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PHYSICAL AND COLOUR PROPERTIES OF SUGAR BEET AND BEETROOT SEEDS

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Abstract

In this study, we conducted a comprehensive analysis and comparison of the physical and colour properties of sugar beet and beetroot seeds. The research involved measuring key parameters alongside evaluating colour characteristics. By employing frequency distribution curves, we visualized the variations in these properties, providing insights into the differences and similarities between the two types of seeds. The findings revealed distinct patterns in the physical dimensions and colour attributes, contributing valuable information for agricultural practices, and seed selection. From the results, it is clear that the little differences in the average of length, volume, geometric mean diameter, surface area, elongation, roundness, shape index, browning index, and yellowness index were 6.29mm, 79mm^3, 5.2mm, 87mm^2, 0.85, 1.27, 1.2, 174, and 28 for beetroot, and for sugar beet the results for same indices were 6.4mm, 74.5mm^3, 5.06mm, 83mm^2, 0.9, 1.19, 1.3, 213.4, and 35.73 respectively.

Key words**:** *beetroot, sugar beet, seeds, physical, shape, colour properties*

INTRODUCTION

Around the world, beetroot is cultivated in temperate climates. Roughly 260–265 million metric tons of sugar beets, including red beets (also known as beetroot), were produced worldwide in 2023. This number hasn't changed all that much in the last few years. Germany, France, the United States, and Russia are among the top manufacturers. Although sugar beets are mainly farmed for their sugar, food products also use some of the world's production, particularly in North America and Europe [7].

Red beetroot has gained popularity recently since it is a rich source of bioactive substances, especially betalains. Because of their many health-promoting benefits, red beetroot betalains have a lot of potential as a functional food ingredient utilized in the medical and culinary fields. Betalains are naturally occurring pigments found in red beetroot, which primarily consist of red-violet betacyanins or yellow-orange betaxanthins. However, betalains exhibit poor stability during processing and storage due to their high sensitivity to heat, pH, light, and oxygen. Therefore, it's essential to comprehend how processing techniques impact beads.[11].

Beta vulgaris, the beet, is one plant in the Chenopodiaceae family. The most well-known of its several grown varieties is beetroot, a purple root vegetable that is also frequently referred to as table garden beet. The root food sugar beet, together with the leafy crops chard and spinach beets,which is crucial for the production of sugar, are examples of additional cultivated strains. Beetroot can be boiled, baked, or used to extract juice. It can also be eaten fresh. Red beets are great roasted, pickled, chopped and added to salads, or simmered and cooked into soup, a favorite in many of the countries of Eastern and Central Europe. Unlike fruits, sucrose is the primary sugar found in beets. Beets have been used in traditional medicine for hundreds of years to treat constipation, dandruff, and joint and intestinal pain. Extracts from red beets exhibit exceptional antioxidant properties, as well as antihypertensive and hypoglycemic properties, according to modern pharmacology. Their phytochemicals' encouraging effects on health protection point to a potential application for them in functional meals [12].

The approximate nutritional values of red beetroot are as follows: total fiber 87.4 g, fat 1 g, carbs 9.6 g, protein 1.6 g, vitamin C 10 mg, thiamine 0.02 mg, riboflavin 0.05 mg, niacin 0.4 mg, calcium 27 mg, iron 1.0 mg, and phosphorus 43 mg. Beet leaves are nutritionally valuable as well as its root, although they are eaten excessively infrequently. But red beets' distinctiveness has nothing to do with how nutritious they are.Alkaloids (128.8 mg), steroids (16.4 mg), glycosides (0.652 mg), flavonoids (6.15 mg), terpenoids (115.5 mg), saponins (3.789 mg), beta-carotene (11.64 mg), vitamins A (2.6 mcg), K (3.2 mcg), C (4.36 mg), E (0.18 mg), B3 (0.03 mg), B6 (90 mg), B2 (0.034 mg), pantothenic acid (0.151 mg), potassium (20 mg), iron (0.76 mg) are present in 100 g of this plant. Because of its high oxalic acid content, beet root may occasionally need to be considered as having less nutritional value. However, the secondary metabolites betalains, betaine, and nitrates are the most significant red beetroot phytochemicals in terms of their functional importance and advantages that go beyond simple health maintenance [4].

A member of the Chenopodiaceae family, which has its origins in Germany, beetroot (*Beta vulgaris* L.) is related to sugar, fodder, and silver beets. Although they are typically planted as annuals, beetroots are biennial plants that produce enlarged roots and green tops during their first growth season. Beetroot can be preserved in a variety of ways, including pickling and canning, or used in salads, pies, and as a hot vegetable combined with fish and meat. In addition to having high quantities of vitamin B1 and micronutrients, beetroot is a wonderful source of minerals, carbs, and protein [6].

When administered at the right rates, a sufficient supply of N fertilizers encourages growth in beetroot and boosts both output and quality. For beets to thrive, nitrogen is essential. This element is crucial for the growth of plants and is present in proteins, enzymes, and vitamins. Excessive application of fertilizer blends can cause crops to contain too much nitrogen. Since vegetables are the main source of nitrate in human nutrition, the accumulation of nitrate in fresh meals is concerning.However, the buildup of nitrate in beetroot can be harmful to human health. Nitrate can be converted to nitrite once it enters the human body, which can then enter the bloodstream and cause methemoglobinemia[13].

Beetroot, which is regarded as a vegetable, may benefit human health in a variety of ways. Beetroot juice has long been known to be good for the blood, heart, and digestive system. It is now recommended as an immune system booster and a cancer preventative. It is best grown in cool weather and can be produced virtually year-round. Cultivating beetroot in chilly, damp circumstances yields the highest quality results. The primary beetroot-producing regions in South Africa are Kwazulu Natal, the Western Cape, Mpumalanga, Gauteng, and the North West.Production locations have different sowing times. Locations with cool summers from the end of August to the middle of March and those with winter rains from August to the end of March are suitable for seeding. [18].

Beetroot farming requires a fertile soil that has all the nutrients essential to support quality, yield, and growth. There are wide variations in the quantity of nitrogen that soils can supply for plant growth. The type of soil, past cropping and fertilization methods, rainfall totals, and irrigation water use are some of the variables that affect how much nitrogen may be provided. Most recommendations for nitrogen fertilizer come from historical data on agriculture and fertilization. Although some of these suggestions appear reasonable, precise fertilizer recommendations for the best beetroot production necessitate the application of both soil and tissue testing techniques [19].

Latorre Consuming fresh fruit and vegetables is becoming more widely acknowledged to have important functional and nutritional benefits for human diets. Red beetroot has received more attention in recent decades because of its biological and nutritional qualities. However, not all customers find it to be pleasant and delectable because of its distinct scent and taste. Red beetroot is often consumed with various fruits and vegetables, such as apples, carrots, tomatoes, sour cherries, or sweet cherries. Red beets can be consumed raw, shredded for salads, thermally processed (by grilling, boiling, steaming, roasting, sautéing, canning, or even making chips), or powdered and added to other fortified goods [15].

Beetroot (*Beta vulgaris* L.), a member of the Chenopodiaceae family, has its origins in both Asia and Europe. Beetroot is recognized for its elevated levels of bioactive substances, including flavonoids, carotenoids, polyphenols, and betalains, which confer noteworthy nutritional and physiological advantages.Betacyanins, which give beetroot its red color, and betaxanthins, which give it its yellow hue, are the two types of betalains, the bioactive compounds present in beetroot. Red beetroot has large amounts of these pigments, which are composed of water-soluble nitrogen.They have been shown to have antimicrobial and antiviral properties, the ability to stop the growth of human tumor cells in vitro, inhibitory activity against cervical, ovarian, and bladder cancer cells, anti-inflammatory properties, and antioxidant and antiradical properties. Red beetroot also has a high nutritional content, including vitamins B and C [3].

Consuming fruits and vegetables on a daily basis has been shown to reduce the incidence of metabolic, degenerative, cardiovascular, and certain types of cancer. They are an essential component of a healthy lifestyle. A high concentration of fibers, vitamins, minerals, and phytochemicals—such as polyphenols, flavonoids, carotenoids, anthocyanins, etc.—as well as their potent antioxidant activity are the primary causes of this. However, because of their high moisture levels (typically above 85% (w.b.)) and metabolic activity, fresh fruits and vegetables are very perishable goods that spoil quickly if not treated properly [5].

Determining the color characteristics of seeds is essential to guaranteeing their safe passage through the cleaning and separation procedures. This study also looks at particular seed characteristics that might help with the creation of multi-seed planting devices.Notably, there are clear differences between faba bean and soybean seeds. The Hue value was 0.626 for faba beans, while it was 0.565 for soybeans. Furthermore, the intensity and browning index were 91.75 and 16.25 for faba beans, compared to 85.33 and 21.79 for soybeans, respectively [1].

This aids in the design of multipurpose equipment since it is necessary to identify the little variations in length, width, and thickness within the same variety of grain as well as grain that differs in variety but has comparable physical characteristics [8].

The average length, width, and thickness of soybean grains ranged from 5.39 to 5.96 mm,4.76 to 5.16 mm and 3.98 to 4.38 mm respectively. The geometric mean diameter increased from 4.66 to 5.05mm. and the sphericity decreased from 86.94 to 85.1%[9].

The study showed the correlation between RGB colour indices and lead concentration in leafy plants to distinguish heavy metal pollution and its effect on vegetative characteristics. The RGB indices provide a method to detect changes in plant health, allowing for early identification of pollution-related stress [10].

The study aims to compare sugar beet and beetroot seeds by examining their physical attributes, shape, and colour properties. This comparison will explain the differences and similarities between the two seed types, providing valuable insights into agricultural practices. Specifically, these findings can inform the design of metering plates for planting, enhancing planting efficiency and accuracy.

MATERIALS AND METHODS

The experiment was carried out through 2024 at the Department of Agricultural Engineering, Faculty of Agriculture, Tanta University, Egypt. The study focused on measuring the physical and shape properties of seeds and verifying differences in colour properties by analysing the RGB colour bands of sugar beet (*Beta vulgaris* var),and beetroot (Beta vulgaris) seeds.Fig. 1 shows the seeds of two types of beets.

Fig. 1. Sugar beet and beetroot seeds
Source: Authors' determination.

-Measurements and determinations.

-Physical properties.

The seeds' physical properties were meticulously measured to understand their fundamental characteristics as follows [16]:

-Geometric mean diameter (Dg), mm:

Dg=$(X.Y.Z)^{\frac{1}{3}}$…………………………..….(1)

-Arithmetic mean diameter (Da), mm:

Da=$\frac{(X+Y+Z)}{3}$ …………………..…..……….…..(2)

-Volume (V), mm^3:

V = $\frac{\pi}{6}(X.Y.Z)$……………………..…….(3)

-Surface area (As), mm^2 :

As = $\pi(Dg)^2$ ……………………………(4)

-Area of flat surface, mm

A_f=$\frac{\pi}{4}(x.y)$………………………...…......(5)

-Area of transverse surface, mm

A_t =$\frac{\pi}{4}(x.z)$……………………………...(6)

-Aspect ratio, mm

A_r=$\frac{x}{y} * 100$…………………………..……...(7)

-Sphericity (φ), %:

$\varphi = \frac{(x.y.z)^{1/3}}{x} = \frac{Dg}{x}$……………………….(8)

-Shape properties.

The shape properties of the seeds were examined to detail their geometrical characteristics follow[14]:

-Shape index of ellipse seed (SI):

$S_I = \frac{2 \times L}{W+TH}$…………….…………………...(9)

-Projected area (Ap), mm:

$A_p = \frac{\pi}{4}(Dg)^2$…………………………......(10)

-Elongation (E):

E = $\frac{X}{Y}$……………………….………..(11)

-Roundness (R):

R= $\frac{Ap}{Ac}$……………………………………(12)

-Flatness index:

F_I=$\frac{L+W}{2H}$……………………….……..……...(13)

-Circularity index:

I=$\frac{4\pi x Area}{(Perimeter)\text{^}2}$………………....……...(14)

-Area of ellipse:

A=$\pi.a.b$ ……………….……………......(15)

-Perimeter of ellipse:

P=$\pi\sqrt{2(X+Y}$……...………………....(16)

where:

x: length of grains (mm),

y: width of grains (mm) and

z: thickness of grains (mm)

-Colour properties

The colour properties of the seeds were analysed using RGB band measurements to capture their colour characteristics accurately and to help in distinguishing between the seeds according to [2]and[17]:

-Hue

H=$\cos^{-1}\left(\frac{\frac{2R-G-B}{2}}{(R-G)^2+(R-B)+(G-B)^{0.5}}\right)$…………(17)

-Intensity

I=$\frac{1}{3}(R+G+B)$…………………………(18)

-Browning index

BI=

$100\frac{(X-0.31)}{0.17}$…………………………..........(19)

X=$\frac{(a+(1.75*L)*a}{((5.645*L)+a-(3.012*b)}$……………….... (20)

-Yellowness index

YI=142.86*(a/L)…………………………(21)

where:

RGB =Red, Green, Blue Bands

L=lightness of the colour, which range from 0(dark) to 100 (white).

a =indicates green colour.

-b =indicates blue colour

+b =indicates yellow colour.

RGB bands were convert to Lab as shows in Figure 2.

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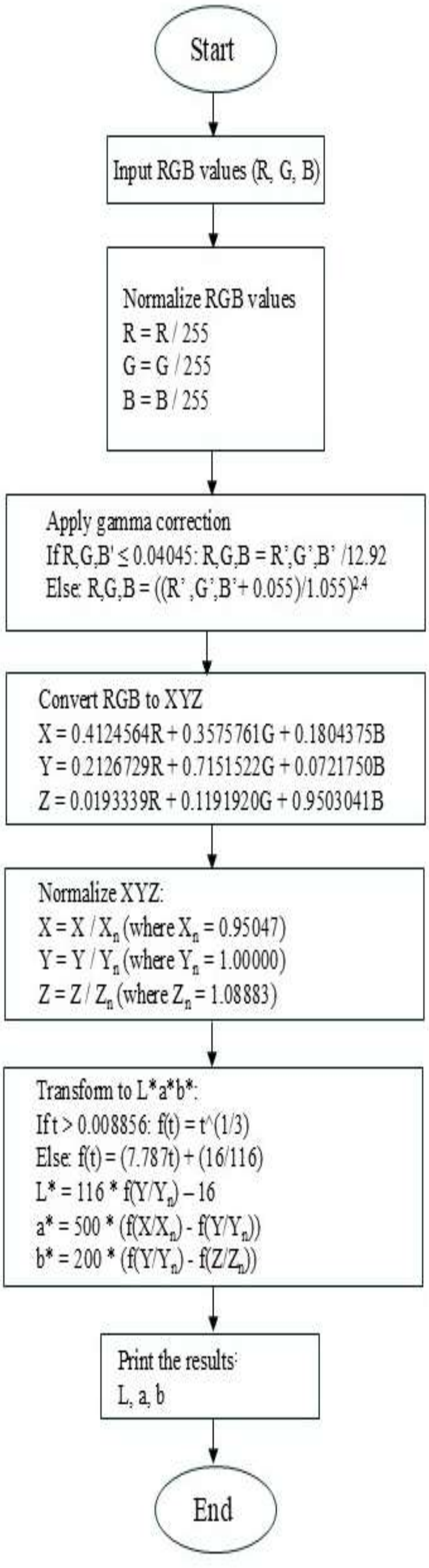

Fig. 2. Flowchart of mathematical model for convert RGB band to L*a*b band
Source: Author's determination.

RESULTS AND DISCUSSIONS

Frequency was used to analyse the physical, shape, and colour properties of the seeds by visualizing the distribution of various measurements, and we could observe that in the results.

Fig. 3 indicates that beetroot seeds generally have a higher frequency at smaller lengths, with the largest seeds measuring around 5.5 mm and representing approximately8% of the total seeds. In contrast, sugar beet seeds exhibit a higher frequency at larger lengths, with the largest seeds being around 7 mm in length and accounting for about 7% of the total seeds according to the frequency distribution. Results show a convergence of seed width values for the two types of beets, where the largest width of beetroot seeds was 8 mm by 14%, and the largest width of sugar beet seeds was 8.5 mm by 11% respectively as shown in Fig. 4.

Fig. 5 shows the similar maximum value of thickness for beetroot and sugar beet were 2.5 for both by 10%, and 15% respectively.

Fig. 6 shows an increase in volume values to 73 mm^3 by 6%for beetroot seeds and by 8% for sugar beet seeds. Geometric, and arithmetic mean diameter ranged from 3.5 to 7.2 mm, and from 4.3 to 7.4 mm for beetroot seeds, also increased from 3.33 to 6.86 mm, and from 4.11 to 7.01 mm for sugar beet seeds as shown in Fig. 7, and Fig. 8, respectively.

For sphericity, the results showed thatbeetroot seeds have their highest frequency at a sphericity range of around 85-90%, while sugar beet seeds peak earlier at around 65-70% as shows in Fig. 9.

Fig.10, Fig. 11, Fig. 12 demonstrate the results of the frequency distribution curve of the area of the flat, transverse surface frequency distribution curve were ranged from 18.8 to 58.4 mm^2, and from 4.86 to 39.5 mm^2 for sugar beet seeds, while ranges from 17 to 63 mm^2 and from 6 to 38 mm^2 for beetroot. Also, for surface area, the value ranged from 34.7 to 148mm^2, and from 39 to 162 mm^2sequentially.

Fig. 13 illustrates the maximum and minimum values of elongation indicator for beetroot,

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and sugar beet seeds were (1.73, 8.68 mm), and (0.40, 0.49 mm) respectively.

Fig. 14 illustrates the results of the frequency distribution curve for the projected area. The curve for beetroot seeds ranges from 9.7 to 40.38 mm², while for sugar beet seeds, it ranges from 8.68 to 37.54 mm².

Fig. 15, and Fig. 16 showed an increase in the results for flatness from 1.12 to 5.29 and from 1.06 to 5.58 for beetroot and sugar beet seeds, while roundness values were increased from 0.58 to2.47 and from 0.59 to 2.05respectively for two types of seeds.

Figs. 17 and 18 show an increase in circularity index values, ranging from 1.06 to 2.23 for beetroot seeds and from 1.16 to 2.50 for sugar beet seeds. Meanwhile, shape index values increased from 0.57 to 2.04 for beetroot seeds and from 0.63 to 2.11 for sugar beet seeds, respectively.

Fig. 19 showed the different values for beetroot seeds. The red colour band ranged from 75 to 158, in greenband ranged from 32 to 122, and in blue band ranged from 14 to 95, and for intensity ranged from 45.33 to 116. Also, for sugar beet, the redband ranged from 95 to 124, in greenband ranged from 28 to 76, and in blue band ranged from 18 to 58, and for intensity ranged from 60.33 to 76.33 respectively.

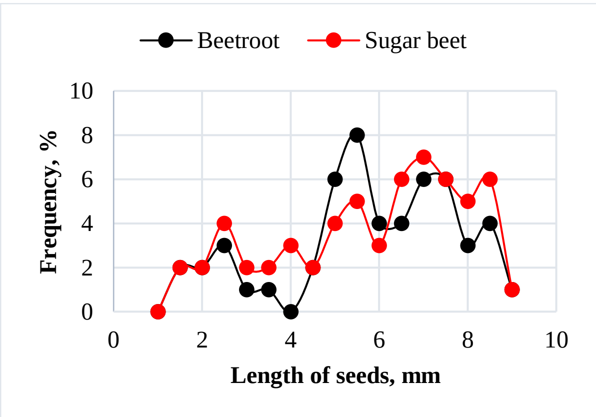

Fig. 3. Frequency distribution curves for the length of beetroot and sugar beet seeds
Source: Authors' determination.

Fig. 20 showed the maximum value of Hue, and red-green ratio of beetroot and sugar beet were (0.65, and4.8), and (0.69, and 4.42). For browning index, the results ranged from 37.02 to 35.5 for beetroot seeds, and from 101.81 to 271.65 for sugar beet seeds. While yellowness index was ranged from 7.32 to 85.4 for beetroot seeds, and from 29.4 to 214.08 for sugar beet seeds respectively as showed in Fig. 21.

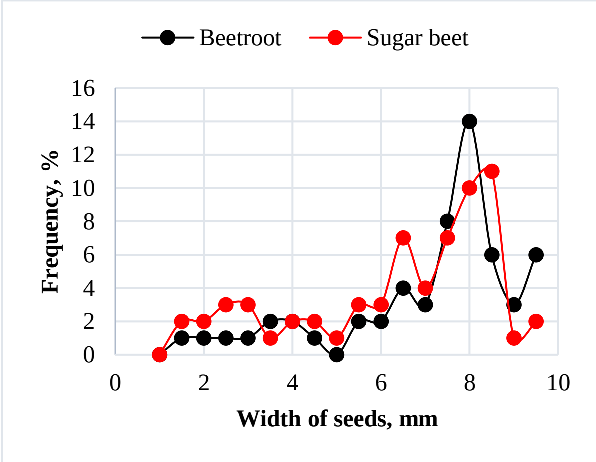

Fig. 4. Frequency distribution curves for sugar beet and beetroot seed width
Source: Author's determination.

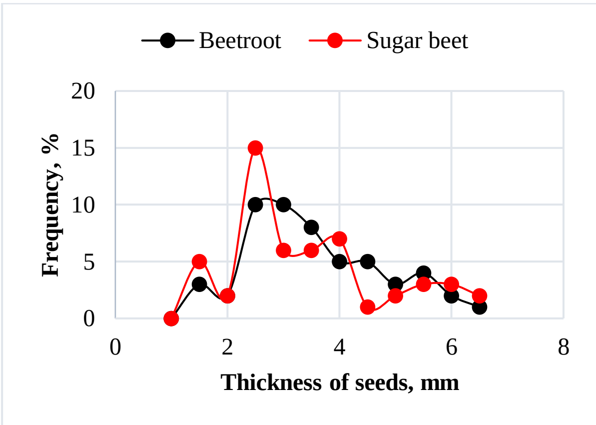

Fig. 5. Frequency distribution curves for sugar beet and beetroot seed thickness
Source: Authors' determination.

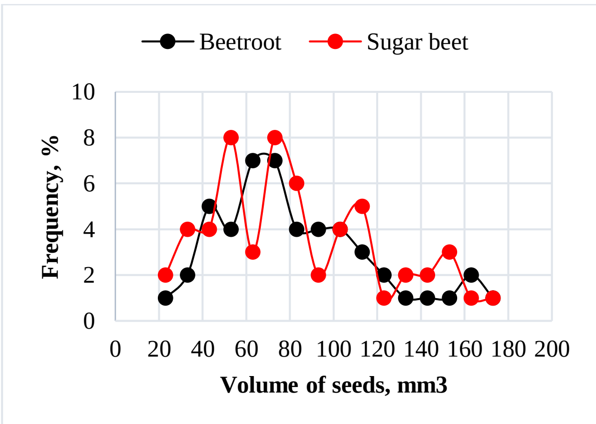

Fig. 6. Frequency distribution curves for beetroot and sugar beet seeds volume
Source: Authors' determination.

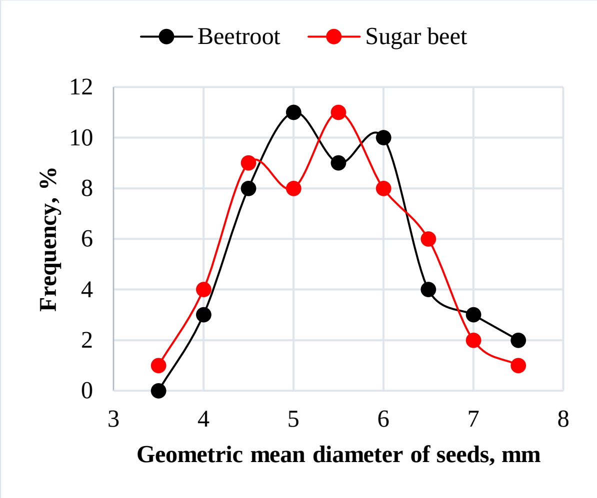

Fig. 7. Frequency distribution curves for beetroot and sugar beet seeds geometric mean diameter.
Source: Authors' determination.

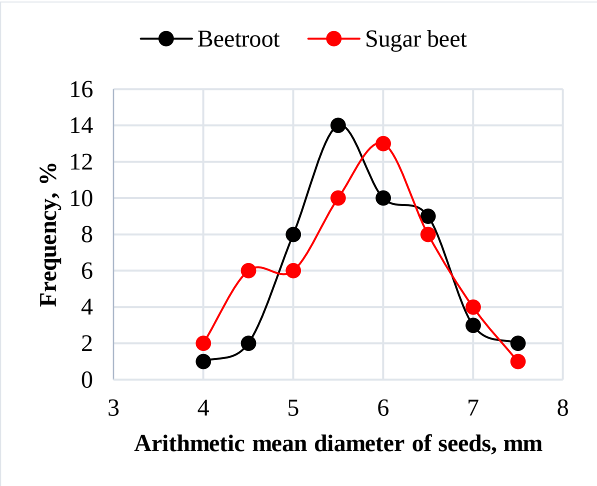

Fig. 8. Frequency distribution curves for beetroot and sugar beet seedsarithmetic mean diameter
Source: Authors' determination.

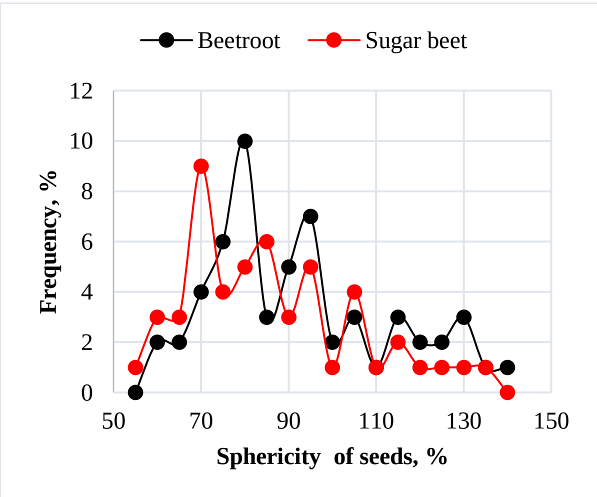

Fig. 9. Frequency distribution curves forbeetroot and sugar beet seeds sphericity
Source: Authors' determination.

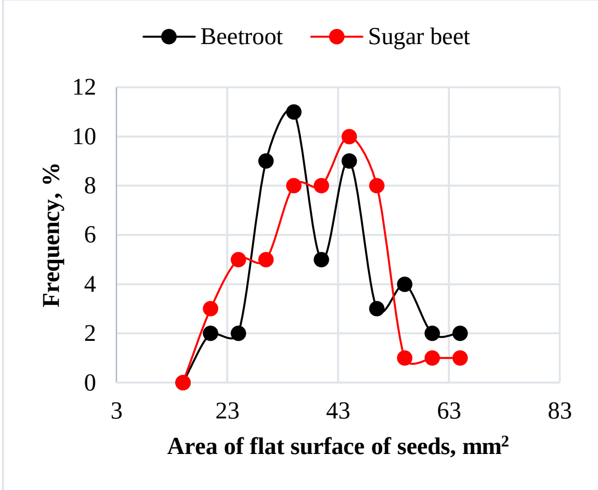

Fig. 10. Frequency distribution curves for the beetroot and sugar beet seeds area of flat surface
Source: Authors' determination.

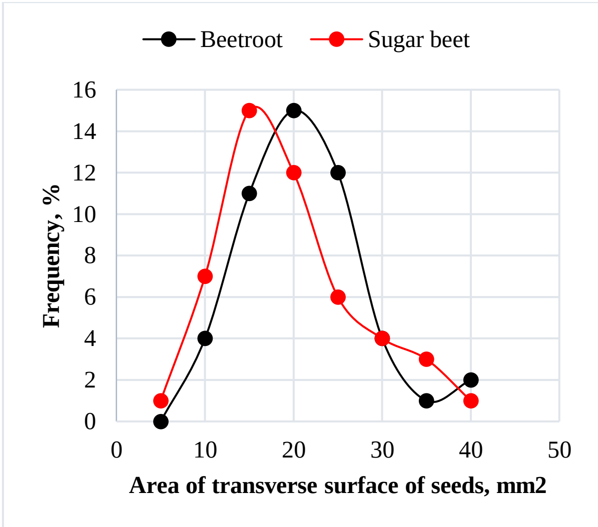

Fig.11. Frequency distribution curves for the beetroot and sugar beet seeds area of transverse surface.
Source: Authors' determination.

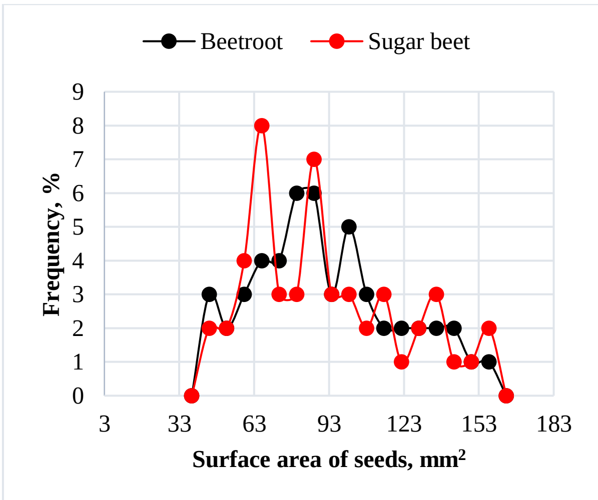

Fig. 12. Frequency distribution curves for sugar beet and beetroot seed surface area
Source: Authors' determination.

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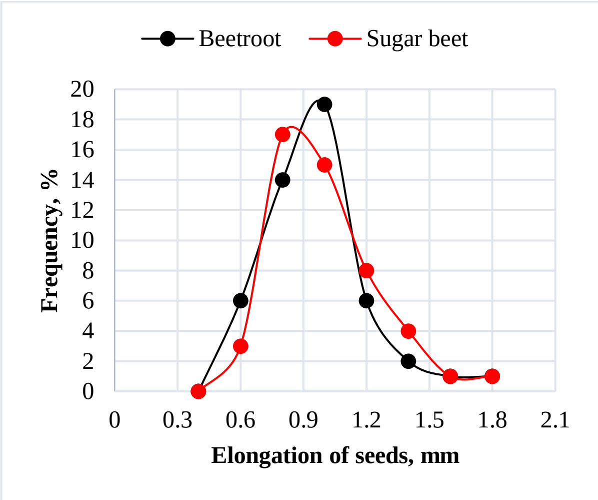

Fig. 13. Frequency distribution curves for beetroot and sugar beet seeds elongation
Source: Authors' determination.

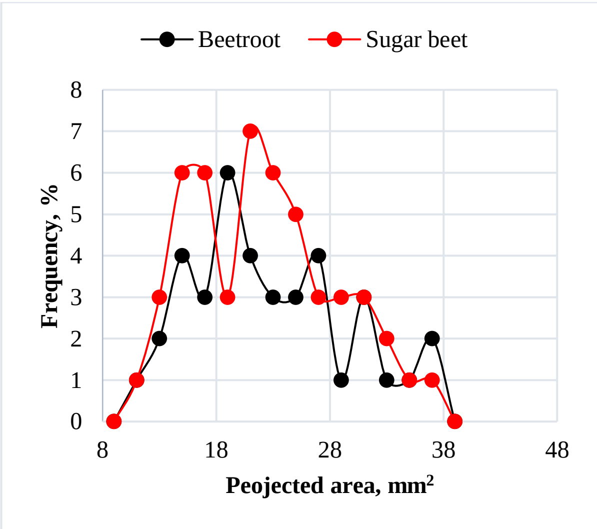

Fig. 14.Frequency distribution curves for beetroot and sugar beet seeds projected area
Source: Authors' determination.

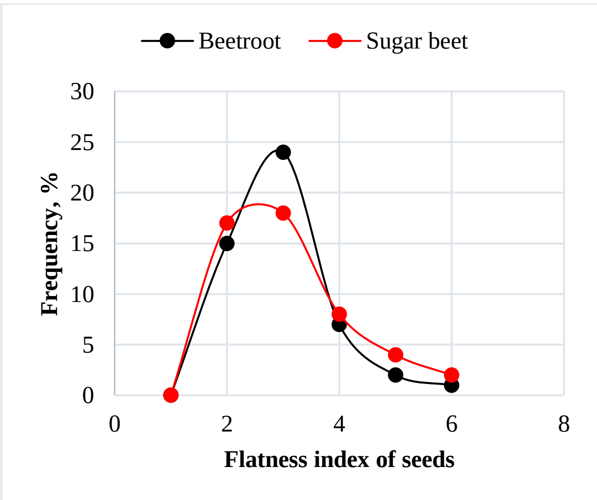

Fig. 15. Frequency distribution curves for beetroot and sugar beet seeds flatness index
Source: Authors' determination.

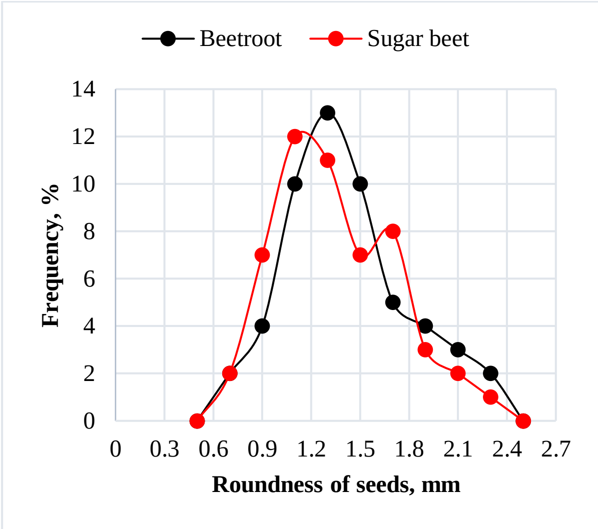

Fig. 16. Frequency distribution curves for beetroot and sugar beet seeds roundness
Source: Authors' determination.

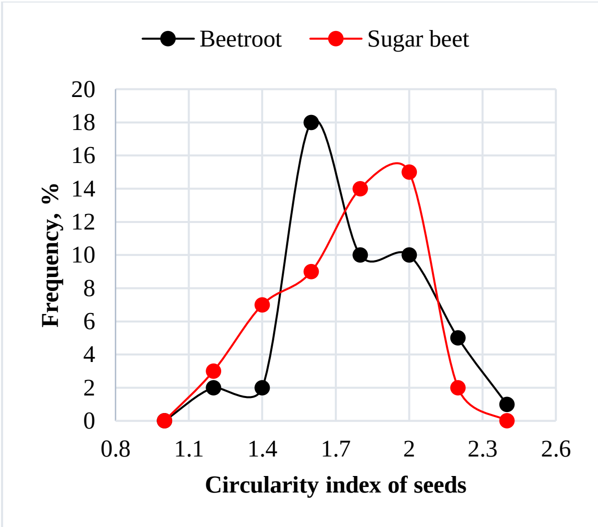

Fig. 17. Frequency distribution curves for beetroot and sugar beet seeds circularity index
Source: Authors' determination.

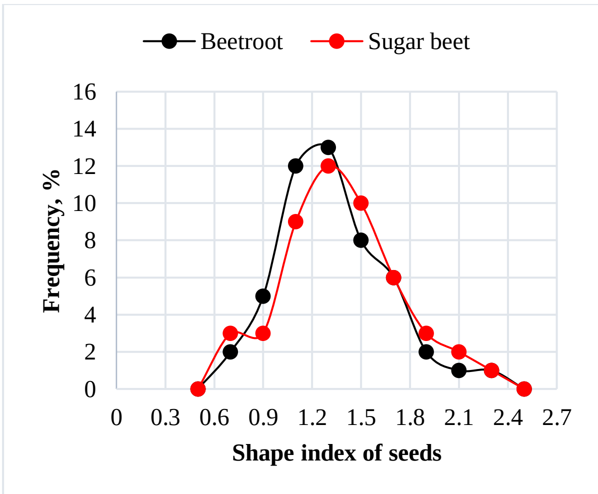

Fig. 18. Frequency distribution curves for beetroot and sugar beet seeds shape index
Source: Authors' determination.

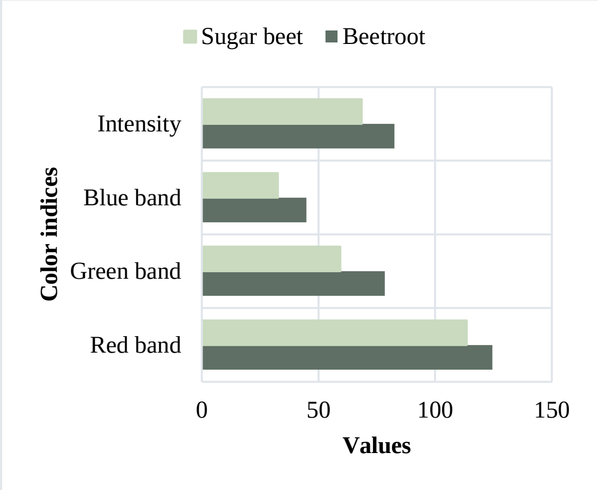

Fig. 19. Relationship between red, blue, green and intensity bands of beetroot and sugar beet seeds
Source: Authors' determination.

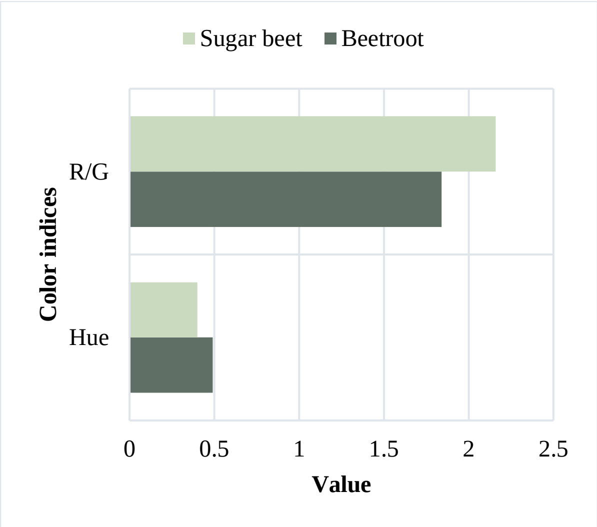

Fig. 20. Relationship between red-green ratio and hue of beetroot and sugar beet seeds
Source: Authors' determination.

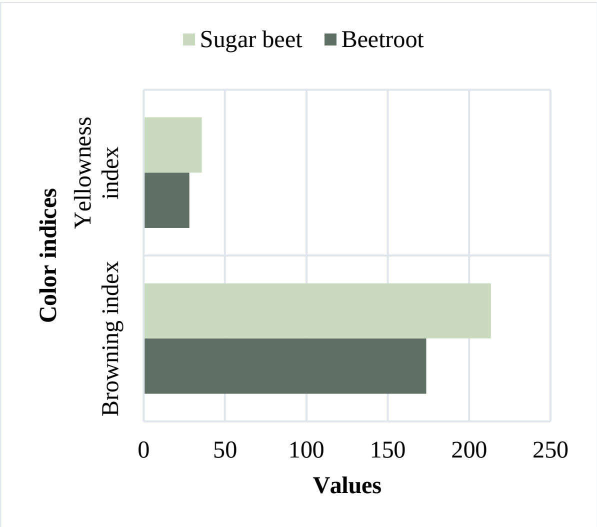

Fig. 21. Relationship between browning, yellowness index of beetroot and sugar beet seeds
Source: Authors' determination.

CONCLUSIONS

The determination and comparative analysis of the physical, shape, and colour properties of sugar beet and beetroot seeds revealed significant differences that have important implications for agricultural practices. The study found that beetroot seeds tend to be more spherical, while sugar beet seeds exhibit greater variability in shape index. Colour analysis highlighted distinct variations in hue, intensity, browning, and yellowness index between the two seed types.

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