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Effect of variation in fruit sizes on the speed of ripening, ripening and eating quality

Salma F.B Abdraba [1 *], Mousa A. A. Abusasiyah [2], Nadia A. A. Elmalki [3] , A. K Thompson [4]
[1] Department of Botany, College of Arts and Science Al-Marj, Benghazi University, Al-Marj, Libya
[2] Department of Botany, Faculty of Science, Sabha University, Sabha, Libya.
[3] Department of Botany, Faculty of Science, Benghazi University, Benghazi, Libya
[4] Department of post harvest philosophy, Silsoe College, Cranfield University, UK

*Corresponding author: salma.abdraba@uob.edu.ly

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Abstract:

This investigation was undertaken to find out the effect of banana fruit size on postharvest ripening, speed of ripening and eating quality. The time needed for fruit to ripen to colour stage 6 (as measured by a^* and b^*) and other measurements (other than total soluble solids content) were not significantly ($p= 0.05$) affected by fruit sizes. No significant difference in diameter ratio either among fruit lengths or fruit ripeness. Sensory evaluation showed significantly higher marks in pulp sweetness and banana flavor for medium and large fruits compared to small fruits. Acceptability of the fruits was not significantly different between all fruit sizes. However, the results indicated that the variation found between the fingers of different sizes was not responsible for the variation in the relative speed of ripening since all finger sizes ripened at about the same time. The study shows that the variation in the fruit length led to a slight variation in the eating quality (medium fingers had a better eating quality).

Keywords: Bananas, Quality, Fruit ripening, Sensory evaluation, fruit sizes.

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تأثير التباين في أحجام ثمارالموز على سرعة النضج وجودة الأكل

سالمة فرج بدر عبدربه [1*]، موسى احميده أبوبكر[2]، نادية عبد السيد المالكي[3]، طومسون[4]
[1] قسم النبات، كلية الآداب والعلوم المرج، جامعة بنغازي، المرج، ليبيا.
[2] قسم النبات، كلية العلوم، جامعة سبها، سبها، ليبيا.
[3] قسم النبات، كلية العلوم، جامعة بنغازي، بنغازي، ليبيا
[4] قسم فلسفة ما بعد الحصاد، كلية سيلسو، جامعة كرانفيلد، بدفورد، بريطانيا

الملخص

أجري هذا البحث لمعرفة تأثير حجم ثمرة الموز على نضج ما بعد الحصاد وسرعة النضج وجودة الأكل. الوقت اللازم لنضج الثمار لتلوين المرحلة 6 (كما تم قياسه بواسطة a^* وb^*) والقياسات الأخرى (بخلاف إجمالي محتوى المواد الصلبة القابلة للذوبان) لم تتأثر بشكل كبير ($p= 0.05$) بأحجام الثمار. لا يوجد فرق معنوي في نسبة القطر سواء بين أطوال الثمار أو نضج الثمار. أظهر التقييم الحسي وجود علامات أعلى بكثير في حلاوة اللب ونكهة الموز للفواكه المتوسطة والكبيرة مقارنة بالفواكه الصغيرة. ولم تختلف قبولية الثمار معنوياً بين جميع أحجام الثمار. ومع ذلك،

أشارت النتائج إلى أن التباين الموجود بين الأصابع ذات الأحجام المختلفة لم يكن مسؤولاً عن التباين في السرعة النسبية للنضج حيث أن جميع أحجام الأصابع تنضج في نفس الوقت تقريبًا. أظهرت الدراسة أن الاختلاف في طول الثمرة يؤدي إلى اختلاف طفيف في جودة الأكل (الأصابع المتوسطة كانت ذات جودة أكل أفضل).

الكلمات المفتاحية: موز، جودة، نضج الثمار، التقييم الحسي، أحجام الفاكهة.

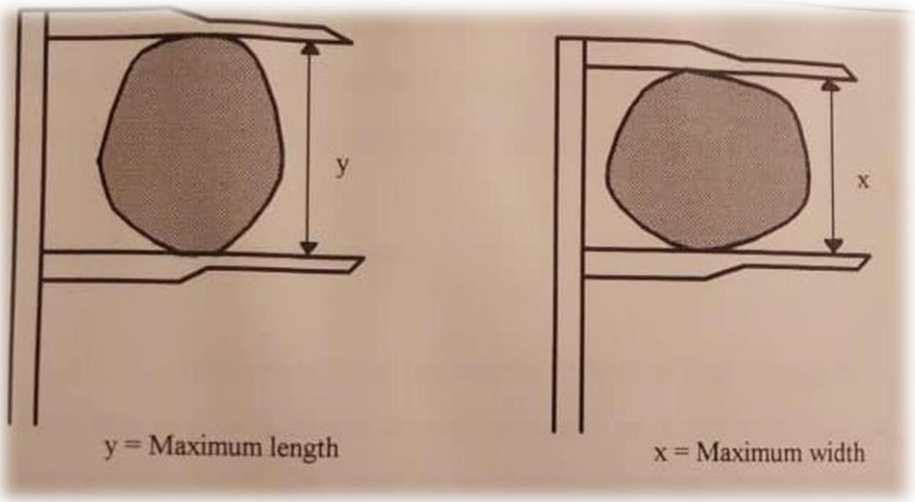
Introduction

Banana is an important fruit crop in the world having a special place in human diets. Banana (*Musa sapientum* L.) is a crop of major economic importance. It constitutes the 4th largest food crop of the world after rice, wheat and maize [2-5]. About 85% of world banana production is consumed in producing countries, while the remaining 15% is exported to developed countries, almost exclusively from the AAA genotype (Cavendish subgroup). Exported bananas are grown and harvested from different climatic areas and transported at the green preclimacteric stage [13] and ripened on arrival before sale. Ripening is the last phase of fruit development, during this phase, fruits become edible and acquire their unique sensory qualities process, most fruit quality traits occur as a result of the activation of major physiological and metabolic path-ways, leading to changes in color, aroma, and texture. These traits are essential in making the fruit attractive to consumers [3-9] However, there is a variation in the fruit sizes due to variation from bunch to bunch and variation in the position of the hands of the fruits on the bunch. These variations include finger diameter length and curvature. Fingur diameter and finger length decrease linearly from the fourth to the last or apical hands [3-11-14-15]. Since the size of individual units of banana can significantly affect consumer appeal, handling practice, storage potential, and market selection [3-8-14], so this experiment was set up to investigate the effect of the variation in the fruit length, grade on the variation of the speed of ripening and the eating quality of the ripe fruits, not on the preharvest environmental conditions.

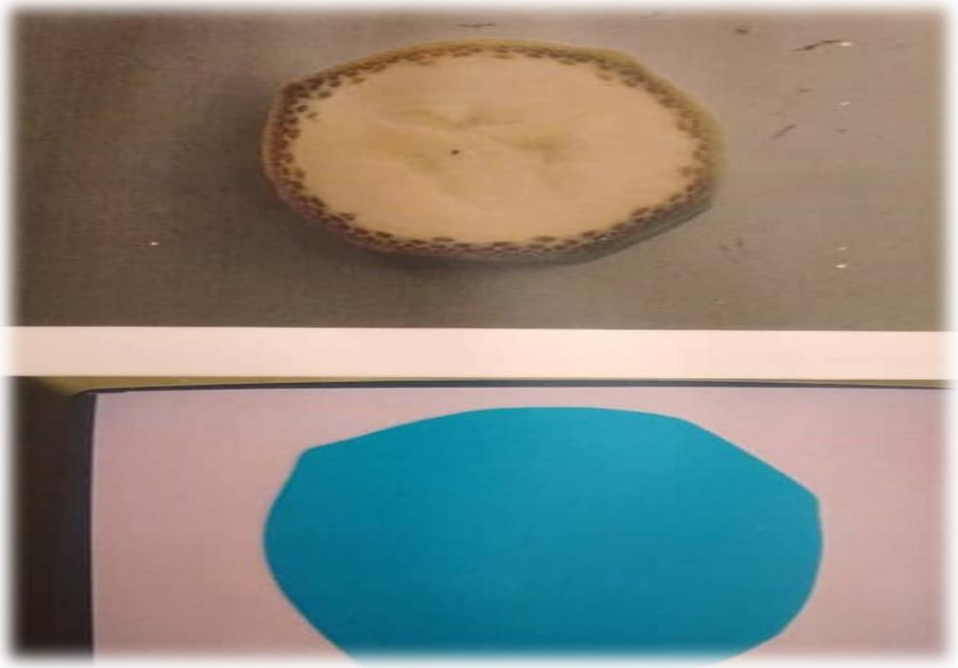
Material and methods

Commercial 3/4 grade green Cavendish fruit fingers (Musa AAA group, Giant Cavendish subgroup) imported from Windward Isles (for first and second replicate) and Jamaica (for third and fourth replicate) were divided into three categories according to their sizes (small, medium and large) and initiated to ripen at 20° C and 80-85 % RH by treatment with 10 µl 1-1 ethylene for 24 hours at 20° C. Fruits were analysed at the beginning of storage and after ripening to colour stage 6. A sample of twelve fingers was used in every analysis. The variation in the fruit sizes was determined by fruit length (cm). The length was measured along the convex curve of the finger from the flower end to the base of the pedicel [15].

The variation in the fruit size was also determined by measuring the surface area of the cross-section (mm^2) (as described by [1]. Diameters (mm) and the diameter ratio pointed by measuring the largest and smallest diameter of each finger at two specified points in the middle of the fingers, determined by rotating the finger inside electronic caliper jaws which displayed the value in digital form (plate 1). The ratio between the two diameters was taken and expressed as the diameter ratio. Cross section area (mm^2) was measured by using an Optomax V image analyser (Synoptics Limited, Cambridge, U.K) (plate 2). The surface area of the trace around the middle cross sections of bananas was used in the experiments. The instrument comprised a main image analyser and a video camera (Model HV-725K Hitachi Denshi Ltd. Japan) fitted with a 1: 3.5-4.5 telemacron 28-70 mm zoom lens (Tamron Co.Ltd. Japan). The camera was mounted vertically on an optical bench 95 cm from the surface of the cross section of the sample to be measured and a white 22-watt fluorescent lamp (Crompton lighting, U.K) was placed at the top of the measurement path. The instrument was first calibrated to obtain a correction factor for the measured area of the sample on a monitor screen. Each whole cross-section sample was placed vertically parallel to the camera lens and the best focus on the monitor screen was obtained at an aperture opening of f-22 . A user-defined frame was selected and the boundary of the cross-section was plotted using a cursor. The area was then measured was determined. The variations in the speed of ripening were measured by recording the time needed for the fruits to ripen to colour stage 6.



(Plate 1): Measuring maximum and minimum fruit diameter by using an electronic calliper.



(**Plate 2):** The cross-section of banana fruits (above) and the area of this cross-section measured by using the Optomax (below)

Objective and subjective analysis to assess ripening and eating quality were carried out at the beginning and when the fruits reached colour stage 6. The experiment was repeated four times and the mean was taken.

The following parameters were measured, colour of the peel in individual fruits was recorded using Tristimulus Colorimeter model Minolta CR-200/CR 200 b where a* is a negative value for green fruit and b* is positive value for yellow fruits. Each fruit was measured at three predetermined points and an average value was taken. Peel rupture force was determined by using an Instron Universal Testing Machine model 1122 and a cross-head speed of 10 mm minute $^{-1}$. The force required for 8 mm diameter cylindrical plunger to penetrate the skin was measured. The amount of total soluble solids (TSS) in the pulp was determined using an Atago Digital Refractometer. Sample of the pulp was made into puree and put directly onto the detector of the instrument. Titratable acidity was determined according to [12], using 0.1 N NaOH with phenolphthalein as an indicator and expressed as percent of malic acid.

For sensory evaluation, pieces of banana pulp were served randomly to tin judges, who were asked to assess pulp aweetness, the strength of flavour, and acceptability on five-point scale from (1 = low or weak to 5 = very high or strong). Off flavour was assessed on six-point scale from (0 = no off flavour to 5= very high off flavour) the results were transformed to percentages of the maximum score using the following equation:

$$\% \text{ of sensory evaluation} = \frac{\text{Score}}{\text{maximum score}} \times 100$$

These percentages were then converted to angular transformations [4] for statistical analysis (analysis of variance) but the data is presented as percentages.

Results

The time needed for fruits to ripen to colour stage 6 was not significantly (P = 0.05) affected by fruit length (Table 1).

There were no significant (P = 0.05) variations in peel colour as measured by a* or b* values found between different fruit lengths when they were still in the green unripe stage. Fruit firmness, total soluble solids content, acidity and surface area of the cross-section showed significant variation between the different-sized fruits at the unripe stage (Table 2). Small length fruits have the lowest fruit firmness, acid content and cross-section surface area. whilst the medium length had the lowest total soluble solids content. When the fruits were ripened with ethylene, fruit length had no significant effect on greenness (a*) (Table 1). Small fruits were more yellow in peel colour (b*) compared to medium and long fruit. Irrespective of peel colour change, other measurements were slightly different depending on fruit length. The changes in peel colour were accompanied by a reduction in fruit firmness, increasing the accumulation of total soluble solids content with the lowest accumulation in small fruit length, and increasing pulp-to-peel ratio, but these changes (other than total soluble solids content) were not significantly different when compared between small and large fruit. The weight loss was slightly greater in small fruit than the two larger lengths. The decreases in the cross-section area were not markedly different compared to the initial area but showed a trend to decrease as the fruits ripen. However, it was noticeably different only among fruit lengths. The diameter ratio decreased slightly during ripening; however, no significant difference has been shown in the diameter ratio either among fruit lengths or fruit ripeness.

In the sensory evaluation, panellists gave significantly (p = 0.05) higher marks in pulp sweetness and banana flavour for medium and large fruits compared to the small fruits. Off-flavour levels were negligible in all fruit lengths.

The acceptability of the fruits was not significantly different between all fruit lengths, however, medium fruits had higher acceptability (Table 2).

(Table. 1): Effect of variation in fruit size (cm) on speed of ripening and eating quality of ripened fruits (objective quality).

Parameters	**Small 13.4 (cm) 32%**		**Medium 15.7 (cm) 48 %**		**Large 18.9 (cm) 20%**		**LSD (p=0.05)**	**CV (%)**
	I	R	I	R	I	R		
Firmness (kg)	9.06	1.18	10.59	2.64	10.69	2.39	0.409	10.5
TSS (%)	5.57	23.12	4.62	24.22	6.39	25.21	0.920	9.6
Acidity (%)	0.063	0.125	0.068	0.132	0.113	0.132	0.0071	1.7
MC (%)	69.64	69.41	70.12	68.84	70.62	68.66	0.823	1.9
a* value	-18.48	-3.01	18.47	-3.9	-18.32	-3.51	4.08	7.2
b* value	33.12	52.10	34.15	50.04	34.67	49.52	1.64	6.2
Pulp to peel ratio	1.219	1.822	1.277	1.641	1.264	1.860	0.0845	8.9
Diameter ratio	1.136	1.118	1.116	1.090	1.134	1.099	NS	6.5
Surface area (mm)2	827.4	788.6	978.6	938.4	1067.9	1024.3	NS	7.8
Weight loss (%)	-	8.69	-	7.04	-	6.71	1.09	17.4
Time need to ripen (days)	-	4.2	-	4	-	4.2	NS	16.5

I= Initial analysis (before ripeness with 10 µl 1-1)
R= Analysis at ripe stage (colour score, 6)
NS= Not significantly different at (p=0.05)

(Table. 2) Effect of variation in the fruit size on sensory evaluation (%).

Parameters	Small	Medium	Large	LSD (p=0.05)	CV%
Flavour weak-strong	79.3	88.3	84.5	4.1	7.7
Sweetness low-high	78.9	85.9	84.3	4.2	8.0
Off-flavour low-high	1.0	0.3	0.3	NS	94.4
Acceptability low-high	86.1	89.6	88.8	NS	17.4

Discussions:

There was no indication exactly where the fruit used in these experiments came from. They could have been from different bunches or even from different sites or grown on different soil types [3-11-14-15]. It has previously been shown that there is variation in fruit quality (in terms of colour and texture) due to localized climatic difference [7], However, the results indicated that the variation found between the fingers of different lengths was not responsible for the variation in the relative speed of ripening since all the finger sizes ripened at about the same time. This result is surprising since the mean maturity of the small fruit would have been less than that of the longer fruit.[15] showed that there was a progressive change in fruit diameter starting from the apical hand which was smaller and thinner to the basal hand which was longer and heavier. In theory the smaller thinner bananas would have been less mature than the thicker larger fruit and thus have taken longer to ripen, In other fruit e.g. tomato [3-6] this has been shown to be the case. From the results it was noticed that the variation in the fruit lengths led to a slight variation in the ripening processes and subsequent eating quality in that, although small fingers were generally considered more ripe (softer pulp and developed more yellow colour as measured by b * value) they were considered to have poorer flavour [3-7] hypothesised that these variations in fruit characteristics could be due to inherent agronomic factors or to differences in fruit maturity not identified by the commercial harvest criteria used. The reason that the longer unripe fruits were found to be firmer than the smaller ones could be explained by the fact that the longer fingers will develop earlier than the small fruits. This means that the constituent of the tissues and fibres will develop earlier in larger than in smaller fingers. Because larger fingers are closer to the mother plant and hence, they will have received more nutrients than in the small fruits. This phenomenon could be observed clearly in many other crops like the developing cobs in corn plants which belongs to monoctyledon group of plants as does the banana. However, after fruits ripened it was found that the smaller fingers were less ripe than the larger ones (lower total soluble solids content and lower in sweetness with poorer eating quality) although they had developed a full yellow colour (previously it was indicated that colour was not a good indicator for ripening). In spite of low soluble solids content, the ripe small fingers were softer than other two fruit length and had a high pulp to peel ratio like the larger fruits. This could be attributed to the same explanation in that the constituents of smaller ripe fruits were still less developed than the longer ones. In work on the development of plantain fingers [10] showed that there was some indication that the smaller fruit (at the distal end of the bunch) were softer than the longer fruit at the top of the bunch. [15] reported that removal of the false hand and the last one or two apical hands (usually small fingers) during growth increased finger length of some of the remaining apical hands. reduced the time from shoot to harvest (more rapid increase in size grade and increased the percentage of the first-class fruit (large fruits). They also added that first class fruit usually had a minimum length of 19-20 cm and other fruit ranged in length down to 15 cm. Clusters with finger less than 15 cm are usually not exported. In the recent EC quality standard report for Cavendish bananas [16], it was maintained that individual fruit must not exceed 8" (20.32 in length, and should not be less than 5.5" (13.97 cm).

Conclusion

From the results of this study, it can be concluded that. variation in fruit sizes did not provide an indication that this might be the variation on the speed of ripening. The variation in the fruit size could be due to the variation in the fruit position in the bunch, but production factors could influence this.

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