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Effect of Fruit Maturity on the Quality and Acceptability of Guava Purée

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ABSTRACT

A study was conducted to determine the characteristics of guava fruits and the purée obtained from fruits at six stages of maturity, i.e. stage 1: fruits 14 weeks after inception; stage 2: 15 weeks after inception; stage 3: 16 weeks after inception; stage 4: fruits artificially ripened in 1000 ppm ethylene for 1½ days; stage 5: similar fruits ripened for 2½ days in ethylene; stage 6: similar fruits ripened for 3 days in ethylene. The hardness of the fruits decreased as they matured and ripened. Moisture increased in the first three stages and slowly declined up to stage 6. The pH, titratable acidity and sugars showed similar decreasing trends up to stage 4 and increased thereafter. The tannin content decreased with increasing fruit maturity. The Brix–acid ratio was highest (16·3) at stage 4. Ascorbic acid showed a sigmoid pattern of increase in values up to stage 4 and thereafter decreased.

Evaluation of the purée showed increasing viscosity with increase in fruit maturity. The increase in viscosity was possibly due to increase in amount of soluble pectin (which was highest in stage 4). Cellulose content of guava decreased as the fruits ripened. The amount of protopectin also decreased as the fruits softened. Colours of purées from stage 4 onwards seemed to be less susceptible to browning and were, in fact, improved after addition of sugar. Sensory analysis indicated high preference for samples in stages 2, 3 and 4 but there was no significant difference in flavour among the three samples. Based on these physical and chemical characteristics, fruits from stage 4 were considered to be most suitable for processing into purée.

INTRODUCTION

The Department of Agriculture, Malaysia, has previously identified the varieties of guava (*Psidium guajava* L.) that are suitable for processing and

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for table use (Ibrahim *et al.*, 1980). The classification is based more on physical attributes, e.g. taste, flesh thickness, etc. The current Vietnamese variety is only recently known and there is some doubt about its acceptability for processing into purée since the common practice is to consume the guava fresh.

Earlier studies (Yusof & Mohamed, 1987) had found that guava fruits of this variety were not able to ripen on the tree. Attempts to keep them longer before harvesting only ended in rotten fruits due to mold and fungus attack. This situation thus posed a question of whether there would be any advantages for fruits, harvested at the commercial stage of maturity, to be ripened before processing. Previous attempts to process the fruits at that stage have encountered problems such as: (i) difficulty in machine handling since the fruits were hard in texture; (ii) suceptability to browning and (iii) lack in body of purée. The objectives of the present study are to evaluate the physical and chemical characteristics of guava fruits of the Vietnamese variety at different stages of maturity and the quality of purée obtained from them. From the results it may be possible to decide on the stage of fruit maturity suitable for processing into purée.

MATERIALS AND METHODS

Sample and treatment

Guava fruits of the Vietnamese variety were obtained from a farm in Selangor, Malaysia. They were harvested at three different stages of maturity: dark green (stage 1: approximately 14 weeks); green (stage 2: approximately 15 weeks) and light green (stage 3: approximately 16 weeks, often called the commercial stage of maturity). Some fruits at the light green stage were ripened artificially using approximately 1,000 ppm initial concentration of ethylene gas. The fruits were later sampled at various stages of maturity as follows: yellow-green (stage 4: i.e. after $1\frac{1}{2}$ days in ethylene); light yellow (stage 5: $2\frac{1}{2}$ days in ethylene) and bright yellow (stage 6: 3 days in ethylene).

Physical and chemical analysis of fruit

Four fruits were taken from each stage of maturity for physical and chemical analysis and observations were made on individual fruits.

Hardness was determined on fresh fruits using an Instron 1140 with an 8 mm diameter plunger, at a drive speed of 50 mm/min. Two peak force readings were taken from each side of a fruit. The juice exuded during the

texture measurement was taken with a syringe to measure the total soluble solids content using the Otago refractometer.

Three longitudinal sections of each fruit were taken for the analysis of moisture (AOAC, 1980), ascorbic acid and titratable acidity (Ranganna, 1977). Samples prepared for titratable acidity were used to determine pH and tannin (AOAC, 1980). The remaining samples were sealed in plastic bags and frozen at −20°C until analyzed.

The HPLC method (Hunt *et al.*, 1977) was used to determine the sugars in guava with slight modifications in the solvent used. The eluent used in this trial was acetonitrile and distilled water (80/20, v/v). The sugar standards used were fructose, glucose, sucrose and maltose in the concentration range 1 to 5% (w/v). A calibration curve was obtained for each of the four sugars. Sugars in the samples were quantified by comparing peak areas of samples with those of the sugar standards. The extraction and preparation done prior to injection into HPLC was carried out according to Wills *et al.* (1980). Ten grams of the fruit material were heated with 100 ml of methanol on a steam bath for 30 min. The mixture was filtered through Whatman No. 1 filter paper into a round bottom flask and the residue was re-extracted twice in 75 ml portions of methanol, and filtered. The filtrate was evaporated to about 10 ml under vacuum at 50°C in a rotary evaporator. The volume was made up to 10 ml in a volumetric flask. The solution was then filtered through a Sep-pak C_{18} cartridge and a 0·45 μm membrane filter, using a syringe. The injection volume was 10 μl.

The alcohol-insoluble solids (AIS) obtained after the extraction of sugars were washed in acetone and dried in an oven for 10 min and later used to measure pectin (Rouse & Atkins, 1955) and cellulose. The anthrone reagent was used for the determination of cellulose after starch and hemicelluloses had been removed from the sample (Wenlock *et al.*, 1985).

Analysis of purée

For the preparation of purée, fruits were cut into small pieces and blended with equal amounts of water (1:1; w/v) in a Waring blender for 2 min. The purée was later passed through a 2 mm pore size screen (mesh No. 8) to filter the seeds, and later homogenized in a pulper homogenizer to improve its texture (Luh, 1971; Luh, *et al.*, 1975). Freshly prepared purées were filled into 180 ml sterilized glass bottles and kept aside at 5°C for sensory evaluation on the following day. Five experienced panelists were requested to indicate their preferences for the typical guava aroma and flavour using a hedonic scale of 1–9 (1: dislike very much; 9: like very much) (Larmond, 1977). Their scores were analyzed using the Analysis of Variance and Duncan's Multiple Range Test (Bender *et al.*, 1982).

Colour was measured using the Hunterlab Colorimeter at three different stages of sample preparation; first, on freshly homogenized sample, then after addition of sugar where the final concentration was 45°Brix, and, finally, after samples were heated at 99°C for 3 min. A white plate ($L = 92{\cdot}3$; $a = -0{\cdot}9$; $b = 0{\cdot}5$) was used as reference.

Viscosity was measured only on fresh purées at 25°C using the Brookfield viscometer, spindle No. 2, at a speed of 60 rpm.

RESULTS AND DISCUSSION

Fruit quality

Due to their inability to ripen on the tree, guava fruits of the Vietnamese variety have often been used for juice or purée processing at the light green stage where problems of handling, product browning and low viscosity were encountered. The present work reports on the physical and chemical characteristics of the fruits when they were ripened artificially to various stages of maturation and their effects on the quality of purée obtained.

Figure 1 shows there was a linear decrease in the hardness of fruits from stage 1 to stage 5 as the fruits ripened. This result suggests that the hardness measure may be used as an index of maturity for this guava variety as was the case for mango fruits (Roe & Bruemmer, 1981). The decrease in texture during the first three stages was due to enlargement of individual cells since, during these stages, the fruits were still growing until they reached their maximum size at stage 3, i.e. about 16 weeks after fruit set (Yusof & Mohammed, 1987). Cell enlargement was accompanied by a corresponding increase in moisture from 85·4% to 88·7% at stages 1 and 3, respectively (Fig. 2). Softening or ripening of fruit tissues began at stage 4. At

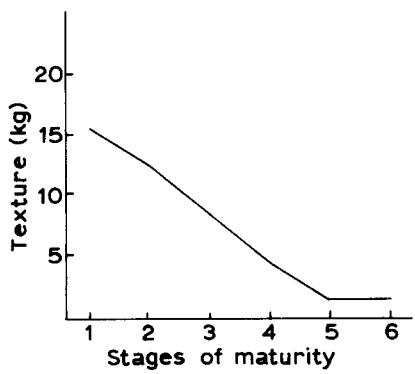

Fig. 1. Texture of fruits at different stages of maturity.

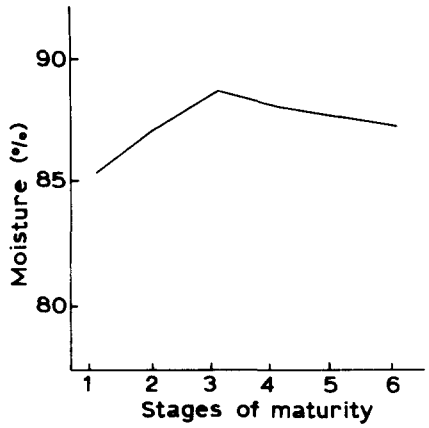

Fig. 2. Moisture content of fruits at different stages of maturity.

this stage, the fruits were considered suitable for processing. Their soft texture would allow them to be more easily machineable. From stage 4 to stage 6 there was a linear decrease in moisture whereas the hardness reading decreased linearly up to stage 5. The loss in moisture content during the final three stages was likely to be due to respiration, evaporation or transpiration which continued even after the fruits were harvested. The decrease in the hardness readings in stages 4 and 5 could be due to the loss in moisture which may have caused: (i) breakdown of structural cellular components, e.g. protopectin as described by many workers (Postlmayr *et al.*, 1956; Shewfelt, 1965; Pressey *et al.*, 1971; Shewfelt *et al.*, 1981; Roe & Bruemmer, 1981) and (ii) loss in turgidity of cells. The latter may explain the reason for the imperfect corresponding decrease in protopectin (Fig. 3) with the decrease in fruit hardness with advancing stage of maturity.

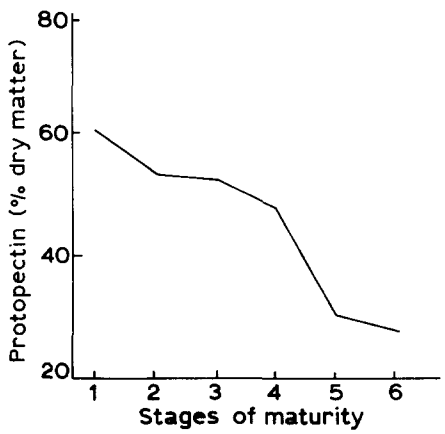

Fig. 3. Protopectin content of fruits at different stages of maturity.

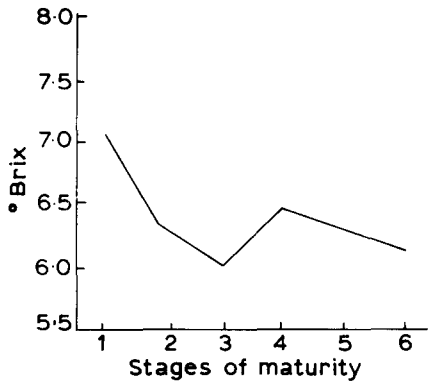

Fig. 4. Total soluble solids content of fruits at different stages of maturity.

Total soluble solids (TSS) (Fig. 4) decreased markedly from stage 1 to stage 3 (7·0°–6·0°Brix); increased slightly at stage 4 (6·6°Brix) then continued to decrease again until stage 6 (6·1°Brix). In processing, TSS are often used as a rough indicator of readily dissolved sugar content in fruit. Their correlation in papaya fruit was found to be in the range 0·61–0·99 (Murashige & Abuzeid, 1964). However, in this case there seemed to be a poor relationship between TSS and sugar contents (Fig. 5).

Analysis of the sugars showed that fructose, glucose and sucrose were the only sugars present in guava fruit of this variety. Maltose was not detected. This finding was similar to the work of Mowlah & Itoo (1982*a*). At all stages

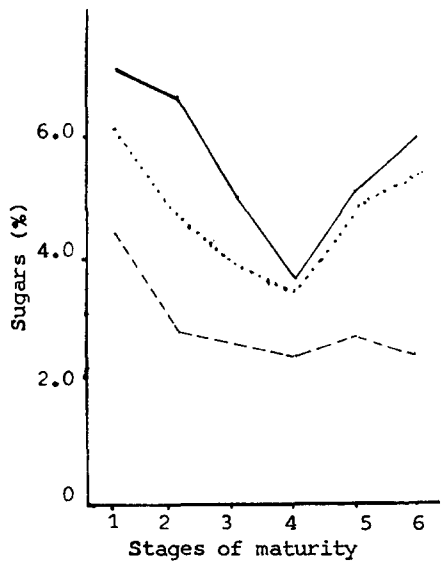

Fig. 5. Sugar content of fruits at different stages of maturity. (——), Glucose; (– – –), sucrose; (· · ·), fructose.

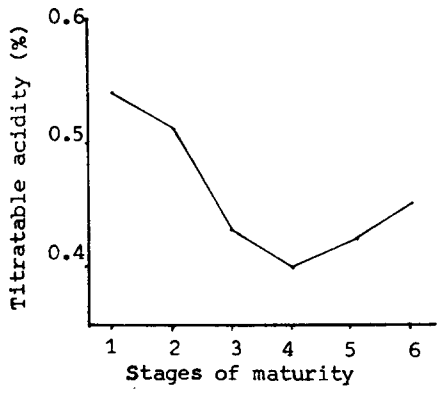

Fig. 6. Titratable acidity content of fruits at different stages of maturity.

of maturation, the amounts of sugars present were in the order glucose > fructose > sucrose. The values were lowest at stage 4, after which they increased again; however, these did not contribute to increase in sweetness of the fruit in the latter stages (5 and 6).

Titratable acidity decreased on maturity up to stage 4 (Fig. 6) like the sugar components. Nevertheless, calculation of the Brix–acid ratios showed that fruits at stage 4 had the highest value (16·3) compared to stages 5 and 6 (15·8 and 13·6, respectively). Fruits in stages 1, 2 and 3 had Brix–acid values of 13·1, 12·4 and 13·9, respectively. Although the Brix–acid ratio is often overlooked in materials intended for processing, it is important to indicate the optimum stage of fruit maturity in order to achieve maximum fruit flavour. This result shows that fruits at stage 4 were best for processing. Beyond stage 4, it was observed that the increase in titratable acidity was accompanied by a more prominent sour taste in fruits. The increase in titratable acidity could be due to breakdown of sugars to acid when the fruits senesce (in stages 5 and 6). The increase in pH value from stage 4 to stage 6 (Fig. 7) may indicate an increase in the buffering capacity of the fruit due to breakdown of protein to amino acid or breakdown of other macromolecules.

Another factor that determines the quality of fruits for processing is the tannin (polyphenol) content. High tannins, which normally occur in young fruits, are known to contribute to an astringent taste (Haslam, 1974). The tannin content showed an almost linear decrease with increasing stage of maturation (Fig. 8). The level of tannins was reduced by 42% from stage 1 to stage 6 with a lowest value in stage 4. Mowlah & Itoo (1982*b*) reported a 45% decrease in total polyphenol content in a white guava variety and also pointed out that the reduction in tannin had caused a loss in astringency in ripe fruits.

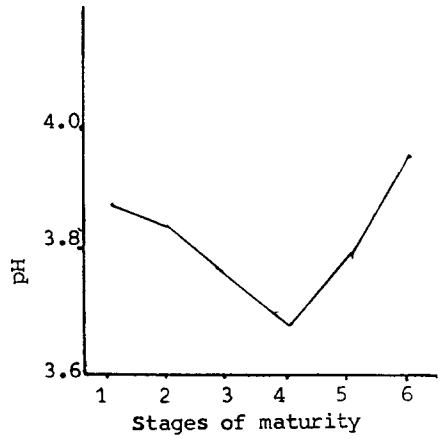

Fig. 7. pH of fruits at different stages of maturity.

The ascorbic acid content (Fig. 9) increased in a sigmoid pattern and was highest at stage 4. The ascorbic acid decreased as the fruit senesced. A purée which is produced from fruits at stage 4 would result in the highest vitamin C content since, at that stage, the vitamin C content is almost double that at stages 2 or 3. This result shows another important reason for the need to ripen fruits to stage 4 prior to processing.

Purée quality and acceptability

Analysis of variance on the flavour scores indicated that there was a significant difference ($P < 0{\cdot}05$) between the flavour of samples at various

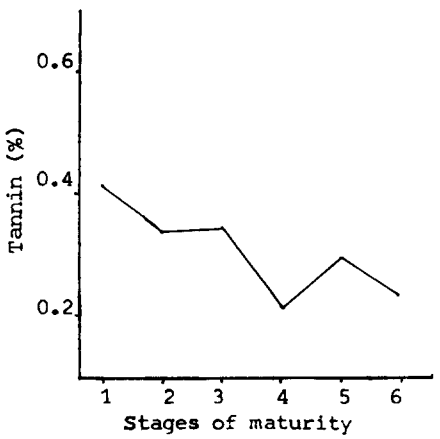

Fig. 8. Tannin content of fruits at different stages of maturity.

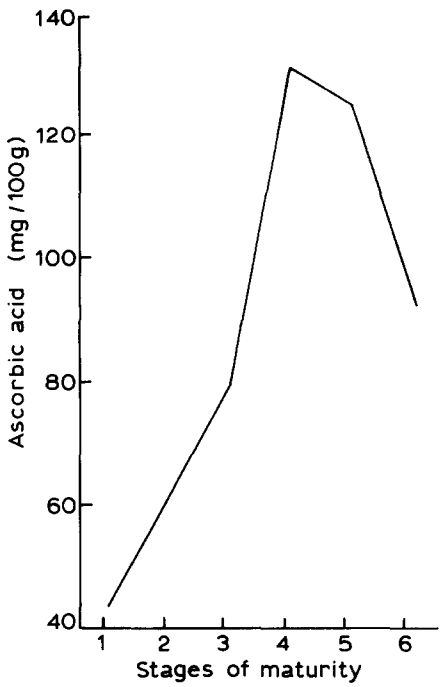

Fig. 9. Ascorbic acid content of fruits at different stages of maturity.

stages of maturity. Higher preferences were indicated for samples from stages 2, 3 and 4 while low preferences were given for samples in stages 1, 5 and 6. Panelists commented that samples from stage 1 had an immature fruit flavour accompanied with astringent taste. Samples from stage 5 had too strong ripe guava flavour and those at stage 6 produced the flavour of bad fruits which, in both cases, the panelists did not like. Table 1 shows the results of the Duncan's Multiple Range Test on their means comparison. From the flavour point of view, there was no significant difference between sample purée from stages 2, 3 or 4.

TABLE 1
Means of Samples Compared by Duncan's Multiple Range Test

Sample	*1*	*2*	*3*	*4*	*5*	*6*
Means of flavour*	$1{\cdot}8^{a}$	$4{\cdot}8^{b,c}$	$6{\cdot}4^{b}$	$6{\cdot}0^{b}$	$3{\cdot}4^{a,c}$	$3{\cdot}6^{a,c}$
Means of aroma*	$3{\cdot}6^{a}$	$5{\cdot}4^{b,c}$	$6{\cdot}6^{b}$	$5{\cdot}8^{b,c}$	$4{\cdot}4^{a,c}$	$3{\cdot}2^{a}$

* Means with similar superscripts within a row are not significantly different at the 5% level.

There was also a significant difference ($P < 0{\cdot}05$) between aromas of samples. High preferences were given to samples in stages 2, 3 and 4. Analysis of mean scores indicated no significant difference in aroma in the three most preferred samples (Table 1).

Figure 10 shows the Hunter 'L' values of purée at different stages of maturity and under different treatments. Large 'L' values mean the samples were brighter in appearance. The 'L' values of fresh samples increased with increase in the stage of maturation. The difference was due to the decrease in intensity of green colour (due to chlorophyll) as the fruits became more mature and ripe. Calculation of the correlation coefficient between 'L' value and chlorophyll content showed a high negative correlation ($r = -0{\cdot}96$).

Addition of sugar caused the product to turn brown. There were large drops (between 15–16 units) in 'L' values of all samples at the various stages of maturity. Browning of purée was accompanied with a loss in the original green colour of the product. Larger decreases in green colour ($-a$ value) (between 1·2 and 1·3 units) were observed for greener fruits compared to the more mature ones (between 0·95 and 0·35 units). Purées from stages 1 and 2 appeared blackish-brown and were unacceptable. Meanwhile, samples from stages 3, 4, 5 and 6, which gradually became slightly brown, appeared more attractive compared to the initial pale whitish colour of fresh purée. It was apparent that there were three reasons for the browning of purée at this stage: (i) due to addition of sugar, as observed by the large drop in 'L' values; (ii) due to breakdown of chlorophyll, as observed by the change in $-a$ value

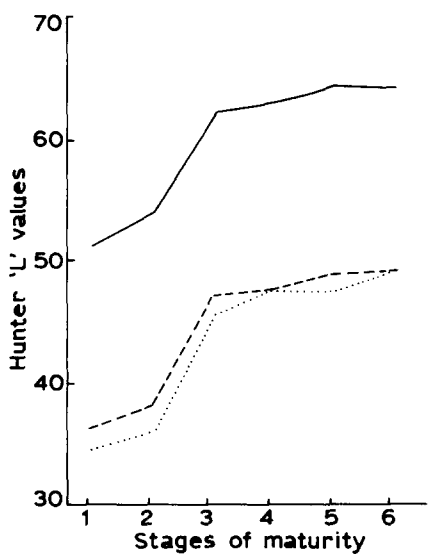

Fig. 10. Colour of purée at different stages of maturity. (——), Fresh purée; (– – –), after addition of sugar; (· · ·), after heating.

of unripe fruit purées and (iii) due to enzyme action which was more pronounced in younger fruits. Previous work on polyphenol-oxidase (Augustin *et al.*, 1985) did not report on the amount or activity of the enzyme at the various stages of maturation. It is possible that the higher tendency for younger fruit purées to turn brown was due to the presence of high amounts of substrate polyphenols (Fig. 8), similar to the work reported by Mowlah & Itoo (1982*a*). Their work also reported that the specific activity of the enzyme increased as the fruits ripened.

After heating (99°C, 3 min), there were only slight (0·2–0·3 unit) changes in '*L*' values for all samples. This means that browning due to heating (non-enzymic) does occur but at a low level. A suitable limit could be established with purées from stages 3, 4, 5 and 6 with '*L*' values above 40, which were considered acceptable and attractive.

Viscosity of purée increased with increase in fruit maturation up to stage 5 but decreased in stage 6 (Fig. 11). This observation was contrary to that of strawberry purée (Spayd & Morris, 1981) in which case viscosity decreased as the fruit matured and ripened; the decrease in viscosity of strawberry purée was thought to be contributed by the decrease in cellulose content. The cellulose content of guava also decreased with increase in stage of maturity

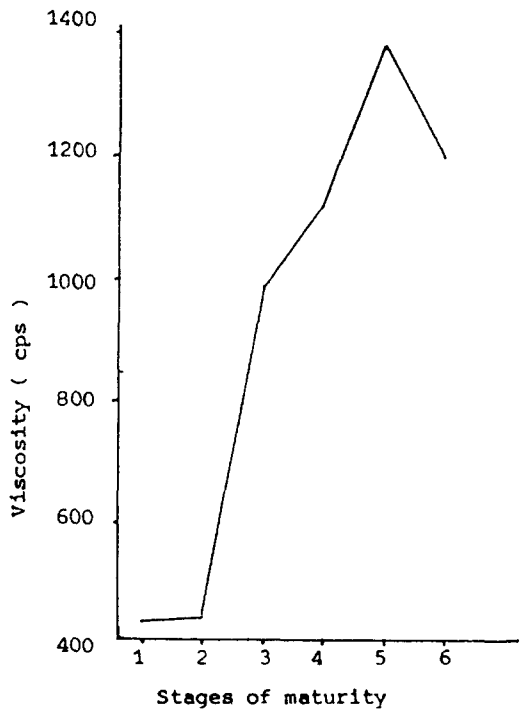

Fig. 11. Viscosity of purée at different stages of maturity.

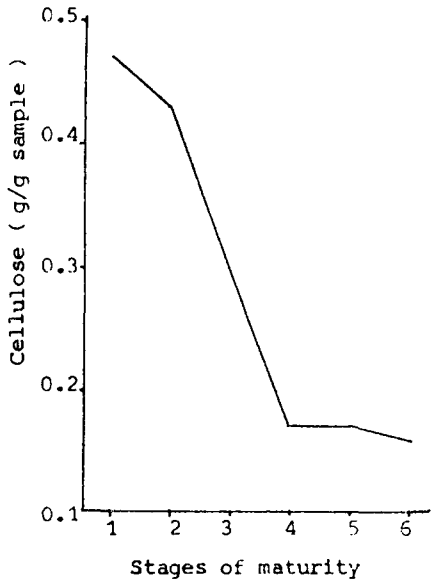

Fig. 12. Cellulose content of fruits at different stages of maturity.

(Fig. 12). However, the increase in viscosity was perhaps due to the increase in soluble pectins (Fig. 13). Calculation of the correlation coefficient for viscosity against pectin and cellulose gave a high negative correlation for cellulose ($r = -0{\cdot}96$) and a lower correlation for pectin ($r = 0{\cdot}89$). This means that the increase in viscosity of guava purée was more due to reduced cellulose than increased pectin. The soluble pectin was highest when the fruits began to soften at stage 4 and decreased after that. There might be other factors which contributed to higher viscosity of purée at stage 5 since the cellulose level at this stage was similar to stage 4.

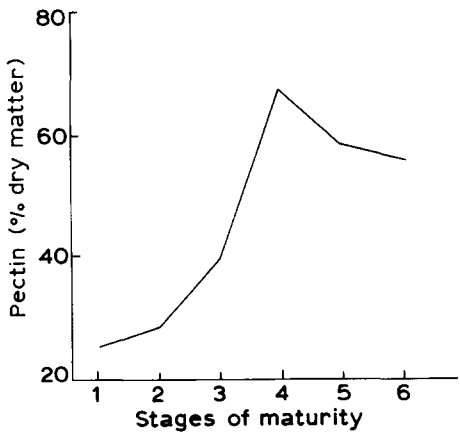

Fig. 13. Soluble pectin content of fruits at different stages of maturity.

CONCLUSION

From the many characteristics studied, perhaps the parameters that are critical to processing are fruit texture, tannin content, soluble pectin content, flavour and colour. Based on these characteristics, stage 4 fruits are recommended for processing into purée since, at this stage, the fruits are already soft and easy for machine handling. The low tannin content improves the taste and reduced tendency to brown; the increased soluble pectin content improves the body (viscosity) of purée and also, at this stage, the flavour and aroma are more enhanced. This means that guava fruits of the Vietnamese variety can be processed but need to undergo post-harvest ripening in order to achieve a good quality purée.

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