The Effect of Homogenization, Stabilizer and Amylase Treatment on Viscosity of Passion Fruit Juice.

A. R. Kahawa *B.Sc.,(Hons) M.Sc., University of Nairobi; **M. W. Okoth**** Ph.D., ETH Zurich; **J. K. Imungi**. Ph.D, Cornell University.

Department of Food Technology & Nutrition, University of Nairobi, P. O. Box 29053, Nairobi, Kenya.
** Corresponding author
* Uganda Industrial Research Institute, Ministry of Trade Nairobi,
P. O. Box 7103, Kampala, Uganda

Abstract

The effects of homogenization, stabilizer (Mexpectin) and amylase individually and in two factor combination on the mean viscosity during storage of sweetened, pasteurized passion fruit juice were investigated. Homogenization before or after pasteurization lowers the viscosity at all pressures considered. Compared to the control sample, stabilizer levels of 0.3% and above increase the viscosity, the higher the stabilizer level the higher the viscosity. Addition of amylase lowers the viscosity and the longer the amylase action time the lower the viscosity. A combination of homogenization and addition of stabilizer the higher the viscosity. A combination of homogenization and addition of amylase lowers the viscosity, treatment before pasteurization leads to lower viscosity than treatment before pasteurization. Addition of both stabilizer and amylase results in much higher viscosity than in the control sample with the level of stabilizer determining the viscosity. The higher viscosity was obtained by a combination of 0.4% stabilizer and 45 minutes of amylase action after pasterurization, while the lowest steady viscosity was obtained by only homogenization at 2000psi. **Key words; Passion fruit, juice, Viscosity, Homogenization, Stabilizer, Amylolsis.**

Introduction

Passion fruit is produced in most tropical and sub-tropical areas of the world as well as in a few temperte zones. Eight countries (United States, Australia, Papua New Guinea, Fiji, South Africa, Kenya Colombia and Sri Lanka) account for 80-90% of the world's production.

Because of its unique intense flavour and high acidity, passion fruit juice has been described as a natural concentrate. When sweetened and diluted, it provides a high quality palatable beverage and the flavour blends well with other fruit juices. For most general consumer acceptance, the sugar to juice ratio should not be less than 45:100, and the rate of dilution should be three parts water to one part of juice to make a single strength juice. In Germany, single strength passion fruit juice has concentration of 14 Brix (Wild and Benk, 1985)

Viscosity is an important quality attribute of passion, fruit juice because it imparts the real mouthfeel and the body of the juice. Furthermore, viscosity reduction makes juice pumping, filtration, clarification and concentration (Evaporation) more efficient (Schmift, 1981, Crandall et al., 1989). Crandall et al, (1989) report that, as a result of decreased viscosity, energy saving of 3-4% is achieved in evaporating homogenized starch constitutes, 1.0 - 3.7% of the edible portion of passion fruit (Cillie and Joubert, 1950). Kwok et al (1974) found that increased starch contents of passion fruit juice results in higher viscosity.

They showed that alpha-amylase was effective in reducing viscosity of passion on fruit juice in which the starch has been gelatinised by heat. Viscosity of passion fruit juice increases with increase of pulp, water soluble pectin and total pectin (Bourne, 1982). Viscosity can be increased by pasteurization and addition of stabilizers and sugar, but can be decreased by homogenization.

The objective of the study reported in this paper was to determine and compare the effects of homogenization, addition of stabilizer and addition of alpha-amylase individually and in two factor combination on the viscosity of sweetened, pasteurized passion fruit juice.

2. Materials and Methods

2.1 Materials

2.1.1 Passion fruits

Purple passion fruits were purchased from *Wakulima* market in Nairobi.

2.1.2 Chemicals and equipment

3.2.1.1, Bacterial Crude Type III-A from (*Bacillus subtilis*), and Mexpectin stablizer.

A two-stage homogenizer (Type 15M 8TH, Gauline Corp., Massachusetts) was used.

2.2 Processing methods

2.1.1 Preparation of passion fruity juice

The fruits were sorted out then washed thoroughly in running tap water and drip dried. Each fruit was opened by cutting in halves with a kitchen knife and the pulp scooped out with spoons. The pulp was passed through a 2mm sieve of a Lipp's kitchen machine to remove the seeds and fibrous material. The juice was fine-filtered through one layer of Muslim cloth after which the total soluble solids were adjusted to 45.0^0 Brix with white sugar.

2.2.2 Sample treatments

2.2.2.1 Sample treatment for the effect of individual factors

A Randomized Block design experiment with two blocks and three treatments was used. The two blocks were "before" and "after" pasteurization respectively. The three treatments were represented by homogenization, stabilizer and addition of amylase. Preliminary investigations were analyzed using Least Significant Test (LSD) to determine the minimum and maximum levels of each factor which give significant changes ($P \leq .100$) in viscosity. Homogenization pressures between 1000 and 4000 psi, stabilizer levels between 0.2 and 0.5% and amylase action times between 15 and 60 minutes were found to give significant changes in viscosity. For each treatment, of "before" and "after" pasteurization, 16 litres of the juice were used as follows;

(a) **Before Pasteurization:**

Homogenization: The juice was warmed to 40-50° C then divided into four equal parts. Each of the parts was homogenized at 1000, 2000, 3000 and 4000 psi respectively, then pasteurized at 75° C for 15 minutes.

The juice was filled hot in 250 ml PTE bottles then cooled to about 25° C and stored at 22+1°C.

Stabilizer: The juice was warmed upto 40-45°C, then provided into four equal parts. Each of the respective parts was treated with 0.2, 0.3, 0.4 and 0.5% of the stabilizer by adding the *stabilizer* as a dispersion in 5g sugar to avoid lumping. Each juice was pesteurized at 75°C for 15 minutes, filled hot into 250 ml bottles then cooled and stored at 22±°C.

Amylase treatment: The juice was divided into four equal parts. For each part, 0.02% by weight of amylase was first suspended in about 30ml of water at 40-50° and left to stand for 20 minutes to activate the enzyme. The suspension was then mixed in the juice and allowed to act for 15, 30, 45, and 60 minutes, after which temperature of the juice was quickly raised to 85° in less than 5 minutes in a boiling water bath to destroy the enzyme as recommended by Reed (1966). The juice was filled hot in PTE bottles then cooled to about 22°C and stored at 22±1°C

(b) **After Pasteurization**

Homogenization: The juice was pasteurised at 75°C for 15 minutes, then cooled to 40%-50°C. It was then divided into four equal parts and the parts homogenised for at 1000, 2000, 3000, and 4000 psi respectively. The juice was filled into 259ml PTE bottles and stored at 22± 1°C

Stabilizer: The juice was pasterised to 75°C for 15 minutes then cooled to 40-50°C. It was divided into four parts and the parts and the parts and treated with stabilizer at the level 0.2, 0.3, 0.4, and 0.5% respectively by addition in a dispersion in 5g of sugar and mixing thoroughly. The juice was filled into 250ml PTE bottles and stored at 22±°C

Amylase treatment: The juice was pasteurised at 75°C for 15 minutes then cooled to 40-50°C. It was divided into four parts and the parts treated each with 0.02% amylase for 15, 30, 45, and 60 minutes after which the temperature was raised quickly to 85°C to inactive the enzyme and cooled immediately to 40-50°C The juice was filled in 250 ml PTE bottles and stored at 22± 1°C

The Control sample was pasterised but did not receive homogenization, stabilizer or amylase treatments.

Sample treatment for the effect of to-factor combinations

The experiments were set out in a 2 x 3 x 2 Factorial Design with the 2 blocks represented by "before" and after" pasterization and the treatments represented by Homogenization + Stabilzer, Homogenization + Amylase and Stabilizer + Amylase and the factors by Homogenization pressures of 1000 and 3000 psi, Stabilizer levels were 0.2 and 0.4 percent, and amylase action times were 15 and 45 minutes. These values were selected so as to have low and high levels of each factor which make significant changes ($P \leq 0.05$) in viscosity when the factor is used alone.

The following combinations were used for both "before " and "after" pasteurization:

Stabilizer + Homogenization:

0.2% Stabilizer + 1000 psi
0.2% Stabilizer + 3000 psi
0.4% Stabilizer + 3000 psi
0.4% Stabilizer + 1000 psi

Amylase + Homogenization

15 minutes + 1000 psi
15 minutes + 3000 psi
45 minutes + 100 psi
45 minutes + 0.4% Stabilizer

Amylase + Stabilizer

15 minutes + 0.2% Stabilizer
15 minutes + 0.4% Stabilizer
45 minutes + 0.2% Stabilizer
0.4% Stabilizer + 45 minutes

The sample were prepared in the same manner as in the simple effect situations and also stored at 22± 1°C in 250ml PTE bottles.

This sample was pasteurated but did not receive homogenization stabilizer or amylase treatments.

2.3 Analytical Methods

2.3.1 Determination of viscosity

Viscosity was determined in duplicate as flow time in seconds using a capillary viscometer (App. Nr. 44904, k = 0.094, Schott & Gen., Mainz) and the mean value taken. An aliquot of the juice at 20±1°C was thoroughly mixed and carefully poured into the viscometer. Using a stop watch, the time (seconds) taken for the given volume of juice to flow through the capillary was recorded. The longer the time of flow for the volume of juice the higher the viscosity.

The viscosity of each sample was measured soon after preparation and after one week for the next eight weeks in the case of single factor experiments and for the next 16 weeks in the case of two-factor experiments. Statistical analysis was based on all the viscosity measurements.

3. Results and Discussion

3.1 Effect of Individual factors

Effects of homogenization pressure on flow time during storage of passion fruit juice homogenized before pasteurization and after pasteurization are shown in **Figure 1** and 2 respectively. It can be seen that increase in homogenization pressures decreased flow time when homogenization was done after pasteurization and the reverse happened in the juice which was homogenized before pasteurization. Grandall *et al* (1989) found similar results when concentrated orange juice was homogenized before and after heat treatment. Decrease in flow time of the juice which was homogenized after pasteurization was due to enhanced size reduction of juice particles which include

Figure 1: Changes in flow time during storage of passion friut juice homogenized before pasteurization

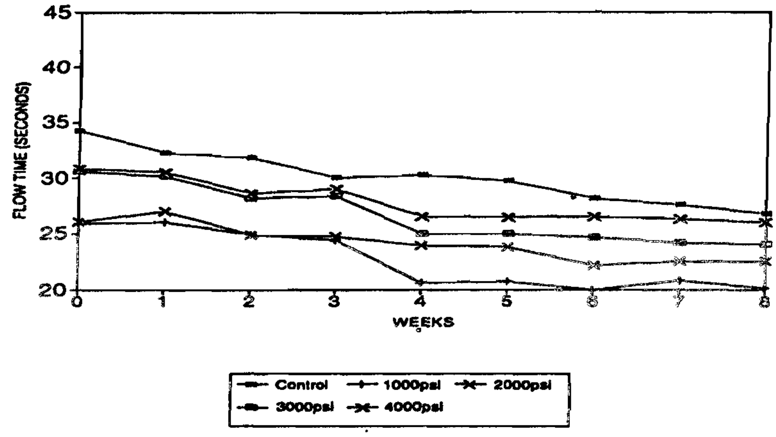


Figure 2: Changes in flow time during storage of passion friut juice homogenized after pasteurization

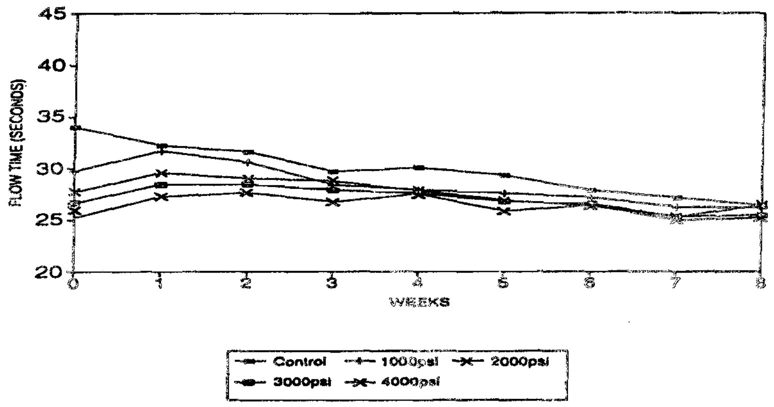


Figure 3: Changes in flow time during storage of passion friut juice with stabilizer added before pasteurization

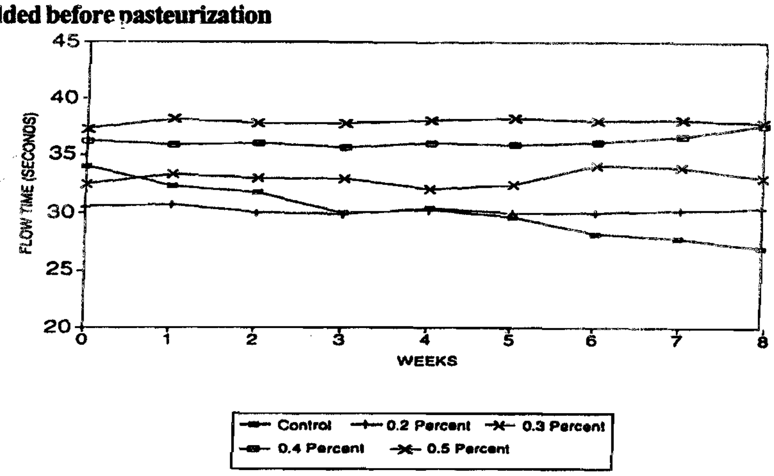
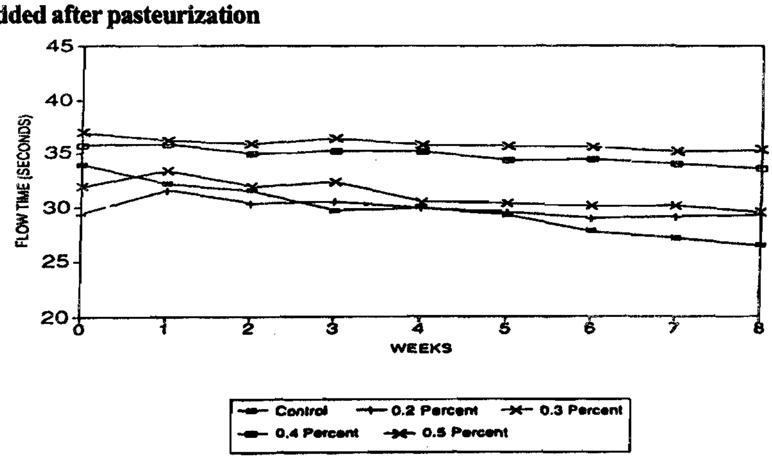


Figure 4: Changes in flow time during storage of passion friut juice with stabilizer added after pasteurization



sugars, pectin substances and pulp due to heat. Dickinson (1982) agrees that homogenization disperses particles into a colloidal system that lowers the viscosity. Indeed, in the present study, the flow times of homogenized juice were lower than those for the control sample at all pressures. The control sample had an average flow time of 33.89s. Statistical analysis of the data collected throughout the eight weeks storage period, however, showed that there was no significant difference ($P \leq 0.05$) between the flow times for homogenization before and after pasteurization.

Figures 3 and 4 show the effect of stabilizer levels on the flow time during storage of the passion fruit juice. The flow time increased with increase in stabilizer level irrespective of whether the stabilizer was added before or after pasteurization. Compared to the control sample, stabilizer contents above 0.3% resulted in significant ($p \leq 0.05$) increase in flow time. This is in agreement with the treatise of Friberg (1976). The stabilizer binds juice water (Robert 1980) and hence reduces motility of particles. There was no significant difference ($p \leq 0.05$) between the juices in which the stabilizer was added before and after pasteurization, respectively.

The effect of amylase action time during storage of the juice treated with amylase before pasteurization and after pasteurization on flow time is shown in **Figures 5** and 6 respectively. There was not significant ($p \leq 0.05$) decrease in the flow time with increase in amylase action time irrespective of whether amylase was added before or after pasteurization. The decrease in flow time was due to amylolysis of starch (Robert, 1980). The control sample had a significantly ($P \leq 0.05$) higher flow time than the juice samples in which amylase was added. There was no significant ($p \leq 0.05$) difference between the juices treated with amylase before or after pasteurization.

3.2 Effect of the two-factor treatment combination

3.2.1 Homogenization + Stabilizer Combination

The combined effects of homogenization pressures and stabilizer levels on flow time

Figure 5: Changes in flow time during storage of passion friut juice treated with amylase before pasteurization

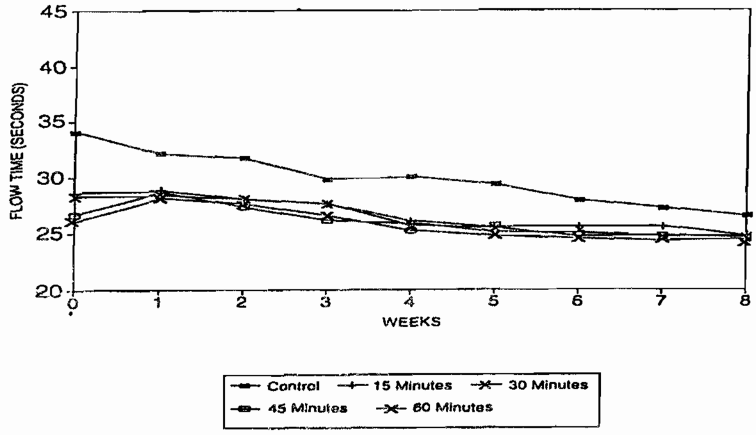


Figure 6: Changes in flow time during storage of passion friut juice treated with amylase after pasteurization

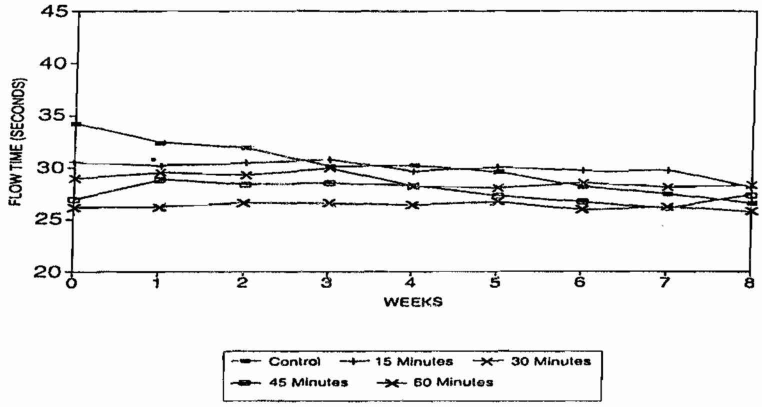


Figure 7: Changes in flow time during storage of passion friut juice treated by homogenization and stabilizer before pasteurization

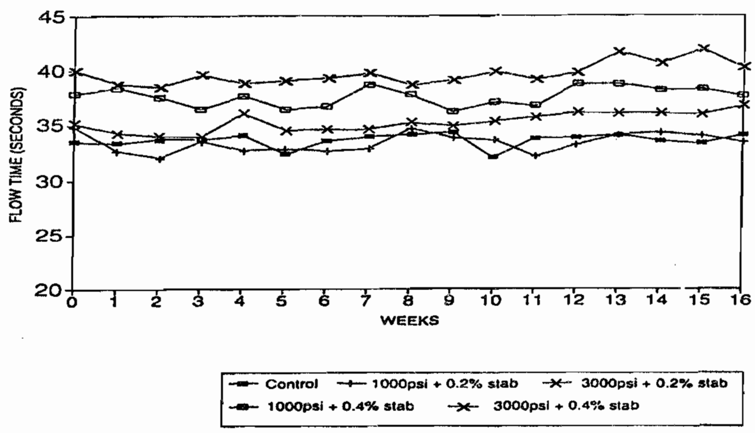
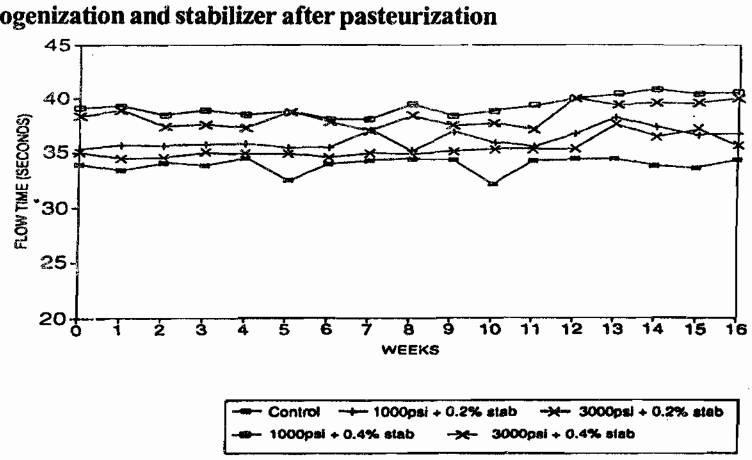


Figure 8: Changes in flow time during storage of passion friut juice treated by homogenization and stabilizer after pasteurization



during storage of passion fruit juice treated before pasteurization and after pasteurization are shown in **Figures 7** and **8**, respectively. Compared to the control sample, the flow time of the juice which was both homogenized and had stabilizer added was significantly ($p \leq 0.05$) higher. This was the case whether the treatment was done before or after pasteurization. The presence of the stabilizer dominated in determining the viscosity of the juice.

The viscosities of treatment 1000 psi + 0.2% stabilizer and 1000 psi + 0.4% stabilizer after pasteurization were significantly ($p \leq 0.05$) higher than those of the treatments before pasteurization. The reverse happened for the 3000 psi + 0.2% stabilizer and 3000 psi + 0.4% stabilizer treatments. This implies that homogenization of pasteurized juice at low pressures gives higher viscosity, whereas higher viscosity is obtained when juice which is not yet pasteurized is homogenized at higher pressures. This confirms the same effect when homogenization was done alone. **Figures 7** and **8** clearly show what has been stated above, namely that the level of stabilizer is more important than the homogenization pressure in determining the viscosity of the juice. The higher the level of stabilizer, the higher the viscosity. In fact the treatments 1000 psi + 0.4% stabilizer and 3000 psi + 0.4% stabilizer were very significantly different ($p \leq 0.001$) from the other two treatments and the control. The stablizer factor was significant ($p \leq 0.05$), whereas homogenization and their interaction were not significant ($p \leq 0.05$) in determining the viscosity of the juice.

3.2.2 Homogenization + Amylase combination

Figures 9 and **10** show the combined effect of homogenization pressures and amylase action times on the juice flow time during storage of the juice treated before the after pasteurization. The flow times were significantly ($p \leq 0.05$) lower than the value for the control sample apart from the treatment 1000 psi + 15 minutes which was slightly higher. Treatment of the juice after pasteurization resulted in significantly ($p \leq 0.05$) higher flow times than were obtained by treatment before pasteurization. This shows the dominance of the effect of addition of amylase over the effect of

Figure 9: Changes in flow time during storage of passion friut juice treated by homogenization and amylase before pasteurization

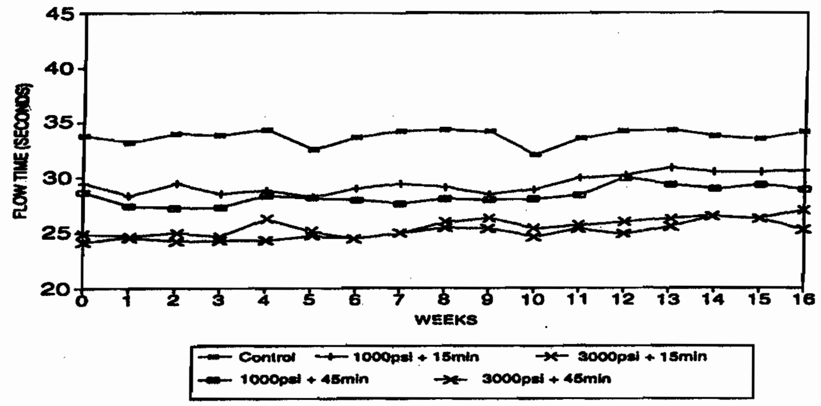


Figure 10: Changes in flow time during storage of passion friut juice treated by homogenization and amylase after pasteurization

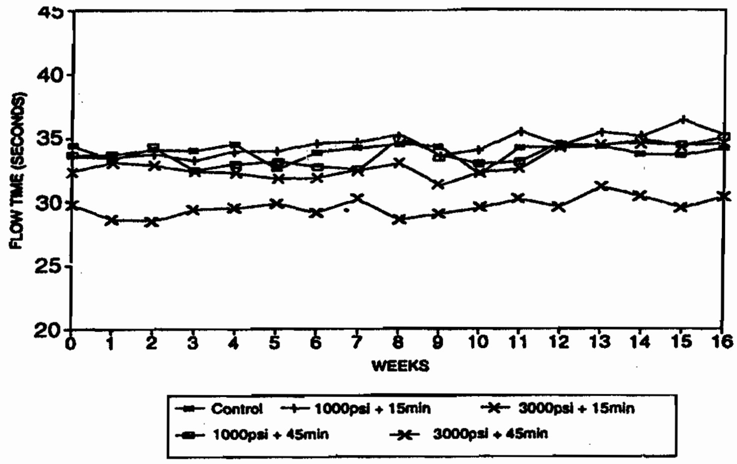


Figure 11: Changes in flow time during storage of passion friut juice treated with stabilizer and amylase before pasteurization

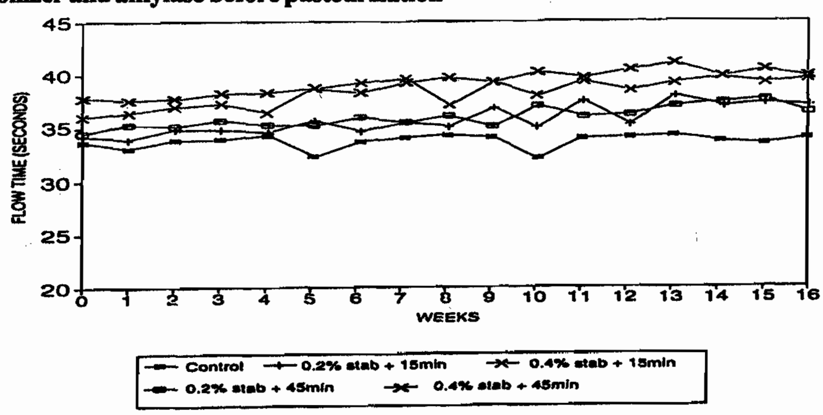
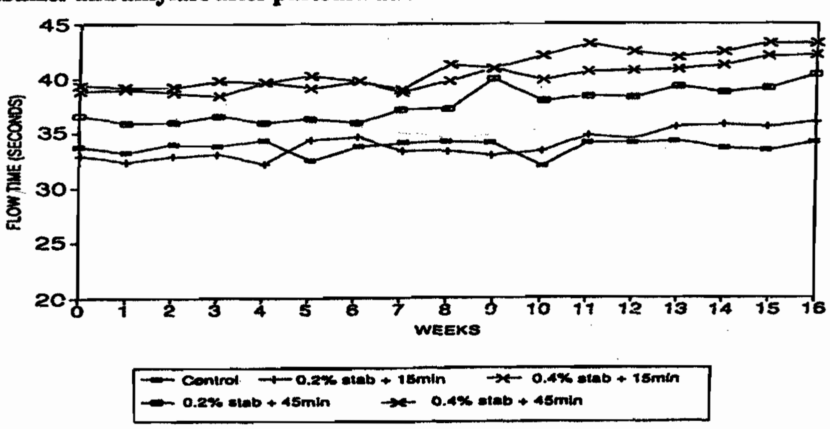


Figure 12: Changes in flow time during storage of passion friut juice treated with stabilizer and amylase after pasteurization



homogenization with regard to the timing of the pasteurization process since the same outcome was observed when amylase was used alone.

Whether the treatment was done before or after pasteurization, 1000 psi + 15 min. treatment had the highest flow time and was followed in decreasing order by 1000 psi + 45 min. This order indicates that homogenization was more dominant in decreasing the viscosity of the juice. The decrease in viscosity by the treatments was significant ($p \leq 0.05$) when compared to the control sample and the treatments themselves were also significantly different from each other. Both homogenization and amylase treatment were significant and their interaction was not significant ($p \leq 0.05$) in reducing the viscosity of the juice.

3.2.3 Stabilizer + Amylase combination

Figures 11 and 12 show the combined effect of stabilizer levels and amylase action times on flow time, during storage of the juice treated before and after pasteurization respectively. Most of the flow time readings were well above the control sample reading. Only the flow time for 0.2% stabilizer + 15 min. treatment was close to that for the control sample. When the stabilizer was used alone the flow times were higher than the value for the control sample and the reverse was true when amylase was used alone. Therefore the effect of the stabilizer overshadowed that of the amylase. There was no significant difference ($p \leq 0.05$) between the flow times for the juice treated before pasteurization and those for the juice treated after pasteurization.

The order from the highest to the lowest flow times for both treatments before pasteurization and the reverse was 0.4% stabilizer + 45 min., 0.4% stabilizer + 15 min., 0..2% stabilizer + 45 min. and 0.2% stabilizer + 15 min. Compared to the control sample, the increase in flow times was highly significant ($p \leq 0.05$). The viscosities for 0.4% stabilizer + 15 minutes treated juices were significantly higher ($p \leq 0.05$) compared to the other two treatments. The stabilizer factor was significant in increasing the flow time, while the amylase factor and the interaction between the two factors were not significant ($p \leq 0.05$).

4. Conclusion

Homogenization of passion fruit juice before or after pasteurization lowers the viscosity at all pressures considered.

Compared to the control sample, stabilizer levels of 0.3% and above increase the viscosity compared to the control sample, the higher the stabilizer level the higher the viscosity.

Treatment with amylase lowers the viscosity; the longer the amylase action time, the lower the viscosity.

A combination of homogenization and addition of stabilizer results in a higher viscosity than in the control sample; the higher the level of stabilizer, the higher the viscosity.

With one exception, homogenization at 1000 psi plus 15 minutes amylase action time, a combination of homogenization and addition of amylase lowers the viscosity, treatment before pasteurization leading to lower viscosity than treatment after pasteurization.

Addition of both stabilizer and amylase results in much higher viscosity than in the control sample, with the level of stabillizer determining the viscosity.

The highest viscosity, higher than that for the control sample, was obtained by a combination of 0.4% stabilizer and 45 minutes of amylase action after pasteurization while the lowest steady homogenization at 2000 psi.

Acknowledgements

We thank the Swiss Development Cooperation for financial assistance.

References

Bourne, M. C. (1982). Food Texture and Rheology. Academic Press, New York.

Cillie, G.G. & Joubert, F. J. (1950). Occurrence of amylopectin in the fruit of grandila (passion edulis). *J. of Sci. Food Agric.k, 1,355-357.*

Crandall, P. G.; Davis K. X.; Carter, R. D. & Sudler, G. O. (1989) Viscosity reduction by homogenization of orange juice concentrated in pilot taste evaporator. *J. of Food Sci.*, 53(5), 1477 - 1481.

Dickson, E. (1982). Colloids in Food. Applied Science Publishers, Barking, Essex.

Friberg, S. (1976). Food Emulsions. Mercel Dekker, Inc., New York.

Kwok, S. C. M.; Chan, H. T. Jr.; Nakayama, T. O. M. & Brekke, J. E. (1974). Passion fruit starch and viscosity. *J. of Food Sci.*, 39(3), 431-433.

Reed, G. (1966). Effect of temperature and pH. In Enzymes in Food processing, ed. G. Reed Academic Press, New York, pp. 31-41.

Robert, A. B. (1980). The role of pectin in citrus quality. In Citrus Nutrition and Quality, ed. S. Nagy & J. A. Attaway. American Chemical Society, Washington D. C., pp. 109-124.

Schmift, R. (1981). Liquefaction of fruits and vegetables by enzyme treatment. FL. Obst, 48(8). 239-240, 258-260.

Wild, R. & Benk, E. (1985). Composition and evaluation of Industrialpassion fruit. Industrielle obst -und Gemueseverwertung, 69 (9), 374 - 380..