels obtained from the dehulling of seeds.

The objective of this study was to determine the physical properties of moringa seed and kernel; investigate their relationship with moisture content and establish their roles in the mechanical processing of the seeds. The properties include size, one thousand seed and kernel weight, particle (true) density, bulk density, porosity, static coefficient of friction, kinetic coefficient of friction and angle of repose. Relevant literature was studied in order to select the appropriate method of determining each of the above properties. The selection of a method was based on simplicity, accuracy of results and wide acceptability.

2. Materials and methods

A bulk quantity of moringa seeds was obtained from Lassa in Askira-Uba Local Government Area of Borno State, Nigeria. The seeds were cleaned to remove foreign matter and broken or immature seeds. To obtain intact kernels, the seeds were sampled using a multi-slot riffle box divider and manually dehulled.

Since the kernel of the seed is oil-yielding, the moisture contents of both and kernel were determined using the method reported by Ajibola et al. (1990). This involved the oven drying of seed and kernel samples at 130 °C with weight loss monitored on hourly basis to give an idea of the time at which the weight began to remain constant. Weight of samples was found to remain constant after about 5 h of oven drying. Four moisture levels in the ranges of 8.43–31.66% (d.b) and 6.75–31.50% (d.b) for the seed and kernel respectively, were used to investigate the effect of moisture content on the physical properties. Seed and kernel samples of desired