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Evaluation of the Underutilized Agro-morphologic features of Aroids for improved Food Security, Nutrition, and Economic Development

Unyime Enobong Okure[1*], Joyce Gosata Maphanyane[2], Victoria Okure[3], Alìck Muvundika[4]

[1]Dept of Chemical Engineering, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria
[2]University of Botswana, Department of Environmental Science, Gaborone, Bostwana
[3] Dept of Biochemistry, University of Uyo Akwa Ibom state, Nigeria
[4]Dept of Water, Energy and Environment, National Institute for Scientific and Industrial Research, Nigeria

*Corresponding author: Unyime Enobong Okure; Email: okureunyime@gmail.com

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Abstract

Aroids or Cocoyam are often referred to as "women's crops" because women dominate the value chain. Women are primarily responsible for producing, processing, and sales of this root plant, while ensuring a year-round supply. Aroids, i.e. taro (*Colocasia esculenta*) and tannia (*Xanthosoma sagittifolium*) are underutilized root crops in the tropical and subtropical regions of developing nations. In Nigeria, there is abundance of Aroids. It can be boiled, fried, steamed, or roasted, pounded to produce a paste for porridge thickening, dried to make flour, sliced and fried to make chips, and prepared in a variety of other ways. A variety of local foods utilizes aroids. The investigated physiochemical properties of *Xanthosoma sagittifolium* and *Colocassia esculenta* include length, width, thickness, geometric mean diameter ,sphericity),mass, volume, density, moisture content, porosity, and angle of repose. The development of machinery for the harvesting, storage, and processing of aroids requires adequate knowledge of their agro-morphologic features.

Key words: root crop, marginal resource, storage equipment, post-harvest condition, food processing, *Xanthosoma sagittifolium*, *Colocassia Esculenta.*

1.0 INTRODUCTION

Aroids also known as Coco-yam, many readers are unfamiliar with the name. This is amongst the most neglected crops, so this is hardly surprising. Aroids in West Africa refers to tannia *(Xanthosoma sagittifolium*) and taro, two distinct root and tuber crops (*Colocasia esculenta*). It can be cooked, fried, micro waved, or roasted, pounded to make a paste, dried to flour, sliced and fried to produce chips, among other preparations. The plant's leaves are also fit for human consumption and it can be added to meals such as broths as a vegetable. Aroid is cultivated less frequently, most especially in central and western Africa compared to similar crops like potato, yam and cassava, but it plays a crucial role in food and nutrition security. This plant's health benefits are well documented, and it has the potential to generate substantial income for the rural people, particularly women. Aroids have a multitude of advantages, so why are they not highly regarded and utilized? Aroid is often ignored as a "women's crop," and women monopolize the value chain [Otekunrin et al., 2021]. Women are primarily responsible for the production, processing, and sales of this root vegetable, ensuring a continuous supply throughout the year. Nonetheless, women control the finances associated with cocoyam. Besides their commitment to the cocoyam value chain, women are excluded from the majority of decision-making process steps and face discrimination in terms of land access for cocoyam farming [Abdulrahman, 2015]. Aroids are typically grown on low-quality land allocated by husbands to their wives. Resulting from a lack of resources, women face: inadequate planting material, poor storage – resulting in a high incidence of rotting, pests, and diseases – and insufficient processing facilities are additional obstacles that limit the income-earning opportunities of aroid farmers. Taro has been particularly impacted by taro leaf blight, a disease in which there is currently no resistance. Women play a crucial role in achieving food security, and Aroid is a rich source of protein, pro-vitamin A, carotenoids, iron, and zinc, which, if exploited, plays a crucial role in food security (Aniekwe, 2015). The research of the agro-morphologic properties of aroids will aid engineers in resolving the problem of constructing storage and processing facilities for aroids, thereby enhancing food security.

Aroids are members of the Araceae family, and some species include *Xanthosoma sagittifolium*(tannia), Alocasia, *Colocasia esculenta*(taro), eddoe or eddo (*Colocasia antiquorum*), tarul, arum, elephant's ear, *Alocasia macrorrhizos*, and alocasia. Root and tuber crops derived from aroids are renowned for their high nutritional value. Quite a few of them have high nutritional value that can help fill in nutritional gaps and balance certain dietary needs. Aroids are among these useful root and tuber crops. It is an aroid because it is cultivated primarily for its edible corms. However, its leaves can be used for medicinal and culinary purposes as well. This root crop is native to tropical and subtropical regions, and research indicates that it is one of the least studied root plants.

Tannia, also known as Aroid (AFIA IKPONG in Annang), originated in the humid valleys of northeastern South America. It was domesticated and spread by migrating Indian tribes throughout the Caribbean basin. Within this genus, there is a great deal of confusion because the same plant has been given multiple species names. Moreover, tannia is frequently mistaken for taro (Adane et al., 2013).Taro is a tropical tuber crop that is primarily grown for its underground corms, which are consumed in tropical regions of the world. It is referred to as "ako-nkongma" in the Annang language. According to reports, taro contains 70 to 80% starch in the form of small granules (Adejumo et al,2013). Due to the small size of its starch granules, taro is easily digestible and has been reported as an ingredient in infant foods. Within this genus, there is a great deal of confusion because the same plant has been given multiple species names. Moreover, tannia is frequently mistaken for taro (Adane et al, 2013).

Tannia is one of the six most significant root and tuber crops in the world. It has been domesticated in the majority of communities in Oceania, Africa, and Asia (Adejumo et al., 2013), providing food for more than 400 million people. It remains an underutilized food resource, with production levels declining in Ghana and Cameroon. Existing confusion in taxonomy and nomenclature, which prevents researchers from utilizing data from one local area to another, exacerbates the problem of underutilization.

The global market of Aroids shows United State of America leading in importation with 768.68(USD million) while Russia was the least at 49.32(USD million). In Aroid export, China was leading with 417.18 million USD, while France was lagging behind with 63.93 million USD.

Utilization of aroids can be in several distinct food for nutrition and feed products, as well as industrial applications. Boiling, roasting, baking, frying in oil, and pasting, milling, and pounding are mechanisms for sustaining and adding value by conversion to semi-finished and final products. In Nigeria, it is used as a soup thickener called fufu, which is a pounded, boiled Aroid mass. It is also utilized in bakery as flours, beverages, as porridge, and the production of foods for people with gastrointestinal disorders. According to Adejumo (2001), taro starch could indeed effectively replace maize as a binder in tablet production.

Meals and feed usage of fresh Aroids is hindered due to the acrid nature of the corms, which irritates upon ingestion and reduces palatability. This reduces the potential for processing. Corms are so acrid that eating them raw causes swelling of the lips, mouth, and throat, along with bitterness, astringency, and a scratchy sensation in the mouth and throat. Anti-nutritional and off-taste issues have been linked to the presence of needle-like raphides of calcium oxalate crystals as well as other acidic and protein-rich components (Christian, 2016])

2.0 MATERIALS AND METHODS.

Sample collection

Colocassia esculentum and *Xanthosoma sagittifolium*, the two most popular varieties of cocoyam, were purchased from the itam market in uyo, Akwa Ibom, Nigeria. It was preserved in a cool location covered with leaves. Then, laboratory preparations were made for the investigations. These two species were rinsed with water, dried and labeled for purposes of identification. All analyses were conducted using standard procedures.

Fig 1. (A)Tannia (Xanthosoma sagittifolium) (B)Taro (Colocassia esculenta)

Determining some agro-morphologic features of Aroids

***Size**:* The size of the fresh Aroid cormels were determined by measuring the dimensions along three principal axes, namely, (length), (width) and (thickness) of each cormel piece using vernier calipers of sensitivity 0.01cm and the range of 0.01cm to 15.0 cm (Tadesse, 2019). The sizes of 40 cormels of each of the two distinct types were evaluated, and the average value for each species was utilized.

***Determination of weight**:* Both the initial and final weight was measured to 0.001 g accuracy with electronic balance of range 0.01g to 5000 g (Tadesse, 2019).

***Relative humidity**:* The cocoyam samples' moisture content was determined by gravimetric methods.

Determination of moisture content

Utilizing the microwave method, the moisture contents of the cormels was assessed. The cormels were chopped and weighted using a digital balance before being oven-dried at 70 ^{o}C for twenty-four hours (1day). The moisture content wet basis percentage was computed and documented.

$$Moisture\ content\ wet\ basis\ = \frac{(W1 - W2)}{W1} \qquad (1)$$

Where W_1 = Initial weight of material (wet weight)
W_2 = Final weight of material (oven dry weight)

***Shape*:** The major (x), intermediate (y) and minor (z) diameters of each cocoyam cormel were measured with vernier caliper to an accuracy of 0.01cm. The values obtained were used to calculate geometric mean diameter (GMD) and sphericity.

$$\text{GMD} = (xyz)^{1/3} \tag{2}$$

$$\text{Sphericity} = \frac{(xyz)^{1/3}}{x} \tag{3}$$

***Volume**:* The mass of each cocoyam cormel was determined using a precision electronic balance of sensitivity 0.01g and the range of 0.01g to 5000g, and the model is EK 5055. Volume of cormel was determined as true volume by immersing the cormel in water contained in a measuring cylinder. The volume of water displaced was measured as specified by Water displacement method .The volume of water displaced is equal to volume of the material.

Porosity: The porosity of the fresh aroids was a computed using the formula: The bulk density was calculated by dividing the mass of the cocoyam cormels in a storage container by its volume. A container was filled with cormels, and the mass of the contents was evaluated. The real density of sample of cocoyam was evaluated using the platform scale method. The tuber is weighted on a scale in the air before being driven into the water using a sinker rod. The actual sample volume was determined and documented.

$$True\ volume\ (cm3) = weight\ of\ displaced\ water\ (g)/Weight\ density\ of\ water\ (g/cm3) \tag{4}$$
0

$$Weight\ of\ displaced\ water\ (g) = (weight\ of\ storage\ container + weight\ of\ water + weight\ of\ tuber) - (weight\ of\ container + water) \tag{5}$$

$$True\ density\ (kg/m3) = mass\ of\ cocoyam\ tuber\ (kg)/\ True\ volume\ (m3) \tag{6}$$

Porosity is given by:

$$\mathcal{E} = 1 - \left(\frac{P_b}{P_t}\right) \times 100 \tag{7}$$

Where, Ɛ is the porosity (%); P_b is the bulk density (kg/m^3); P_t is the true density (kg/m^3)

Angle of Repose: The angle of repose is the angle made by Aroids cormels with the horizontal surface when heaped from a known height (Falade and Okafor, 2014). The surface was tilted gently until the cormels began to slide freely. The slant height of the heap was determined and the radius of the heap was calculated from the circumference of the heap. The angle of repose was calculated by using the formula:

$$\theta = \cos^{-1}\left(\frac{R}{h}\right) \tag{8}$$

Where, θ is the angle of repose, R is the radius of the heap, cm; h is the slant height of the heap, cm.

3.0 RESULTS AND DISCUSSION

A summary of the results for all the measured engineering properties for *Xanthosoma sagittifollium* and *colocassia esculentum* are shown in Fig. 2,3,4, and 5 below:

Porosity

The porosity of *Xanthosoma sagittifolium and Colacassia esculenta were observed to be 38.2 -52.4%, and 30.4-50.2% respectively.* When solid material is put in a container, total volume includes air in it. Porosity of packed materials is the total volume, which is occupied by air. The porosity value is also known as a packing factor, Properties of the material in bulk should be known for mixing, transportation, storage and packaging processes (Habib et al, 2004). Porosity value is an important engineering property for system designing post-harvest operations like drying, storage and aeration, etc. (Ojeniyi et al, 2013).

Angle of repose

The angle of repose of *Xanthosoma sagittifolium* and *Colacassia esculenta* were observed to be 29.4 - 35.1% and 30.1-36.6%; respectively. When solids are piled on a flat surface, the sides of the pile are at a definite reproducible angle with the horizontal leveled surface. This angle is called the angle of repose of the material. The angle of repose is essential for the design of particle processing, storing, and transport systems. Materials with low angle of repose are highly flowable and can be transported using gravitational force or a little energy. The angle of repose helps to ensure free flow of solids in the hopper (Tadesse and Teferra, 2019).

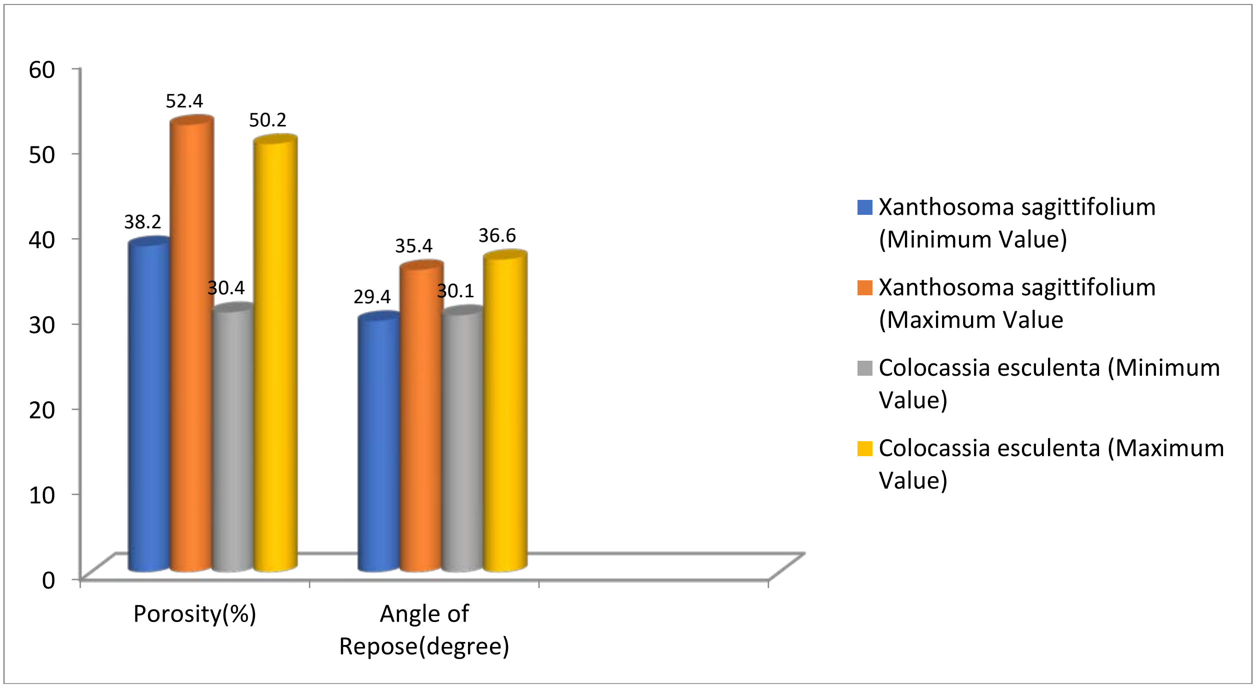

Figure 2. Comparison of agro-morphologic features two species of Aroid (porosity and angle of repose)

The mean dimension were measured for two varieties of cocoyam: *Colacassia esculenta*and *Xanthosoma sagittifolium*. The, minimum, maximum and maximum values of each species of Aroids was measured and recorded as seen above. *Xanthosoma sagittifolium* was found to have length of 4.0 - 20.0 cm, width of 3.0-5.2 cm, and thickness of 4.2 - 5.8 cm. Also, the dimensions of *Colacassia esculenta* are: length 4.6 - 18.0 cm, width 2.8 - 4.1 cm and thickness of 3.8 - 5.1 cm

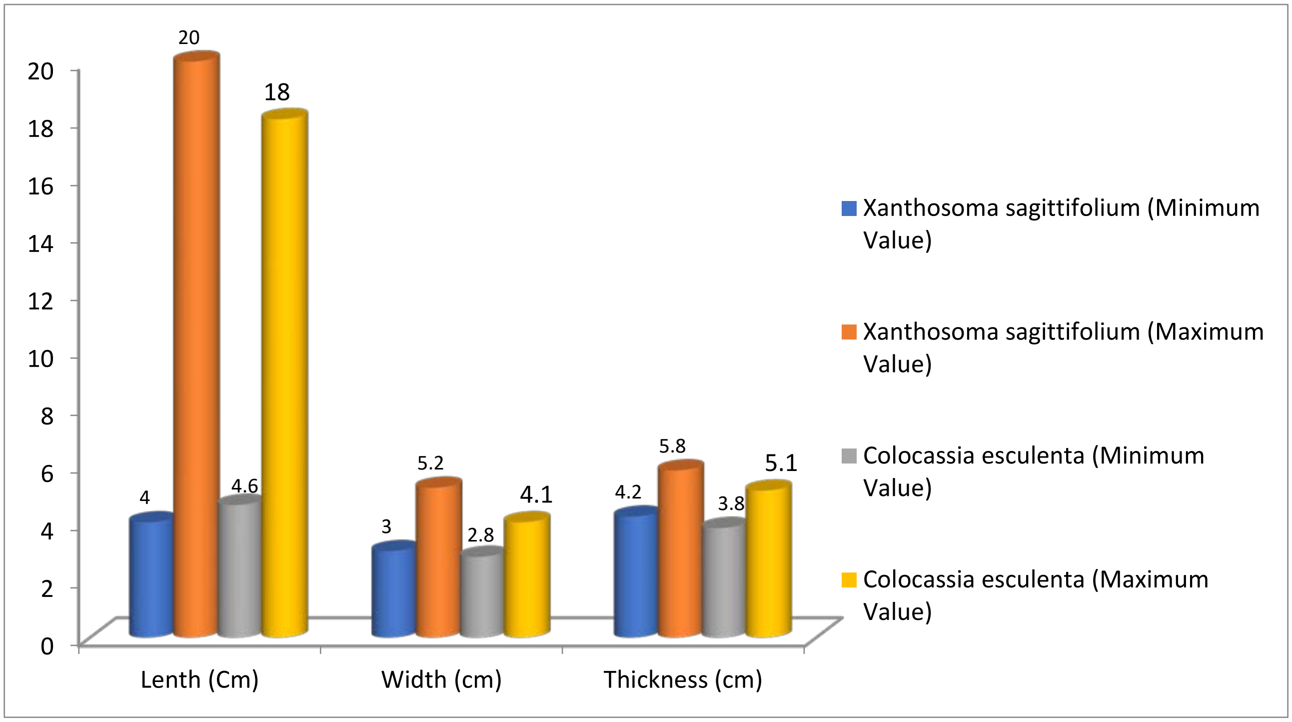

Figure 3. Comparison of agro-morphologic features of two species of Aroid (length, width and thickness)

The sphericity ranged from 0.4 to 0.9 and from 0.2 to 0.8cm, while the mass ranged from 35.9 to 320.1 and from 26.9 to 167.5 g for *Xanthosoma sagittifolium* and *Colacassia esculenta*, respectively. The Engineering properties of seed such as size, shape and sphericity helps determine the maximum size of the cup in the seed plate planters and post-harvest machine, the weight help in the material selection for the frame of the machines.

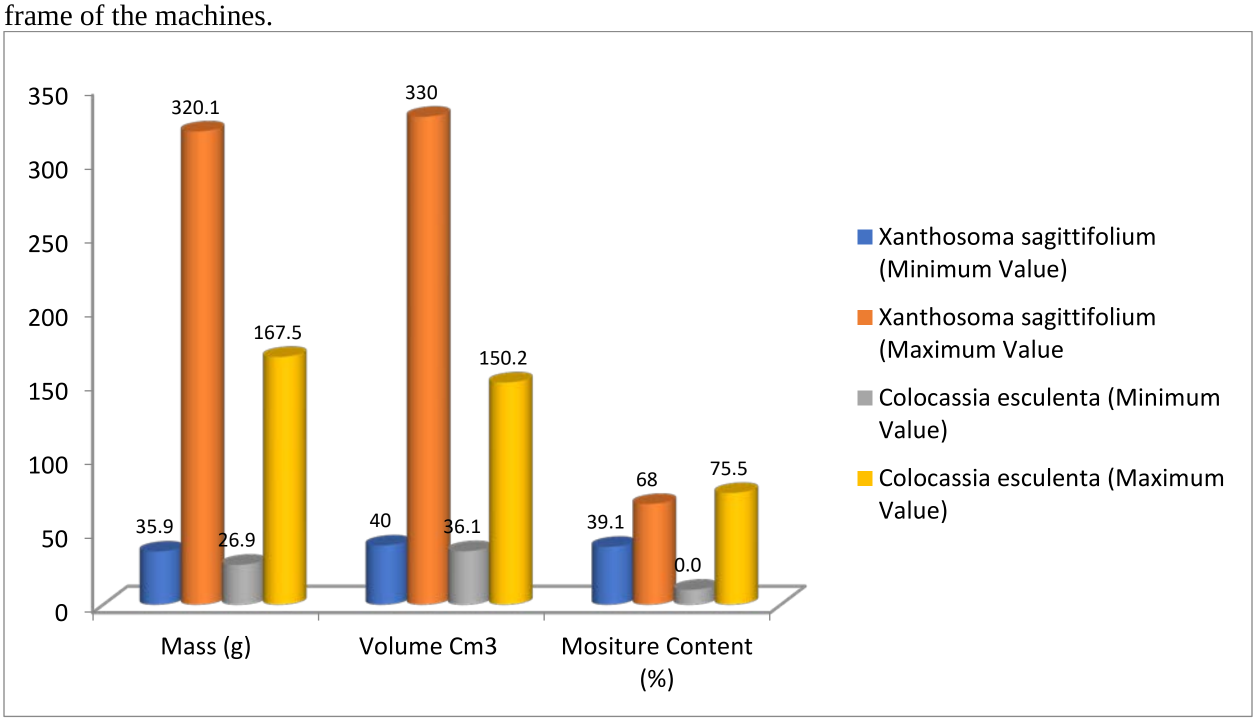

Figure 4. Comparison of agro-morphologic features of two species of Aroid (mass, volume, and moisture content).

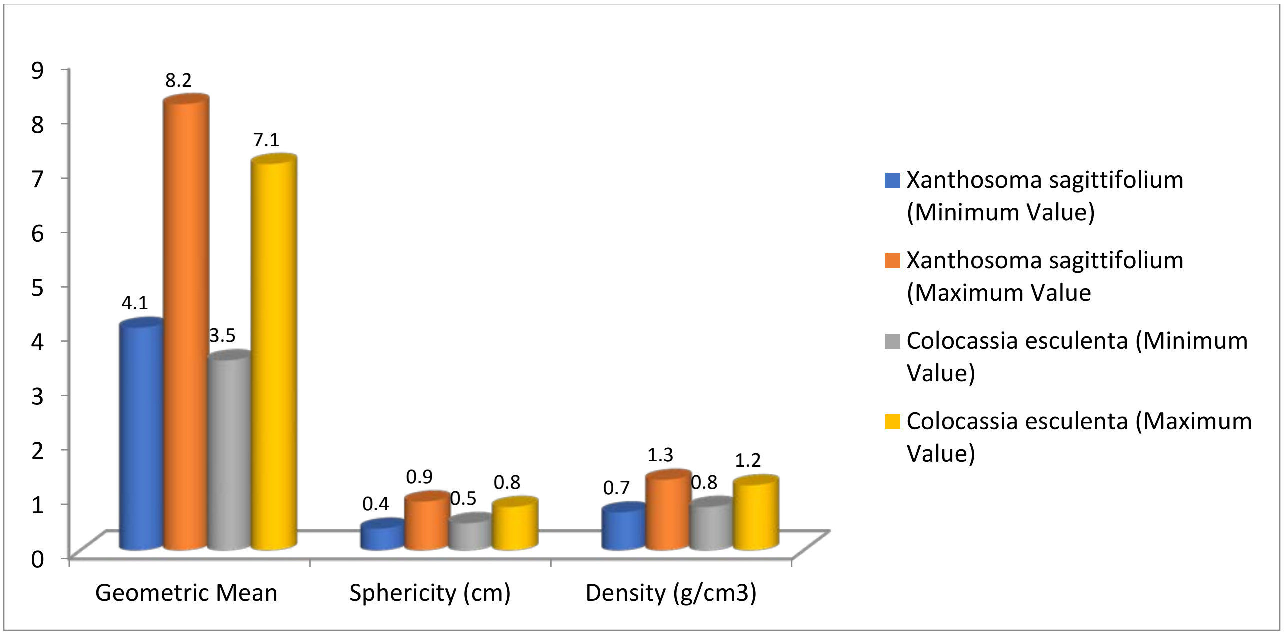

Figure 5. Comparison of agro-morphologic features of two species of Aroid (geometric mean, sphericity, and density)

The moisture content of *Xanthosoma Saggittifolium* and *Colocassia esculenta* fresh seed production helps know the interaction between the seed and the material used for the hopper of the planter at maximum heat level. Data obtained ranged from 39.1 to 60.0 and from 10.0 to46.9, respectively. A small change in seed moisture content has a large effect on seed storage conditions. Therefore, it is important to know the seed moisture content in order to make a reasonably accurate prediction of the possible storage conditions of each accession (Otekunrin et al, 2021).

4.0 CONCLUSION

Engineering features help in specifying the design considerations of post-harvest, processing and storage equipment because it will be a waste of time, resources, effort and money if after fabricating, the machine fails to deliver up to assumptions. The agro-morphologic features of two cocoyam species, *Xanthosoma Saggittifolium* and *Colocassia esculenta*, were explored. The engineering characteristics determined in this study are essential for the scientific design and construction of diverse equipment and machines for the cultivation, harvesting, and post-harvesting of Aroids. Women majorly dominate the aroid value chain, as they are primarily responsible for the production, processing, and marketing of this nutritionally balanced root crop, whose exploitation is crucial for food security and economic development.

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