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Research paper

Morphological characterization of cassava roots for equipment design

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Abstract

Cassava (Manihot esculenta, Crantz), native from Latin America, is one of the main food crops which contribute to ensure alimentary security in Cameroon. In Adamawa region, especially in NGAN'HA area, it is one of the principal food crops cultivated, but not really exploited. According to FAO, there are more than 40% of cassava production lost because of lack of processing equipment like conservation and transformation equipment. The purpose of this study is to carry out the morphological characterization of cassava roots to guide cassava processing equipment design. Twenty cassava roots were harvested at NGAN'HA, have been labeled, measured and weighed. The ends of each cassava root were removed, measured and weighed. The different shapes of the remaining part have been identified by analyzing the diameter variations on the root, separated by scission and the dimensions of each piece have been measured according to the 3D basic solids existing shape at which it was closer. The study revealed that for an entire root, we have 240mm to 845mm of length and 0.42 K to 2.54Kg of weight. The analysis of the central part pieces revealed that a major part of roots has cylindrical shapes (68.57%), and followed by truncated conical (22.86%) and spherical (8.57%). The mean value of diameter for cylindrical roots is 72.44mm, 55.3mm and 75.96mm for truncated conical roots respectively for the smallest and the highest diameters. Spherical roots have 71.78mm of mean diameter. The distribution of length and weight or a single root showed that the cylindrical part can represent until 87.50% of the length and 91.89% of the weight; truncated conical part can represent 53.67% of the length and 4% 0f the mass; spherical part can represent 30% of the length and 45% of the mass; the analysis of the ends revealed that they can represent 4.5% of the total mass of roots. Their mean length is 49.39mm for the left ends and 29.11 for the right ends; the mean weights have the same value of 0.03Kg. The characteristics obtained from this study revealed that the model of equipment to design for industrial transformation of cassava is Lathe.

Keywords: *Cassava; Cylindrical Shape; Morphology; Equipment Design; Lathe.*

1. Introduction

Cassava (Manihot esculenta, Crantz), native to Latin America, is increasingly grown in tropical and subtropical areas (Q. Liu, S. He, 2014). It is the fifth largest food crop after maize, rice, wheat and potato in the world and the global production is estimated at 263.58 million tons in 2012 (FAO, 2014). Cassava has an edible starchy root tuber (P. Clifton, J. Keogh, 2016), which provides more than half of the calories consumed by more than 800 million people in Sub-Saharan Africa (SSA), Latin America and Asia (Gina Kennedy, Elise. F, 2019 ; Charts-Bin.com ,2024). Cassava contributes not only to the food and feed, but it is also used in manufactures (textile, paper, etc.) (Kariuki Samwel Muiruri, Anwar Aliya Fathima, 2024). According to the Agricultural research Council review on Cassava (2023), cassava is the most important food crop in Africa with more than 113 million tons of tuberous roots and their processing products are consumed. In Adamawa region the production of cassava is estimated at 370 389 tons in 2021(Minader report, 2021). Cassava is produced in all the regions of Cameroon by 584 000 producers and provides multiple local products (Baton de manioc, gari, Donga, mitumba, Cassava flour, kwem, etc) which are intended for national and regional trade (FAO, 2018). Moreover, there are more than 40 % of fresh cassava roots which are lost because of lack of processing equipment (Sanni, L. O, M. D. Mussagy, 2009) and principally conservation and transformation equipment (FAO, 2018), time consumption, labor intensiveness, less quality of the product. Previous studies on morphological characterization of cassava based on the variability within the collected germplasm helped to classify the genotypes of cassava plants, to identify the cultivars used by farmers and to provide information for conservation and management purpose (Chu Duc Ha et al, 2016 ; Djirabaye Nadjiam et al, 2016 ; N'zue Boni et al, 2014 ; A. P. Agre et al, 2015).The aim of the present study is to carry out the morphological characterization of

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cassava roots based on the measurement of their dimensions and weights. Thus, this information will provide suitable data to guide cassava processing equipment design.

2. Materials and method

2.1. Sample preparation

Twenty cassava roots were harvested at NGAN'HA (7°26' N and 13°56'E) on 19th July 2022.The farm in which the roots were harvested was two years old and the roots were labeled and submitted to a physical characterization laboratory experimentation. The ends of each cassava root were removed, measured and weighed. The different shapes of the central part have been identified by visualization and separated by scission. The dimensions of each piece have been measured according to the 3D basic solids existing shape at which it was closer.

2.2. Laboratory equipment

2.2.1. Digital caliper

A digital caliper type IHM-1150M with 0 to 150mm measuring range has been used for measuring the diameter of the roots (for cylindrical, truncated conical and spherical shapes).

2.2.2. Tape measure

A tape measure with 0-150 cm measuring range has been used to measure the lengths.

2.2.3. Balance

A LARIO balance from CURIONI & C (Italy) with 0-W12 Kg measuring range and 20g measurement accuracy has been used for weighing the roots.

3. Results and discussion

3.1. Morphological characteristics of entire roots

The morphological characterization of cassava roots reveals that the minimal value of the average length of cassava roots is 240mm and the maximal value is 845mm. The weights have a minimal value of 0.42 Kg, and the maximal value is 2.54 Kg. These results agree with standards published for bitter cassava by CODEX-Alimentarius under norm CODEX STAN 300-2010. This information is important for transportation and the conservation of the roots.

3.2. Morphological characteristics of remaining parts of roots for the transformation

The shape analysis of remaining parts pieces of roots after scission according to the 3D solid basic shapes at which it was closer reveals that a major part of roots has cylindrical shapes (68.57%) and followed by truncated conical (22.86%) and spherical (8.57%). These results agree with those published by N'zue Boni et al which revealed that the shapes of entire cassava roots were at 63% cylindrical and 23% conical in a sample of 159 roots.
According to the fact that the cassava's farm is two years old, most roots have already reached their maturity and have a uniform shape (cylindrical).

Table 1: Diameter of Cassava Roots and Percentage of Different Shapes

Identified forms	Number (%)	Mean value of diameters (small and higher for truncated conical shapes)
Cylindrical	68.57	72.44
Truncated conical	22.86	55.3
Spherical	8.57	71.78

Some cassava roots are in the growth phase, so the dimensions are not uniform, and the identified shape is truncated conical. Due to the hardness of the soil in some places, some roots have developed spherical shapes. Concerning diameters of roots, the mean value of diameter for cylindrical roots is 72.44mm, 55.3mm and 75.96mm for truncated conical roots respectively for the smallest and the highest diameters. Spherical roots have 71.78mm of mean diameter. These results agree with standards published for bitter cassava by CODEX-Alimentarius under norm CODEX STAN 300-2010.
The distribution of length and weight for a single root showed that cylindrical part can represent 87.50% of the length and 91.89% of the total weight of one root as described in Figure 1 and Figure 2.

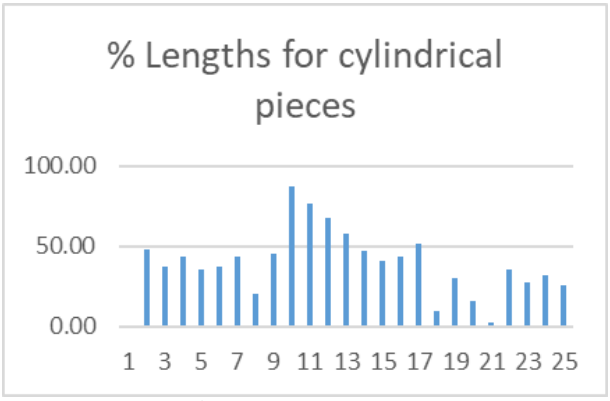


Fig.1: Longitudinal Distribution of Cylindrical Shape in Cassava Pieces Obtained by Scission

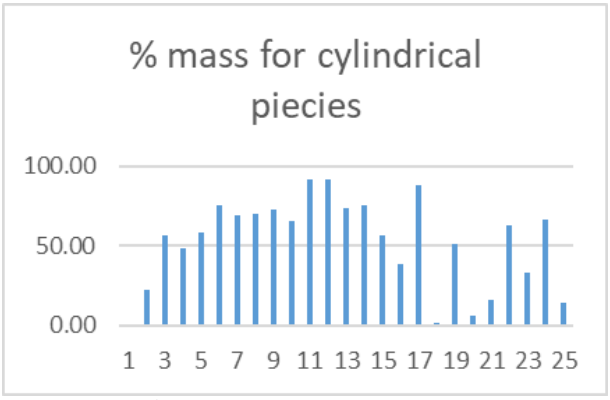


Fig. 2: Average Mass of Cylindrical Shape in Cassava Pieces Obtained by Scission

Truncated conical part represent 53.67% of the length and 46 % of the mass of one cassava root as described in Figure 3 and Figure 4:

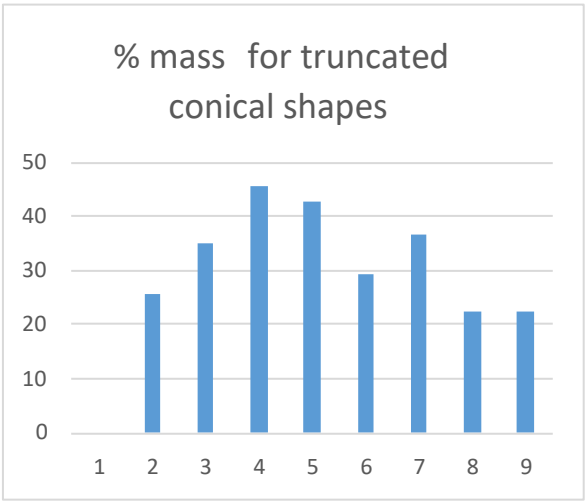


Fig. 3: Longitudinal Distribution of Conical Shape in Cassava Pieces Obtained by Scission

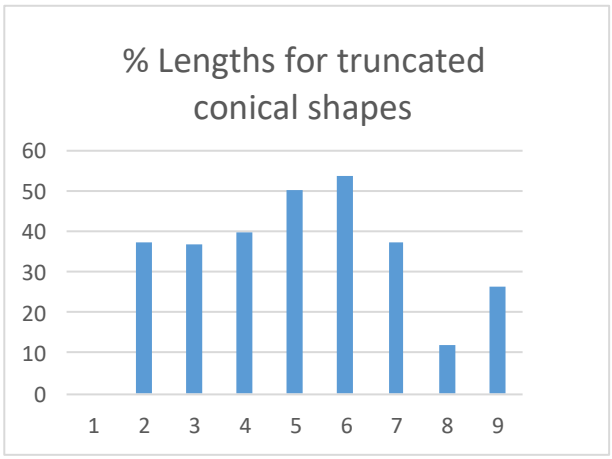


Fig. 4: Average of Conical Shape in Cassava Pieces Obtained by Scission.

The spherical part can represent 30 % of the length and 45 % of the mass except for the unique root for which the total length and mass was distributed into spherical shape in the collected samples. This distribution is presented in Figure 5 end Figure 6.

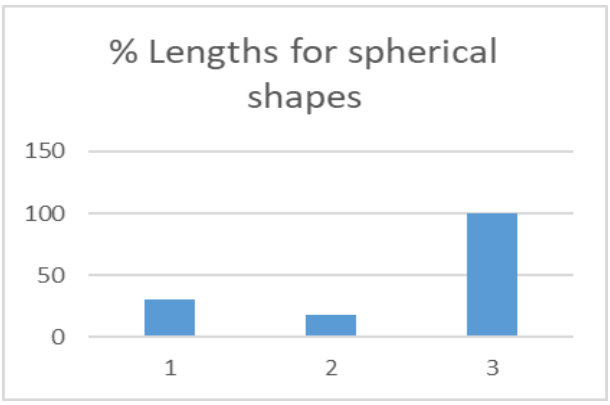


Fig. 5: Longitudinal Distribution of Spherical Shape in Cassava Pieces Obtained by Scission.

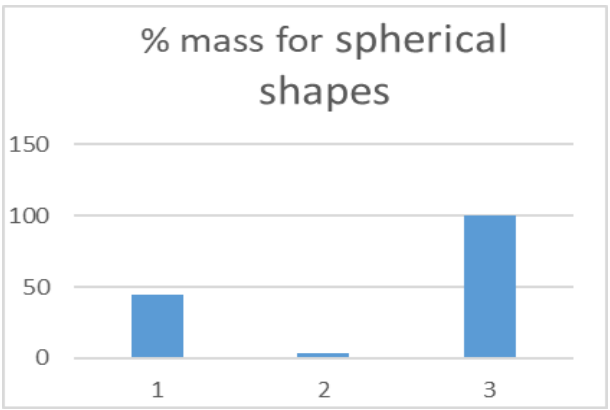


Fig. 6 : Mass Distribution of Cylindrical Shape in Cassava Pieces Obtained by Scission.

3.3. Analysis of ends

The physical characterization of the ends for the selected roots reveals that the average mass for the whole quantity of the ends is 4.5% of the total mass of roots. The standards published for bitter cassava by CODEX-Alimentarius under norm CODEX STAN 300-2010 present that the stalk end of the root should have a clean cut between 1 cm and 2.5 cm in length in case of varieties that have distinct stalk for commercial bitter varieties of cassava roots grown from Manihot esculenta Crantz, of the Euphorbiaceae family, to be supplied fresh to the consumer, after preparation and packaging. Cassava for industrial processing is excluded for this standard. Our study has been conducted in the case for industrial processing purpose and the mean value of length is 49.39mm for the left ends and 29.11 for the right ends. The mean weights have the same value of 0.03Kg. These results show that the final product which can be obtained from the ends of cassava roots is negligible. So, the whole useful material is contained in the central parts of cassava roots.

Table 2: Dimensions and Weight of Cassava Ends

Parameters	Total weights (%)	Length (mean values)	Mass (mean values)
Left ends	4.50	47.39	0.03
Right ends		29.11	0.03

4. Conclusion

The study revealed that the average length for a root move from 240mm to 845mm and the weights from 0.42 Kg to 2.54 Kg. For the pieces obtained from the central part of roots there are three frequently observed shapes which are at 68.57% cylindrical, at 22.86% truncated conical and at 8.5447% spherical for mature roots. The mean diameter is 72.44mm for cylindrical roots, 55.3mm and 75.96mm for truncated conical roots respectively for the smallest and the highest diameters. Spherical roots have 71.78mm of mean diameter. The distribution of length and weight for a single root showed that cylindrical part can represent 87.50% of the length and 91.89% of the weight; truncated conical part can represent 53.67 % of the length and 46 % of the mass; spherical part can represent 30 % of the length and 45 % of the mass excepted the unique root for which the total length and mass was distributed into spherical shape. The study also revealed that the ends of cassava roots represent 4.5% of the total mass of roots and the mean value of the weights of the ends is 0.03Kg which makes negligible the final product which can be obtained from the ends. So, the whole useful material is contained in the central parts of cassava roots and the equipment design for transformation of cassava should consider only the central part of roots. The characteristics obtained from this study revealed that the model of equipment to design for cassava processing is in the universal machine tools family. The state of knowledge could help in the development by innovative way to the design of suitable equipment for cassava processing.

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