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Characteristic and Some Physical Properties of Dried Ripe Fruit of Sacha Inchi (*Plukenetia volubilis* L.)

Nuttaphon Sokudlor[1,2,3]*, Kittipong Laloon[1,2,3], Sakda chumpana[2,3], Somposh Sudajan[1,2,3]

[1]Department of Agricultural Engineering, Faculty of Engineering, Khon Kaen University, Khon Kaen, 40002, Thailand
[2]Postharvest Technology Innovation Center, Commission on Higher Education, Bangkok 10400, Thailand
[3]Agricultural Machinery and Postharvest Technology Center, Khon Kaen University, Khon Kaen, 40002, Thailand
*Corresponding author: Tel: +66-8-6853-3832, Fax: +66-43-362-149, E-mail: sokudlor@kkumail.com

Abstract

The physical properties of agricultural products are very useful in processing improvement such as harvesting, transportation and storage. In this study, physical properties of sacha inchi is important in designing machinery to preparation of processing chain from raw materials to product. Dried ripe fruit of sacha inchi from Lampang province (Northern part of Thailand) with moisture content of 4.05% w.b. was studied. The fruit was composed of skin (Exocarp Part) 19.32%, shell (Mesocarp Part) 26.84%, seed soat (Endocarp Part) 18.73 % and kernel (Endosperm) 34.85%. The fruit's diameter was in the range of 35.17 to 50.95 mm. Thickness was in the range of 22.82 to 24.47 mm. Breadth of pod and seed were 23.38 to 25.45 mm. and 15.67 to 17.68 mm. Length of pod and seed were 21.15 to 25.20 mm. and 18.85 to 21.43 mm. Thickness of pod and seed were 14.54 to 15.61 mm. and 8.34 to 8.80 mm. Angle of repose of fruit, pod and seed were 41.0 to 52.5 degrees 23.2 to 27.0 degrees and 27.2 to 31.3 degrees, respectively. Static coefficient of friction on steel /stainless /rubber were fruit: 0.781 to 0.869/ 0.726 to 0.839/ 0.839 to 0.932 pod: 0.754 to 0.810/ 0.781 to 0.839/ 0.839 to 0.932 and seed: 0.600 to 0.753/ 0.488 to 0.554/ 0.649 to 0.753 respectively. Bulk density of fruit pod and seed were 655.0 725.5 and 999.4 kg/m^3 respectively.

Keywords: Sacha Inchi, Physical Properties, Fruit composition of Sacha Inchi

1 Introduction

Native to the Amezon jungles plant, sacha inchi (Plukenetia volubilis L.), also known as the ''Inca peanut''. Plant of the Euphorbiaceae family alike Cassava (*Manihot esculenta*), castor plant (*Ricinus communis*) and jatropha (*genus Jatropha*). Sacha inchi is a potential oilseed crop because the seeds of this plant are rich in oil and proteins (35–60% oil and around 27-33% proteins) (M.D. Guillén et al., 2003; A.K.L. Nascimento et al., 2013), The oil is characterized by its high content of unsaturated fatty acids (FAs), particularly A-Linolenic Acid (ALA), a kind of omega-3 fatty acids and in less proportion Linoleic Acid (LA), a kind of omega-6 fatty acids (Gustavo F et al., 2014).

Many researches have reported the benefits of sacha inchi oil (SIO). Such Longjian Niu et al. (2014) have reported sacha inchi oil has agreat potential for applications in the food and pharmaceutical industries according Luis-Felipe Gutiérrez et al. (2011) have reported sacha inchi is an important new crop with applications in the food and pharmaceutical industries and Gustavo F. et al. (2014) have reported sacha inchi oil consumed has good acceptability after week-1 of consumption and it is safety. Most Informations and research supported the performance of SIO indicated this crop can be apply to commercial production. However, there is very little information on the physical properties of sacha inchi dried fruits or seeds. The physical properties very important for processing chain, which affects to quantity and quality from raw materials to product.

The objective of this study was to determine characteristic and some physical properties of dried ripe fruit of sacha inchi, so that the knowledge gained will be used in optimizing machine design parameters.

2 Materials and Methods

2.1 Raw material and sample preparation

Dried ripe fruit of sacha inchi used in this study were procured from north parts (Lampang province: 8°20'54.2"N 99°24'31.6"E) of Thailand. The sample

was cleaned manually to remove all foreign materials. The initial moisture content was determined by drying samples in a hot air oven set at 105°C (±1°C) for 24 h (ASAE, 1994) and was found to be 4.05% w.b.

Five sample were selected from a total bulk of 200 kg, each sample weighted with an electronic balance with an accuracy of ±0.001g then separated into classes according number of pods. Counted and weighed each classes, it was found that can be divided into four groups include 4 5 6 and 7 pods, each group has proportion by number were 45.81% 37.06% 14.94% and 2.19% respectively, and proportion by weight were 42.5% 38.2% 17.9% and 1.4% respectively. Because proportion of 7 pods are very small compared to other groups, and not enough for study. The preparation of sample for this study were divided into three main groups were characterized by 4 pods, 5 pods and 6 pods.

After the separation process, samples were were kept in an airtight plastic bags and stored at 5 ◦C until use. Before starting a test the samples were allowed to warm up under ambient room conditions (22–25 ◦C, 30–40% RH) to the equilibrium moisture (V. Sharma et al., 2011).

2.2 Structure and composition of fruit

Randomly three sample from three main groups (30 fruits per sample), weighted with an electronic balance. Then, separate and weighted the fruit components according fruit structurals as shown in Fig. 1 include 4 parts were skin (*Exocarp*) husk (*Mesocarp*) seed coat (*Endocarp*) and kernel (*Endosperm*) (Cappers & Bekker, 2013) , and computed percentage by weight.

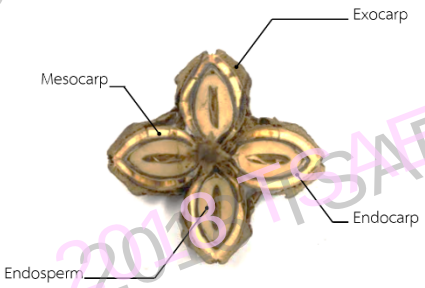

Figure 1 Fruit structural of Sacha Inchi Dried Ripe Fruit.

2.3 Physical properties of Plukenetia volubilis L.

2.3.1. Size of samples

Ninety samples were selected from three main groups. To measuring the average size of the fruits, the diamentions (*D*) and thickness (*T*) were measured using a digital caliper with an accuracy of 0.01 mm. the measurement as shown in Fig. 2, then splitting the pods out of the fruit and measuring the pods size in terms of length (*x*) breadth (*y*) and thickness (*z*) (S. Karaj and J. Müller, 2010). After that, shelled the pods manually and measured the seeds size same the pods methods, the measurement of pods and seeds size as shown in Fig. 2.

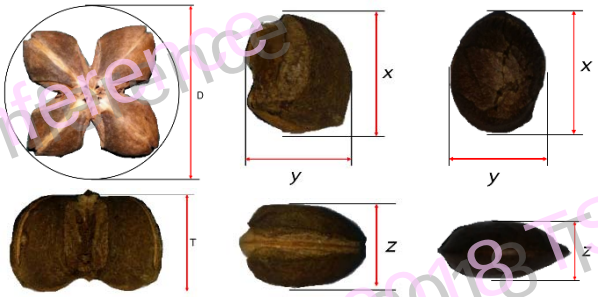

Figure 2 Size measurement of Fruits Pods and Seeds.

2.3.2 Shape of sacha Inchi.

The shape of Sacha inchi fruits, Chiara Fanali et al. (2011) are reported that shaped as a star-shaped. For the shape of pods and seeds determined in terms of arithmetic mean diameter geometric mean diameter and sphericity the procedure of measurement as follow:

The arithmetic mean diameter (D_a) and geometric mean diameter (D_g) of samples were calculated from the geometrical dimensions as (Mohsenin, 1980; S. Karaj and J. Müller, 2010):

$$D_a=\frac{(x+y+z)}{3} \quad (1)$$

and

$$D_g=(x\cdot y\cdot z)^{1/3} \quad (2)$$

Sphericity ($\emptyset$) of samples was calculated based on the isoperimetric property of a sphere (Mohsenin, 1980):

$$\emptyset=\frac{(x\cdot y\cdot z)^{1/3}}{x}=\frac{D_g}{x} \quad (3)$$

The higher the sphericity value nearly one denotes its shape closer to a sphere.

2.3.2 Bulk density, Angle of repose and Coefficient of static friction

The bulk density was measured by weighing a filled measuring cylinder with known volume and calculated as (S. Karaj and J. Müller, 2010):

$$\rho_b = \frac{m}{v} \quad (4)$$

where ρ_b is bulk density (g/cm^3), v is container volume (m^3) and m is mass (g) of the sample.

The angle of repose (θ) is the angle of repose is the angle from the horizontal at which the material will rest in a pile. This was determined by using an open-ended cylinder. The cylinder was placed at the centre of a plate and was filled with samples. The samples was released slowly from cylinder until it formed a cone on the plate. Measured the height (H) and the base diameter of cone. The angle of repose was calculated using the formula (R.C. Pradhan et al., 2009):

$$\theta = \tan^{-1}[\frac{2H}{D}] \quad (5)$$

The static coefficient of friction (μ) was determined on three different materials namely steel stainless and rubber. The procedure of measurment was conducted to the methodology described by R.C. Pradhan et al. (2009) and V. Sharma et al. (2011). The static coefficient of friction was calculated using the formula:

$$\mu = \tan\alpha \quad (9)$$

where μ is the coefficient of friction and α is the angle of tilt in degrees.

3 Results and Discussion

The initial moisture content of sample was 4.05% w.b. The results of this study are presented as follows:

3.1Structure and composition of fruit

Sacha Inchi fruit was composed of skin (Exocarp Part) shell (Mesocarp Part) seed coat (Endocarp Part) and kernel (Endosperm). In 4 pods composed of skin shell seed coat and kernel were 19.46 26.95 18.38 and 33.98 % by weight respectively. In 5 pods were 19.75 26.73 18.73 and 34.13 % by weight respectively and in 6 pods was 18.71 26.85 19.08 and 36.45 % by weight respectively. The result presented in table 1

Table 1 Result of Sacha Inchi fruits composition.

Number of pods		% Composition by weight			
		Skin	Shell	Seed Coat	Kernel
4	Max	22.02	33.33	20.69	39.02
	Min	16.95	24.39	15.38	26.26
	Mean	19.46	26.95	18.38	33.98
5	Max	23.41	31.73	21.74	39.22
	Min	16.09	20.83	18.52	22.12
	Mean	19.75	26.73	18.73	34.13
6	Max	21.33	31.97	21.21	38.68
	Min	16.09	20.45	15.38	22.12
	Mean	18.71	26.85	19.08	36.45

3.2Physical properties of Plukenetia volubilis L.

3.2.1 The size of sacha inchi.

The size characteristics of sacha inchi fruits in terms of length, breadth and thickness presented in Table 2. It was observed that fruit's diameter was in the range of 35.17 to 50.95 mm. Thickness was in the range of 22.82 to 24.47 mm. Breadth of pod and seed were 23.38 to 25.45 mm. and 15.67 to 17.68 mm. Length of pod and seed were 21.15 to 25.20 mm. and 18.85 to 21.43 mm. Thickness of pod and seed were 14.54 to 15.61 mm. and 8.34 to 8.80 mm.

Table 2 Basic dimensions characteristics of sacha inchi.

Properties	Max	Min	Mean	SD
Fruits				
Diameter (mm)	50.95	35.17	42.95	2.46
Thickness (mm)	24.47	22.82	23.69	0.93
Pods				
Breadth (mm)	25.45	23.38	24.01	2.51
Length (mm)	25.20	21.15	23.15	2.01
Thickness (mm)	15.61	14.54	15.19	0.76
Seed				
Breadth (mm)	17.68	15.67	16.52	1.10
Length (mm)	21.43	18.85	19.74	1.20
Thickness (mm)	8.80	7.67	8.27	1.08

3.2.2 The shape of sacha Inchi pods and seeds

The shape of pods and seeds was presented in table 3. It was observed that sphericity of pods higher mean values compared with seeds.

3.2.3 Bulk density, Angle of repose and Coefficient of static friction

Bulk density are presented in table 4 demonstrates since seeds size was smaller than pods and fruits size, more unit of seeds were entering into the container volume compared with unit of pods and fruits. The seeds fraction was highest values of bulk density that

was in the range of 998.8 to 999.9 kg/m^3, fraction of pods was in the range of 717.7 to 729.2 kg/m^3 and fruits fraction was in the range of 650.7 to 660.0 kg/m^3.

Angle of repose of fruits pods and seeds was presented in table 4. The highest values of angle of repose were recorded from fraction of fruits with in the range 41.0 to 52.5 degrees. It was also noticed that angle of repose of seeds that was higher than for pods. Similar results were obtained by Shkelqim Karaj and Joachim Müller (2010). This might be explained by the cohesion forces between seeds units are stronger than cohesion between pods units.

Coefficient of static friction of fruits on various surfaces showed that static friction on rubber is higher then on other surfaces and static friction on stainless is the lowest. Coefficient of static friction of pods similarly fruits was highest on ruber but lowest on steel. Coefficient of static friction of seeds on stainless and rubber surfaces are equally but lowest on steel. The coefficient of static friction of fruits was highest on all surfaces. This might be explained by the friction directed variation with weight. The fruits are heavier combined with roughness skin's surface, which not allowed moving easily on the studied surfaces.

Table 3 Geometric characteristics of Sacha inchi pods and seeds (mean values±standard deviation).

Sample source	Arithmetic diameter D_a (mm)	Geometric diameter D_g (mm)	Sphericity Ø
		Pods	
4 pods number	20.29±0.49	19.95±0.44	0.944±0.031
5 pods number	20.74±1.02	20.21±0.99	0.832±0.028
6 pods number	22.03±1.56	21.45±1.36	0.853±0.030
		Seeds	
4 pods number	15.12±0.53	14.24±0.47	0.710±0.009
5 pods number	14.48±1.47	14.07±1.53	0.798±0.798
6 pods number	15.62±1.32	14.31±1.08	0.669±0.020

Table 4 Complex characteristics of Sacha inchi.

Properties	Fruit			Pod			Seed		
	Max	Min	mean	Max	Min	mean	Max	Min	mean
Bulk density (kg/m^3)	660.0	650.7	655.1	729.2	717.7	725.5	999.9	998.8	999.4
Angle of repose (°)	52.5	41.0	46.0	27.0	21.9	24.0	31.3	27.2	29.4
Static coefficient of friction (μ)									
- steel	0.900	0.759	0.824	0.787	0.776	0.783	0.577	0.554	0.566
- stainless	0.810	0.708	0.761	0.816	0.770	0.799	0.695	0.669	0.685
- rubber	0.907	0.869	0.887	0.913	0.827	0.851	0.695	0.669	0.685

4 Conclusions

The component of Plukenetia volubilis L. dried ripe fruits only 32% can used for the processing of foods in greated values product, orther mass are shell, skin and seed coat more than 60% have to be investigated in further research for value added.

Size characteristics of sacha inchi fruits in terms of geometical diamentions. Average fruit diameter was 42.95 mm and 23.69 mm with thickness. The average diamentions of pod, length breadth and thickness were 23.15 24.01 and 15.19 mm respectively, for the seeds were 19.74 16.52 and 8.27mm respectively.

Shape of Sacha inchi fruits shaped like star-shape. When considered in sphericity for determining the shape of pods and seeds, the pods fraction nearly a shape of sphere than seeds.

The complex properties determining in term of bulk density, angle of repose and coefficient of static friction, it could be used for sorting or designing or designing another process for further.

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