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# CHANGE IN PHYSICAL PROPERTIES OF BANANA FRUITS DURING RIPENING STAGE

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***Abstract***

*The aim of this study is measuring the physical properties of banana fruits. In this study we used Dessert bananas (Musa sap.) from local dedicated banana ripening rooms in the city of Santa, Gharbia Governorate in January 2024 was selected for experimental work. Banana ripening starts with a full green fruit, then pale green, then green yellow, then yellow with green tips, then bright yellow, then pale yellow and yellow with brown spots at last. The measurements indicators are physical properties such as length (L), width (W), thickness (T) arithmetic mean diameter (Da), mm, geometric mean diameter (Dg) mm, surface area (As) $mm^2$, volume (V) $mm^3$, and sphericity (φ) % of banana fruits. The results recorded that there was a rise in length of 140.97 mm to 151.01 mm, width of 34.06 mm to 38.83 mm, and thickness of 30.67 mm to 35.77 mm, in that order. For the Size and shape index indicators of banana fruits, the results showed that the projected area and shape index increased from 1914.5 to 2259.42 $mm^2$ and from 3.83 to 4.5, respectively. Also, Elongation and Flakiness for banana fruits increased from 3.64 to 4.39 % and from 0.83 to 0.98 % respectively.*

***Key words:*** *banana, ripening rooms, fruit, physical properties*

## INTRODUCTION

The banana is a widely grown fruit, for the most part, developed in tropical and subtropical areas of the world. The amount of bananas produced in Egypt in 2022 was 1.21 million tons. Egypt's output of bananas grew at an average yearly rate of 5.52% from 101,000 tons in 1973 to 1.21 million tons in 2022 [6].

The climacteric fruit banana ripens due to continuous ethylene production after harvesting. Ripening is one of the processes controlled by ethylene, a naturally occurring colorless and gaseous plant hormone. Ripening, also known as de-greening, is an organic process devoid of chemicals. Fruits acquire the optimal color, aroma, and texture that are unique to the highest degree of eating quality throughout the ripening process, which involves physiological, biochemical, and organoleptic changes [16].

Bananas are among the most widely consumed and grown fruits in the world. The increasing demand necessitates an increase in supply. A common practice is to harvest bananas while they are still young and consume them once they have fully ripened. Optimizing ripening efficiency is essential to maintaining a stable supply-demand equilibrium. A banana that is immature usually ripens in three to four days. To reduce this time, people commonly use synthetic substances such ethanol, calcium carbide, acetylene, ethylene, propylene, and ethylene (2-chloroethyl phosphoric acid) [4].

Fruit quality is the foundation of fruit marketing and consumer acceptability; although banana cultivars are treated extensively, consumers' awareness of fruit quality is restricted. Customers usually select fruit based on two characteristics: the fruit's flavor and its consistency in terms of size, shape, mass, and color. The grading system is a crucial unit action that influences the fruit's shape, color, size, mass, and texture. Fruits that are identical in shape and size but have different masses have to be manually sorted, which is a time-consuming and complex procedure. Bulk fruit grading is therefore a

better choice because it is precise, less expensive than other grading techniques, and permits ideal packing arrangement while saving money on packaging and transportation [3].

Banana fruit is high in carbs, dietary fiber, minerals, and several vitamins. In addition, it contains a sizable number of bioactive substances, which offer health advantages over and above nutrition. These include polyphenols, carotenoids, flavonoids, amines, vitamin C, and vitamin E [15].

Fruit had average measurements of 15.42 cm for length (L), 4.08 cm for width (W), and 3.59 cm for thickness (T). The geometric mean diameter (Dg) and arithmetic mean diameter (Da) were measured to be 6.08 and 7.7 cm, respectively. The results showed that the radius of curvature, aspect ratio, and sphericity were, respectively, 186.49, 0.27, and 39.60%. The flakiness to elongation ratios were found to be 0.88 and 3.77, respectively. The physical characteristics that were measured led to the conclusion that banana fruit was non-spherical and elongated in shape [8].

In 2020, more than 370,000 metric tons of bananas were imported by Egypt. The Philippines, Ecuador, and India supply Egypt with the majority of its banana imports, which are valued at a combined $180 million. Furthermore, Egypt shipped more than 3,000 metric tons of bananas. The estimated value of banana exports was $2.55 million. A number of European nations and Libya are important export destinations [7].

One of the most important and well-known fresh tropical fruits is the banana (Musa spp.). More than 15% of the fresh fruit produced globally comes from there. Bananas are a great source of vitamins C and B6, carbohydrates, antioxidants, minerals (including magnesium and potassium), and dietary fiber. Bananas are also a delicious and healthful fruit that are rich in fructose, sucrose, and glucose, the three main natural sugars. Consuming bananas can instantly and regularly increase one's energy level [17].

Banana fruit is a common crop in global agricultural production and trade. The fruit belongs to the Musaceae family. The most widely consumed tropical fruit in the world, bananas are enjoyed by all age groups and come in both fresh and dried varieties. Bananas account for about 15% of the fresh fruit produced worldwide. The most inexpensive, highly nutritious, easily digested, and high-energy fruit is the banana. It is made up of carbohydrates, dietary fiber, antioxidants, vitamins B6 and C, and minerals including magnesium and potassium [2].

The best temperatures for the banana to produce dry matter were 25/18°C during the day and 33/26°C at night for the best leaf area generation. Heat injury occurred at 37/30°C and chilling injury occurred at 17/10°C [13].

changes in dry weight, protein, phenolics, starch, chlorophyll, and three enzymes—two transaminases and aldolase—from seven days after inflorescence until bunch maturity. The phrase "storage life" is commonly used interchangeably with the preclimacteric period after harvest, also referred to as "green life," because fruit softens and becomes more susceptible to mechanical damage after the climacteric phase begins, resulting in increased loss. Preclimacteric variables include fruit maturity, temperature during transit, humidity, ventilation, mechanical damage, and fungal inocculum [5].

The minimum acceptable maturity for harvesting dessert bananas may be determined by the ratio of edible pulp to peel and the size of fingers that growers and consumers consider acceptable, respectively. Before reaching this stage of growth, the majority of cultivars have the capacity to ripen to good exterior color, high sugar content, and acceptable, if not optimal, flavor. Fruits change in hardness during development, even at the preclimacteric stage [10].

The most common physiological processes that occur when bananas ripen are transpiration and respiration. In terms of transpiration, the green banana shows a brief reduction in rate. The transpiration rate peaks sharply at the banana ripening stage. The ripening and storage processes of banana fruit result in both chemical and physical alterations that greatly affect the skin color. During ripening and storage, banana fruit changes color from green to yellow [1].

When selling bananas, quality is crucial, particularly if they are meant to be consumed fresh. Although a number of factors, including edaphoclimatic conditions, fertilization, cultivar, planting, and harvest time, affect the physical and chemical characteristics of bananas, evaluating the quality of marketed fruits and whether they meet consumer standards is crucial for analyzing them. The taste, shelf life, and appearance (length, diameter, and color) of the fruits are the most crucial characteristics, based on consumer preferences when buying bananas. Thus, it is crucial to do research on the physical and chemical aspects of fruit quality, including length, diameter, weight, pulp and peel color, pulp firmness, soluble solids, and titratable acidity, in order to preserve the desired qualities demanded by market standards [14].

The information provided by the characterisation of the various banana cultivars is also helpful for commercial development and breeding projects that aim to find disease-resistant cultivars with good fruit quality and quantity. As a result, certain characteristics—like plant height, pseudostem diameter, and leaf blade length and width—are crucial data. Plant height is a crucial phytotechnical component in plant breeding, as it affects planting density, harvesting ease, plant damping off, pseudostem breakage by wind or because of its smaller diameter, and huge cluster formation. In addition, sufficient leaf area is necessary for banana plants to grow and, as a result, provide bunches of superior quality [11].

The main objectives of this study was measured the physical properties of banana fruits to know thebanana changes during the ripeningstages

## MATERIALS AND METHODS

The experiment was conducted In January 2024, a selection of dessert bananas (Musa sap.) varying in maturity stage were obtained from nearby designated banana ripening rooms located in Santa, Gharbia Governorate, to verify the physical and optical properties of banana fruits. These characteristics were used to study the change resulting from different ripening stages of bananas in banana production refrigerators. Samples were randomly selected and cleaned by hand.

**Measurements and determinations.**

The physical properties of bananas were determined with 100 repetitions of banana fruits as showed in Photo 1.

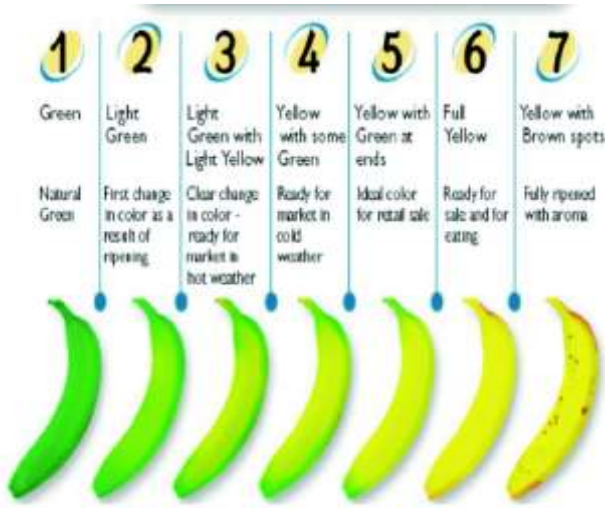


Fig.1 Banana Ripening Chart
Source: Authors' determination.

The different physical properties of plantain banana fruits such as length (L), width (W), and thickness (T) was estimated by digital caliper 150 mm. Average dimensions of banana fruits, arithmetic mean diameter (Da), mm, geometric mean diameter (Dg) mm, surface area (As) mm2, volume (V) mm3, and sphericity (φ) % of banana fruits were calculated as:

-Length (L), (mm): [18]

$$L = \frac{(L_o + L_i)}{2} \quad \text{..... (1)}$$

-Width (mm): [18]

$$W = \frac{(D_3 + D_4)}{2} \quad \text{..... (2)}$$

-Thickness (mm)[18]

$$T = \frac{(d_3 + d_4)}{2} \quad \text{..... (3)}$$

-Geometric mean diameter (Dg), mm: [19]

$$Dg = \sqrt[3]{LWT} \quad \text{..... (4)}$$

-Arithmetic mean diameter (mm): [19]

$$Da = \frac{(L+W+T)}{3} \quad \text{..... (5)}$$

-Volume standard geometrical shape ($mm^3$)[19]

$$V = \frac{\pi}{6} Dg^3 \quad \text{..... (6)}$$

-Surface area ($mm^2$) [19]

$As = \pi Dg^2$ ..... (7)
-Projected area perpendicular to Thickness ($mm^2$) [19]
$PT = \frac{\pi}{4} TW$ ..... (8)
- Projected area perpendicular to length ($mm^2$) [19]
$PL = \frac{\pi}{4} LW$ ..... (9)
-Projected area perpendicular to Width ($mm^2$) [19]
$PW = \frac{\pi}{4} WW$ ..... ...(10)
-projected area ($mm^2$) [19]
$PA = \frac{(PT+PL+PW)}{3}$..... (11)
-Sphericity(φ), %: [19]
$\varphi = \frac{Dg}{L} \times 100$ ..... (12)
-aspect ratio [19]
$Ra = \frac{W}{L}$ ..... (13)
-Flakiness ratio [12]
$Rf = \frac{T}{W}$ ..... (14)
-Elongation ratio [12]
$Re = \frac{W}{L}$ ..... (15)
Shape index [9]
$SI = \frac{2 \times L}{W+T}$ ..... (16)
Elongation [9]
$E = \frac{X}{Y}$ ..... (17)
Circularity index [9]
$CI = \frac{4\pi A}{Perimeter^2}$ ..... (18)
Area [9]
$A = \pi xaxb$ ..... (19)
Perimeter [9]
$P = \pi\sqrt{2(L+W)}$ ..... (20)

## RESULTS AND DISCUSSIONS

The primary measurements of banana fruits were computed, along with an examination of their physical properties. Shows the length, width, and thickness frequency distribution curves for seeds; the frequency distribution curve suggests a tendency toward a normal distribution. There was a rise in length of 140.97 mm to 151.01 mm, width of 34.06 mm to 38.83 mm, and thickness of 30.67 mm to 35.77 mm, in that order. The banana fruit's physical characteristics are displayed in Fig. 2, Fig. 3 and Fig. 4 and Table 1, and the curves demonstrate that the measurements are similar in length, width, and thickness by 27%, 34%, and 32%, respectively.

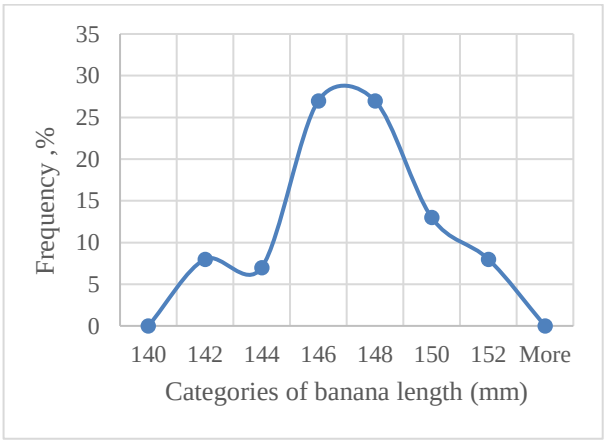


Fig. 2. Frequency distribution curve for Length (mm) of banana fruits.
Source: Authors' determination.

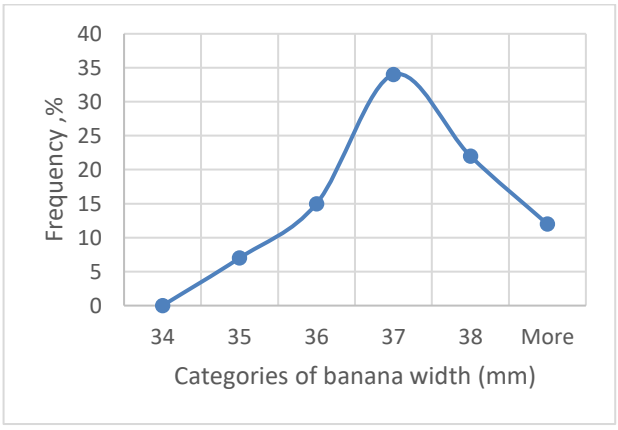


Fig. 3. Frequency distribution curve for Width (mm) of banana fruits.
Source: Authors' determination.

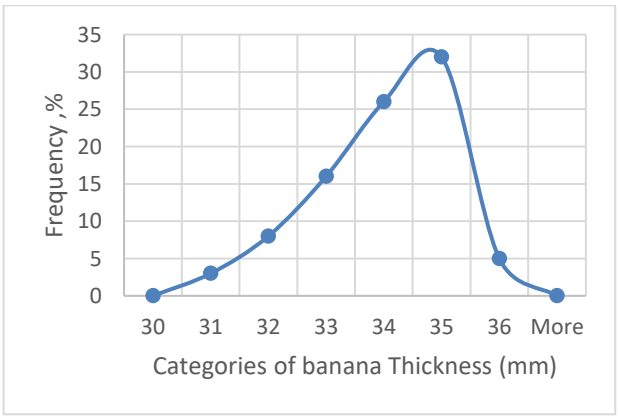


Fig. 4. Frequency distribution curve for thickness (mm) of banana fruits.
Source: Authors' determination.

For the Size and shape index indicators of banana fruits, the results showed that the projected area and shape index increased from

1,914.5 to 2,259.42 mm$^2$ and from 3.83 to 4.5, respectively. There was a similarity between banana fruits by 26 and 30 %, respectively. Also, Elongation and Flakiness for banana fruits increased from 3.64 to 4.39 % and from 0.83 to 0.98 % respectively. There was a similarity between banana fruits by 35 % and 19%, respectively as shown in Fig. 5, Fig. 6, Fig. 7 and Fig. 8.

Table 1. Physical properties of banana fruits

| Items | Average | Min | Max | Frequency% |
|---|---|---|---|---|
| Geometric mean diameter, mm | 56.50 | 54.45 | 58.31 | 39% |
| Arithmetic mean diameter, mm | 72.19 | 69.96 | 74.51 | 34% |
| Surface area, mm$^2$ | 10,026.71 | 9,309.96 | 10,675.64 | 15% |
| Volume standard geometrical shape, mm$^3$ | 94,466.63 | 84,490.06 | 103,746.8 | 12% |
| Sphericity, % | 38.65 | 36.64 | 40.84 | 44% |
| Aspect ratio, % | 0.25 | 0.23 | 0.27 | 44% |

Source: Authors' determination.

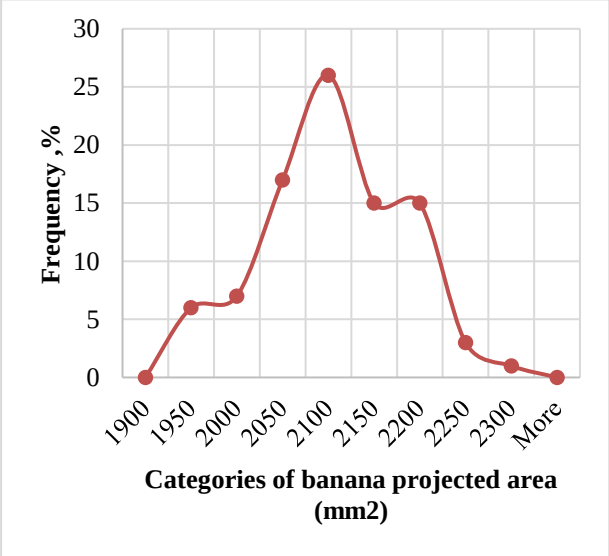


Fig. 5. Frequency distribution curve for projected area (mm$^2$) of banana fruits
Source: Authors' determination.

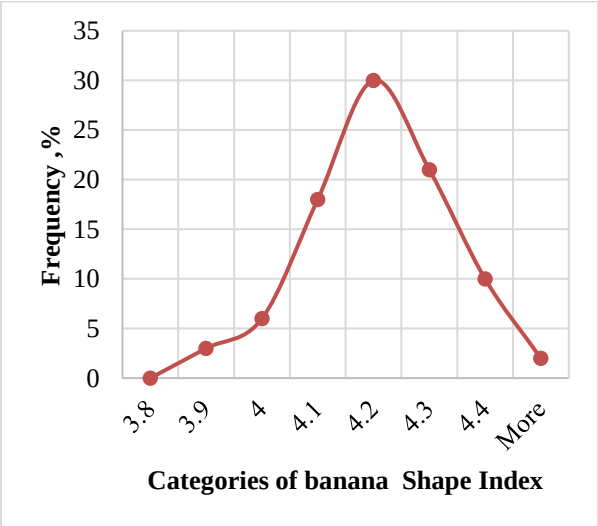


Fig. 6. Frequency distribution curve for shape index of banana fruits
Source: Authors' determination.

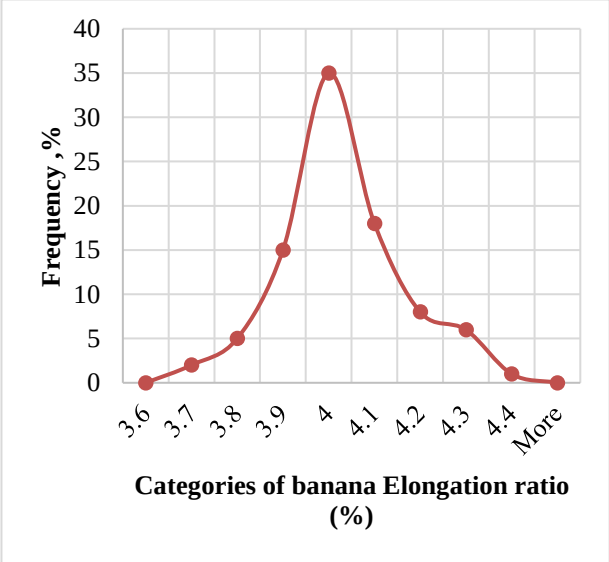


Fig. 7. Frequency distribution curve for Elongation ratio (%) of banana fruits
Source: Authors' determination.

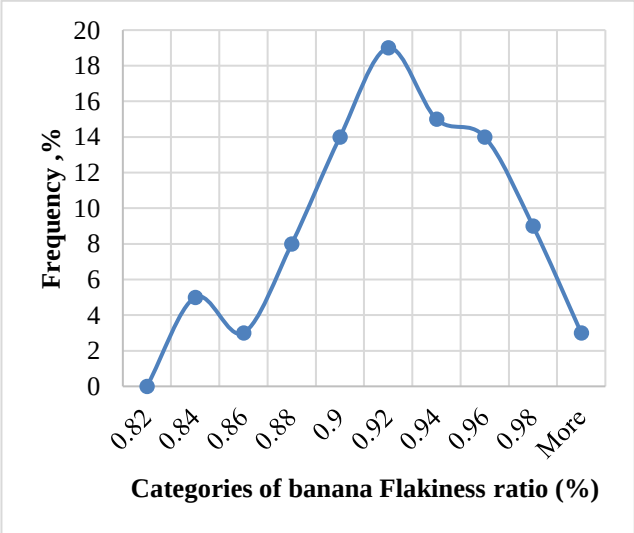


Fig. 8. Frequency distribution curve for Flakiness ratio (%) of banana fruits
Source: Authors' determination.

## CONCLUSIONS

The results showed the banana fruit's physical characteristics, and the curves demonstrate that the measurements are similar in length, width, and thickness by 27%, 34%, and 32%, respectively. There was a similarity in the projected area and shape index between banana fruits by 26 and 30 %, respectively. Also, in Elongation and Flakiness There was a similarity between banana fruits by 35 % and 19%, respectively.

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