Changes in banana pulp colour during ripening.

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CHANGES IN BANANA PULP COLOUR DURING RIPENING.
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ABSTRACT - The pulp colour of banana fruit which was either normal or affected by the condition yellow pulp, was measured during ripening. Colour changes were recorded by the use of a tristimulus colourimeter and results are given for the b* (blue-yellow axes) colour coordinate. The colour of the pulp in both the carpellary region and of the transverse section was yellower, with higher b* values prior to ripening in the fruit affected by yellow pulp. Normal fruit when ripened increased in yellow colour the most with the greatest increase in b* value. However when fruit was fully ripe, those initially suffering from yellow pulp still had a significantly greater b* value and stronger yellow coloured pulp than normal fruit. This evidence supports the suggestion that there is an inherent difference between normal and yellow pulp fruit which is not solely the result of differences in the degree of ripeness. Changes in firmness of fruit pulp and peel colour during ripening are also given.

CHANGEMENTS DE COLORATION DE LA PULPE DE BANANE EN COURS DE MATURATION.
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RESUME - Etude de la couleur de la pulpe de banane de fruits normaux et d'autres affectés du «jaune». Enregistrement des changements de couleur au moyen d'un colorimètre différentiel et expression des résultats donnés par l'axe b (bleu-jaune). Avant maturation dans le cas de fruits affectés, la couleur dans la région carpellaire et sur la section transversale est plus jaune avec des valeurs b plus élevées. Le plus fort accroissement de la couleur, ainsi que de la valeur b, sont enregistrés chez les fruits normaux, lors de la maturation. Cependant, au stade de pleine maturité on observe le jaune le plus intense, ainsi que la valeur b la plus forte, parmi les fruits initialement affectés. On peut donc penser que les différences que l'on constate ne seraient pas liées au seul degré de maturité. Des indications sur la fermeté de la pulpe ainsi que sur la couleur de la peau sont également données.

INTRODUCTION

The physical changes in banana fruit during ripening have been extensively reported. Textural changes when expressed as firmness of the fruit are known to decline sharply with ripening banana fruit (Ramaswamy and Tung, 1989). Peel colour changes from green to yellow, this most often being measured by visual matching of the peel colour against colour charts (United Fruit Sales Corp., 1964). Peel colour of banana has been determined by tristimulus colourimeters (Kanellis *et al*, 1989), which locate a colour as a point in a three-dimensional space using, in the case of the Hunter Colour Meter, the L (white-black), a (green-red) and b (blue-yellow) axes (Francis, 1980).

Little work has been reported on the colour changes of banana pulp during ripening. Deullin (1963), produced a colour chart for scoring pulp colour at the preclimacteric stage of development to estimate the condition of yellow pulp in bananas. Gottreich *et al*, (1969), developed a colourimetric method for determining the stage of ripeness by measuring the content of reducing sugars using Sumner's reagent. More recently, use of a portable tristimulus colourimeter for measuring pulp colour has been reported that gives reproducable and quantifiable results (Wainwright and Hughes, 1989).

Measuring pulp colour changes during ripening is complicated by the condition known as yellow pulp, where bananas at the same size grade and green, have pulp that can be of differing yellow colour. In particular banana fruit grown under stress conditions such as infection with Sigatoka leaf spot (Stover, 1974), nutrient deficiencies (Marchal *et al*, 1972) and water stress (Melin and Aubert, 1973) are known to have yellower pulp and in most cases a shorter green life. If pulp yellow fruit are simply more mature, then after ripening, both normal and affected fruit might be expected to have the same pulp colour. The authors have found no reports relating to pulp colour changes of yellow pulp fruit during ripening. This paper reports the changes in banana pulp colour during ripening of normal and yellow pulp fruit, as well as changes in fruit firmness and peel colour.

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MATERIALS AND METHODS

Investigations were undertaken in the UK with green banana fruit (*Musa* spp. AAA) of the full three quarter stage of maturity which had been air freighted from St Lucia. The colour of the banana pulp was measured in two regions, the darker zone running in a longitudinal band in the carpellary region of the fruit, termed the C3 zone (Deullin, 1963), and the pulp surface of a transverse section through the banana. To obtain flat pulp surfaces for placing against the colourimeter, segments of banana 3-4 cm long were taken by transverse cuts from the mid-region of a banana and then longitudinal cuts made through the carpellary zone (C3). The colour was measured with a Minolta Chroma Meter II Reflectance (Minolta UK Ltd, Milton Keynes) under illuminant C with a 8 mm viewing aperture in the measuring head placed directly against the flat cut surface of the pulp. The colourimeter measures the X, Y and Z tristimulus values and transforms them into the CIE colour space coordinates L*, a* and b* (Anon., 1976).

The pulp colour of banana fruit that were either normal or suffering from yellow pulp symptoms were measured as they ripened. The investigation was repeated with two separate shipments of fruit, though as results and conclusions were similar, data is only shown for one shipment. Three hands were taken from each of four bunches of bananas, of which two bunches were suffering from yellow pulp symptoms. Each hand was divided into two equal clusters, one cluster was exposed to ethylene (1 $ml.l^{-1}$) for 24 hours whilst the other cluster was the control. All fruit were kept at 20°C but in separate compartments during ripening. Fruit firmness was expressed by the pulp rupture force using an electronic force gauge with a 6 mm diameter probe. Single fingers of fruit were removed from each cluster on day 0, 1, 2, 3, 4 and 7 after exposure to ethylene for assessing firmness, and peel and pulp colour. Data was analysed by analysis of variance.

RESULTS AND DISCUSSION

At day 0 prior to ripening the fruit, there were distinct differences between fruit suffering from yellow pulp and the control. Yellow pulp fruit had a significantly higher b* value (more yellow) for the C3 zone (Figure 1) and the transverse section (Figure 2) ; the pulp was significantly less firm (Figure 3) and the peel colour (Figure 4) gave slightly lower b* values.

The peel of fruit treated with ethylene changed from green to fully yellow by day 7 as is seen by the increasing b* value. Normal fruit, untreated with ethylene maintained a green peel for the entire 7 days whilst the yellow pulp fruit untreated with ethylene ripened, but slightly after the fruit that had been exposed the ethylene as measured by the b* value of the peel colour (Figure 4).

The pulp colour in the C3 zone and that of the transverse section of ripened normal fruit exposed to ethylene, gave the greatest change in colour as it became increasingly yellow, with a higher b* value. Normal fruit that was untreated with ethylene had small increases in yellow colour which were not significant. Yellow pulp fruit developed a stronger and deeper yellow colour over time with some fluctuation especially for the C3 zone, but this change was not as large as the ripening normal fruit. However when the yellow pulp fruit and the normal fruit were fully ripe, the former was more yellow and had a significantly higher b* value for both the C3 pulp zone and the transverse section. In contrast, there was no significant difference in firmness of yellow pulp or normal fruit exposed to ethylene when the fruit was fully ripe.

The results reported here indicate that the condition of yellow pulp is not merely an advanced stage of ripeness, but that there is an intrinsic difference between these fruit. This difference as evident by the colour of the pulp is both significant and maintained during the ripening process.

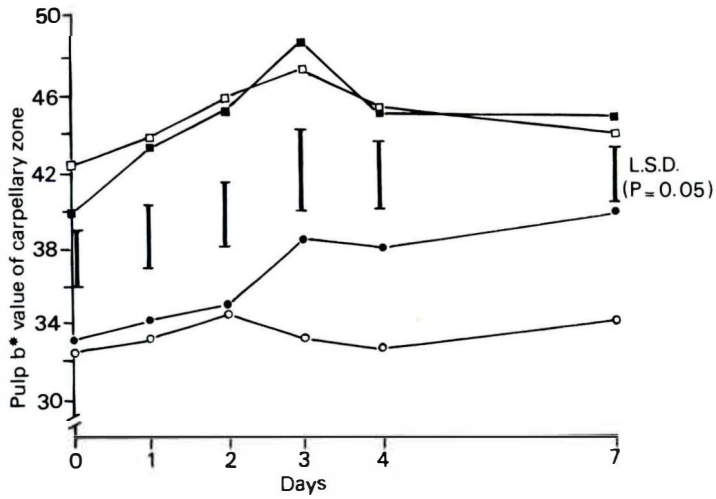

FIG. 1 – Changes in the b* value colour coordinate of the C3 region of normal banana fruit pulp (○, ●) and those suffering from the condition yellow pulp (□,■) during ripening. Half the fruit were exposed to ethylene (1 $ml.l^{-1}$) for 24 hours to initiate ripening (■,●).

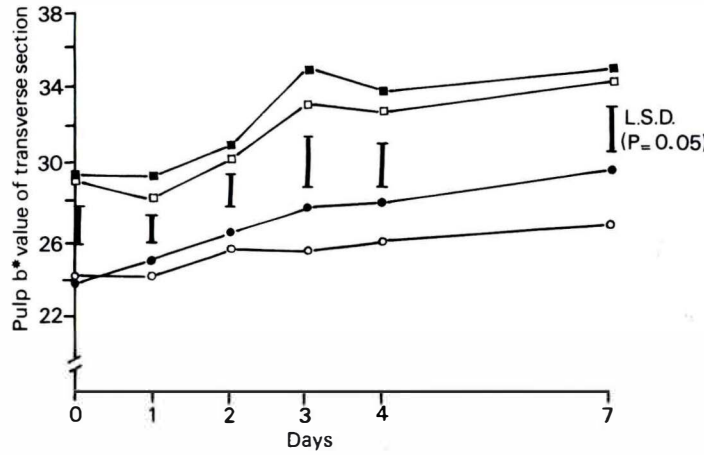

FIG. 2 - Changes in the b* value colour coordinate of the transverse section of normal banana fruit pulp (○, ●) and those suffering from the condition yellow pulp (□,■) during ripening. Half the fruit were exposed to ethylene (1ml.1^{-1}) for 24 hours to initiate ripening (■,●).

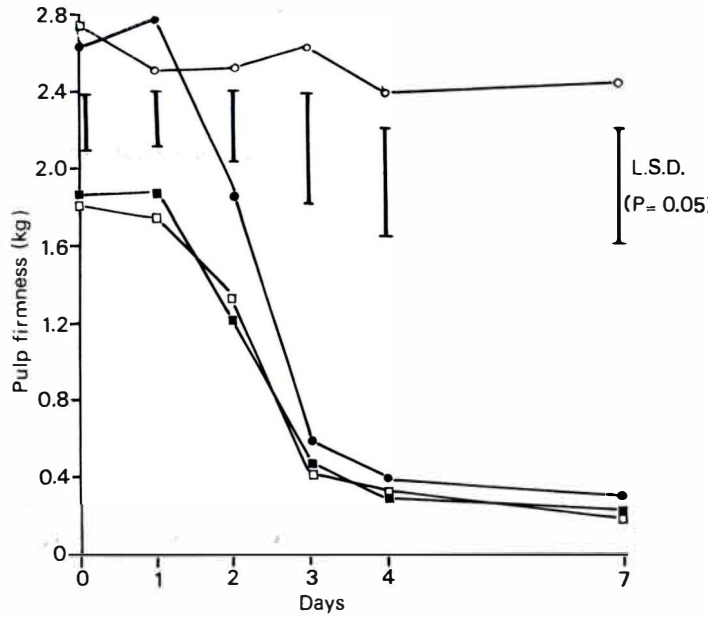

FIG. 3 - Changes in the firmness of normal banana fruit pulp (○,●) and those suffering from the condition yellow pulp (□,■) during ripening. Half the fruit were exposed to ethylene (1ml.1^{-1}) for 24 hours to initiate ripening (■,●).

Studies of the pigment that give rise to yellow pulp may provide an indication of the causal factors at the cellular level. Work reported by Martin Prevel (1983) also suggests that there are inherent differences, though on the carbohydrate status of the pulp and peel of fruit affected by yellow pulp.

The use of a portable tristimulus colourimeter has provided a rapid and quantifiable means of monitoring changes in pulp colour as was proposed by Wainwright and Hughes (1989). Future studies on yellow pulp should also include investigating pulp colour development prior to harvest. This may indicate when in the development of the fruit the pulp begins to become yellow so providing the time when differences in fruit quality and possibly green life are initiated.

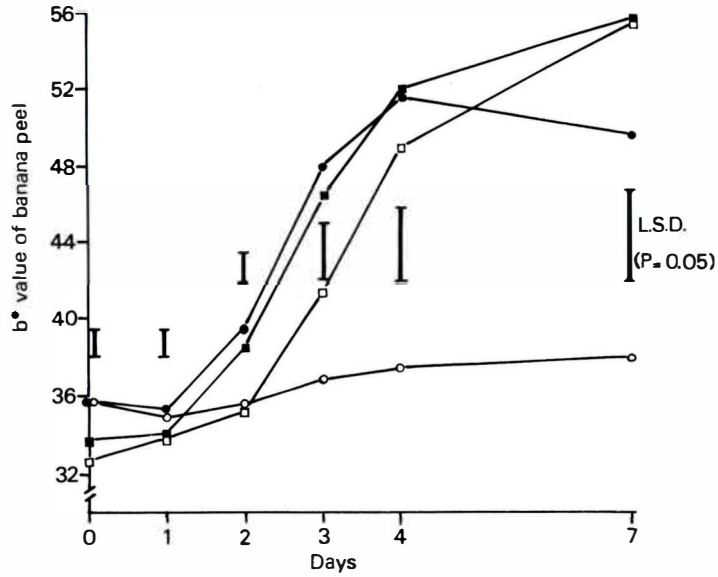

FIG. 4 – Changes in the b* value colour coordinate of the peel of normal banana fruit (o, ●) and those suffering from the condition yellow pulp (□, ■) during ripening. Half the fruit were exposed to ethylene (1ml.l^{-1}) for 24 hours to initiate ripening (■, ●).

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CAMBIOS DE COLORACION DE LA PULPA DE BANANO EN CURSO DE MADURACION.

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RESUMEN - Estudio del color de la pulpa de frutos normales y de otros afectados del «amarillo». Inscripción de los cambios de color por medio de un colorímetro diferencial y expresión de los resultados dados por el eje b (azul-amarillo). Antes de maduración en el caso de frutos afectados, el color en la región carpelar y sobre la sección transversal es más amarillo con valores b más elevados. El más fuerte acrecentamiento del color, así como del valor b, se registra en los frutos normales, en el momento de la maduración. Sin embargo, en el estado de plena madurez se observa el amarillo más intenso, así como el valor b mas fuerte, entre los frutos inicialmente afectados, Se puede pensar, por consiguiente, que las diferencias que se constatan no estarían ligadas al solo grado de madurez. Se dan igualmente indicaciones sobre la firmeza de la pulpa así como sobre el color de la piel.