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RHEOLOGICAL PROPERTIES OF MANGO AND PAPAYA NECTAR BLENDS
BY

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ABSTRACT

Mango-papaya nectars were prepared by blending mango puree with papaya puree (one of the cheaper fruits in the Egyptian market) in different proportions (90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80 and 10:90). The products were analysed for physicochemical, sensory characteristics and rheological properties. Rheological measurements were made by Brookfield Digital Viscometer Model DV-II+ with 18 rotational speeds at shear rate ranged between 0.3 to 100 Sec^{-1} and at temperatures of 5-100 ºC. Four rheological models (Bingham plastic, Power Law (Ostwald), IPC Paste and Casson) were used to calculate the relationship between shear stress and shear rate. Mango-papaya nectars behaved as a non-Newtonian fluids (pseudoplastic behavior) with a yield stress, while the effect of temperature could be described by an Arrhenius-type equation. The effect of temperature on viscosity was very well correlated with the Arrhenius equation (r > 0.999). Activation energy for viscous flow was in the range of 2068.44 to 8534.32 J/mole depending on blending ratio. As the ratio of papaya puree to mango puree increased, flow rate increased, while the scores for sensory quality decreased. The nectar consisting of 80% mango puree and 20% papaya puree with 17 ºBrix. and having a sensory score of 93.1 was found to be the best.

Keywords: Rheological parameters. Flow behaviour . Activation energy . Sensory evaluation . Nectar blends . Mango & Papaya puree and nectar .

Nomenclature

Symbol	Term	Symbol	Term
Con.%	Confidence of model (%)	C_p	Specific heat (kJ/kg .K)
d	Diameter of pipe (m)	E_a	Activation energy (k J/mol)
LSD	Least significant difference	K	Consistency index for Power Law model ($mPa.s^n$)
K`	Consistency multiplier for IPC Paste model ($mPa.s^n$)	M	Mango
n	Flow index for Power Law model (dimensionless)	O.D	Optical density (nm)
P	Papaya	R	Gas constant (8.314 kJ/kg mol.K)
RPM	Round per minute	R`	Rotational speed (RPM)
r	Correlation coefficients	S.E.	Standard error

S	Shear sensitivity factor for IPC Paste model	t	Temperature (°C)
T	Temperature (K)	v	Velocity (m/s)
τ	Shear stress (mPa)	V/V	Volume per volume
τ_{0CA}	Yield Stress for Casson model (mPa)	τ_{0BP}	Yield stress for Bingham model (mPa)
η	Viscosity (mPa.s)	$\dot{\gamma}$	Shear rate (s^{-1})
η_{BP}	Bingham dynamic viscosity (mPa.s)	η_{10}	Viscosity at 10 RPM (mPa.s)
η_{∞}	Constant in eqn. (5) (mPa.s)	η_{CA}	Casson dynamic viscosity (mPa.s)
υ	Kinematic viscosity (m^2 s^{-1})	ρ	Density (kg/m^3)
λ	Thermal conductivity (W/m°C)	α	Thermal diffusivity (m^2/s)

INTRODUCTION

The papaya fruit is one of the best sources of vitamins they are contains a lot of vitamins A and vitamin C and is considered to act as mild laxative processed, it has a neutral taste that can be considerably improved by the addition of passion fruits to make soft drink, jam and various preserves. Papaya fruits are harvested during several months of the year.

Papaya is one of the largest in size of the tropical fruits; it has a pulpy flesh yellow or orange coloured with shades of yellow and red, depending on the fruit var.. Its flavor and aroma are controversial in the sense of being not as abundant and exotic as other tropical fruits but indeed being quite characteristic. Papaya is usually eaten as such or in mixtures of tropical fruits, peeled and cut in segments, cubes or balls. In this form it contributes definitively with its texture and well defined organoleptic properties. The fruit can be easily converted into a thick puree and preserved by common methods and later employed to manufacture papaya nectars, (Carmen *et al.,*1978).

Mango is one of the most important and widely cultivated fruit of the tropical and subtropical world. It is also called king of the tropical fruits. This is because of its succulence, exotic flavor and delicious taste. Mango puree is a popular blending material for many types of mixed fruit juice product.

The largest market for mango puree is the USA which probably consumes around 30000 tonnes per annum with supplies coming mainly from Egypt, Cuba and India (Ashurst, 1995).

Tropical fruits such as papaya and mango are both expensive and popular in developed countries because of their exotic flavor. It is difficult for developing countries to export fresh fruits, because of their delicacy and sensitivity to handling and also because of the lack of technology required for the growing, harvesting, transporting, packing, ripening etc. of fresh fruits. When fruit is transformed into puree or nectar, its external appearance is no longer important; only the edible part of the fruit is important for producing nectar. Even when a fruit is damaged in some manner, its flavor, texture, appearance and color may be perfect for the production of puree or nectar, (Gupta, 1998).

Some workers have described the effect of blending of fruit drinks and nectars on chemical and sensory characteristics, but scarce information is available on the rheological properties of nectar and nectars blends.

Comparative studies were conducted on three papaya juice/passion fruit juice blends ratios of 75:25, 82.5:17.5 and 87.5:12.5, respectively. The results showed that the 82.5:17.5 and 87.5:12.5 blends were preferred to the 75:25 blend, (Salomon *et al*., 1977).

Begum *et al.*(1983) prepared mixture of pineapple juice and mango puree in proportions of 25:75, 50:50 and 75:25. Statistical analysis for sensory evaluation revealed that the products were acceptable in all respects throughout their study. No significant differences in consumer acceptability were observed between the 3 blends, though there was some preference for the 50:50 blend.

Mango and papaya purees were blended by Kalra *et al.*(1991) in 1:0; 1:1; 2:1; 3:1 and 0:1 ratio. The results indicated that 25-33% papaya puree could be incorporated in mango without affecting the quality and acceptability of the mango beverage.

Imungi and Choge (1996) produced fruit nectar beverages by blending mango and passion fruit purees with papaya puree and pear juice. Five blends of beverages were produced from passion fruit & papaya, mango & papaya, passion fruit & pear, mango & pear, and papaya & pear in the following ratios: 10:90, 20:80, 30:70, 40:60 and 50:50. Beverages were then assessed on sensory properties. On the basis of cost of ingredients and sensory scores of beverages, blends of passion fruit & papaya (10:90), mango & papaya (10:90), mango & pear (50:50), and pear & papaya (10:90) were considered as the most acceptable in order of preference.

Mostafa *et al.* (1997) prepared fruit nectars from papaya puree or blends of papaya and mango purees. The nectars contained 20, 30 or 40% puree. Mango puree was added at 0, 25, 37.5 or 50% of total puree content. Nectars from papaya alone had an unpleasant after-taste, whereas adding mango enhanced nectar acceptability significantly. Nectar blends containing 20% puree were rated as being of lower quality, while the consistency of blends containing 40% puree was too thick. A blend of 15% papaya & 15% mango puree was rated as excellent and was characterized by higher acceptability.

A protein-rich mango beverage was prepared by blending mango puree with soy protein (100:00, 90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80 and 10:90). The products were analysed for physicochemical and sensory characteristics. As the ratio of protein isolate to mango puree increased flow rate increased. The beverage consisting of 60% mango puree and 40% protein isolate with 16.00 ºBrix, and having a sensory score of 92.0 was found to be the best, (Chauhan, 1998).

Preparation and properties of a mango-papaya fruit squash are described by Saravana and Manimegalai (1999). Mango and papaya purees were blended in proportions of 50:50 (S1), 75:25 (S2) and 25:75 (S3). Squashes were prepared from fruit blends. Sensory properties of squashes were assessed. Results were compared to a control squash prepared from 100% mango puree. The control squash had the highest sensory scores for all parameters with an overall acceptability of 97.5. The S2 squash prepared from 75:25 mango: papaya was the most acceptable than S3 blended squashes.

Blending of guava and papaya puree at a ratio of 20-40% was studied for preparation of a ready to serve beverage with respect to improvement in colour, flavour and overall acceptability of the beverage. Sensory quality score was highest in guava and papaya blend (70:30) due to better consistency and flavour, Tiwari (2000).

Knowledge of the rheological properties of food products is important for design and process evaluation, process control, and consumer acceptability of a product. Viscosity is usually considered an important physical property related to the quality of food products. Viscometric data are also essential for the design evaluation of food processing equipment such as pumps, piping, heat exchangers, evaporators, sterilizers filters and mixtures.

The viscosity of fluid foods is an important parameter of their structure behavior. It determines to a great extent the overall mouth-feel and influences the intensity of flavor. Therefore, for many years, the viscosity of liquid foods has been of interest to researchers and industrialists. Correlation between sensory and instrumental values of texture parameters can be used for industrial quality control to keep the sensory viscosity within a range assuring good consumer acceptance.

The juices and nectars physical properties, such as density, viscosity, specific heat and coefficient of thermal expansion, are affected by their solid content and their temperature. For this reason, it is necessary to know the physical properties values, as a function of the temperature and the solids content, during the manufacture process, not just to obtain an excellent quality, but also to develop a data base, that is essential for optimizing the installation design and the transformation process itself, (Zuritz *et al.,* 2005).

The objectives of the present work were: (1) Formulating of different blends of mango and papaya fruits to produce a new and lower cost nectars. (2) Determination of rheological parameters of mango and papaya puree, nectars and nectar blendes and following up the changes of rheological properties that occur in different nectars at different temperatures. (3) Study the effect of temperature on flow behavior parameters of mango and papaya nectar blendes.

MATERIALS AND METHODS

1. Materials:

1.1 Mango fruits (*Mangifera indica* L. cv. Alfonso) were picked at the ripe stage from a certain farm in Ismailia Governorate, Egypt.

1.2 Papaya fruits (*Carica papaya* L) are usually collected green mature from the farm of Moshtohor Faculty of Agric. Zagazig Univ., Egypt. The fruits, weighing between 750 to 1750g. The fruit ripened under storage because of its size and fragile skin, transportation and handling are critical. The fruit is climacteric, suffers dramatic chilling injuries and during ripening drastic physical and chemical changes occur.

2- Processing

2.1 Mango puree: ripe mango fruits were washed with running water, hand peeled and cut. The fruits were mechanically extracted by using Moulinex blender (Blender Mixer, type: 741). The puree was strained by 0.023 inch screen to remove stone cells, to avoid coarse pulp particles and to have only fine particles of almost colloidal consistency.

2.2 Papaya puree: papaya fruits were washed, dried in air, hand peeled, seeds carefully removed and cut into small parts. The papaya puree was extracted by Moulinex blender (Blender Mixer, type: 741). It took five minutes blending to get papaya puree. The puree was strained by a stainless steel strainer, then strained again by a clean muslin cloth to get rid of seeds and peels for obtaining papaya puree.

Mango and papaya puree were divided into two parts:

- The first part was used to determine the chemical composition, rheological measurements and sensory evaluation.
- The second part was used in preparation of different blends.

2.3 Mango nectar: nectar was prepared from the 25% mango puree to get: total soluble solids 17% and pH 3.5, according to the method described by Tressler and Joslyn (1971).

2.4 Papaya nectar: nectar was prepared from the 25% papaya puree to get: total soluble solids 17% and pH 3.5, according to the method described by (Tressler and Joslyn, 1971 and Brekke *et al.,* 1976).

2.5 Mango and papaya nectar blends: the mango and papaya purees were blended together as follows:

Blends No.	Mango puree%	Papaya puree%
1	100	0
2	90	10
3	80	20
4	70	30
5	60	40
6	50	50
7	40	60
8	30	70
9	20	80
10	10	90

Each blend was added by 25% to water, sugar and citric acid to production the nectars, and adjusting pH to 3.5 is done conveniently by adding citric acid as 50%(w/v) solution.

2. Methods:

2.1.Analytical methods:

Moisture content, total solids, fat, protein, ash, ascorbic acid and starch were determined according to AOAC (1995). Total soluble solids and refractive index were measured at 25 °C with Abbe refrectometer Model 1T according to AOAC (1995). The pH value was measured with a pH meter model Consort pH meter P107. Titratable acidity was determined by titration with NaOH 0.1 N solution using phenolphthalein as indicator according to AOAC (1995). Total and reducing sugars were determined by Shaffer and Hartman method as described in the AOAC (1995). Total pectin content and fractional pectin components were determined by the method of Robertson (1979). Crude fiber was determined by Weende method which using VELP Scientifica extraction unit, the method is based on the solubilization of non-cellulosic compounds by sulfuric acid and hydroxide solutions as described in AOAC (1995). Pulp content was determined according to El-Mansy *et al.* (2000 a,b). Color index of papaya juice was determined by the method of Meydov *et al.* (1977). Carotenoids were determined according to Harvey and Catherine (1982). Total anthocyanins were measured according to the method of Skalaki and Sistrunk (1973). Specific heat (c_p) was calculated according to Alvarado (1991). Density was determined with a pyknometer at 25 °C according to AOAC (1995). Water activity (A_w) was measured with a (Rotronic Hygromer ™ water activity meter model A2101) operated following the procedure described in detail by Rao and Tapia (1991).

2.2. Rheological measurements:

Viscosity measurement was carried out by the Brookfield Digital Viscometer Model DV-II+ with 18 rotational speeds for comprehensive data gathering (0.3, 0.5, 0.6, 1.0, 1.5, 2.0, 2.5, 3, 4, 5, 6, 10, 12, 20, 30, 50, 60 and 100 rpm), the up and down curve of a shear rate were done. A temperature-controlled water bath was used to regulate the temperature of the samples. The Brookfield spindles UL adapter and Brookfield small sample adapter were used. Data were analysed by using Brookfield Software Rheocalc version (1.1). Bingham plastic (BP), Casson (CA), IPC Paste and Power Law (PL) math models provide a numerically and graphically analyse the behavior of data sets.

Bingham Plastic model (BP):

The Bingham equation is $\tau = \tau_o + \eta\gamma$ **(1)**

According to Bingham (1922) and mentioned by Pastor *et al.* (1996) and Ibarz *et al.*(1996 a,b).

IPC Paste Analysis model:

$$\eta = k`R^{`S} \quad \textbf{(2)}$$

As mentioned by Sharoba (1999) and El-Mansy *et al.* (2000 a,b).

Power law model (PL):

The power law equation is $\tau = k\,\gamma^n$ **(3)**

As mentioned by Pastor *et al.* (1996) and Sharoba (2004).

Casson model (CA):

$$(\tau)^{0.5} = (\tau_{0CA})^{0.5} + (\eta_{CA} \cdot \dot{\gamma})^{0.5} \quad \textbf{(4)}$$

As mentioned by Pastor *et al.* (1996) and Sharoba (2004).

Activation energy and the effect of temperature on viscosity:

Activation energy was calculated using Arrhenius-type equation as mentioned by Ibarz *et al.* (1996 a), El-Mansy *et al.* (2000 a,b) and Sharoba (2004):

$$\eta = \eta_\infty \exp (E_a/RT) \quad \textbf{(5)}$$

where: η is the viscosity, η_∞ is a constant (is the viscosity at infinite temperature), E_a is the activation energy of flows (J/mol), **R** is the gas constant and **T** is the absolute temperature in °K.

2.3. Sensory evaluation:

Sensory evaluations were carried out in a standardized test room in morning sessions (11:00-13:00 h) by a 20 trained sensory panel. Nectars were prepared the day before serving and stored in the refrigerator. Samples were presented at room temperature (≈ 25°C) in glasses containing 30 ml solution and coded with three digit numbers. Nectars were then assessed on texture (mouth feel), color, taste, flavor (odor) and overall acceptance. Mineral water was used by the panelists to rinse the mouth between samples, according to Pastor *et al.* (1996).

2.4. Statistical analysis:

Data for the sensory evaluation of all papaya preparations were subjected to the analysis of variance followed by multiple comparisons using (L.S.D) analysis according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

3.1. Physicochemical Properties of Papaya Puree and Mango Puree:

The results of the physico-chemical characterization of mango puree and papaya puree are shown in Table (1). The values obtained for purees are similar to those reported elsewhere (Guerrero and Alzamora, 1998). Numerous reports on the chemical composition of mango purees have appeared in the literature but refer to old cultivars which are used less and less by industry. Hence, there is a need to characterize new varieties of mango, which have been utilized by the food industry for some years. These results of mango puree were in agreement with Acharya and Shah (1999).

Table (1) : Physicochemical Properties of Mango Puree and Papaya Puree

Components	Mango Puree	Papaya Puree
Moisture%	81.1848±0.4936	87.1002±0.0805
Total Solids%	18.8152	12.8998
Total Soluble Solids °Brix	16.200±0.0000	11.867±0.0033
Fat%	0.4245±0.0530	0.5057±0.0043
Protein%	0.9088±0.0017	0.7585±0.0022
Ash%	0.6295±0.0084	0.7463±0.0098
pH values	4.84±0.0058	5.51±0.0100
Titratable acidity%	0.2619±0.0014	0.1184±0.0002
Ascorbic acid mg/100g	14.8054±0.0411	93.0937±0.4775
Starch%	0.3523±0.0028	0.5908±0.0071
Total Sugars%	11.1758±0.1143	7.1188±0.0066
Reducing Sugars%	1.8714±0.0253	2.8808±0.0197
Non Reducing Sugars%	9.3044±0.0893	4.2380±0.0263
Total Pectin%	2.3838±0.0207	1.9256±0.0082
Water Soluble Pectin%	0.9953±0.0075	0.8751±0.0034
Ammonium Oxalate Soluble Pectin%	0.7014±0.0031	0.6217±0.0019
Protopectin%	0.6871±0.0011	0.4288±0.0006
Crude Fiber%	0.9273±0.0024	1.1986±0.0077
Pulp Content (V/V)%	45.1987±1.1123	53.4274±0.4188
Color index (O.D. at 420 nm)	0.286±0.0018	0.274±0.0009
Carotenoids (mg/L)	20.904±0.0458	22.602±0.0409
Anthocyanine (O.D.)	0.0101±0.0005	0.0125±0.0003
Specific heat (C_p) (kJ/kg K)	3.3587±0.0023	3.5518±0.0014
Density at temperature 5°C (kg/m^3)	1072.88±0.0040	1039.80±0.0085
Density at temperature 25°C (kg/m^3)	1064.29±0.0089	1032.15±0.0056
Water activity (A_w)	0.9127 ± 0.0020	0.9547 ± 0.0020
Refractive index (R I)	1.3574 ± 0.0000	1.3509 ± 0.0033

Each value is the average of three replicates ± S.E. (on wet weight basis)

The importance of determining the density is that it contributes with viscosity and their values are used in calculation of the Reynolds number (Re) as follows:

$$\text{Reynolds number (Re)} = d.v.\rho/\eta$$

which is the most important in calculation of friction loss, pressure drop and pump sizing. Also density, specific heat and thermal conductivity (λ) can be used to estimate the thermal diffusivity (α) which in turn is essential to calculate Prandtl number

$$\text{Thermal diffusivity } (\alpha) = \lambda/\rho C_p$$

$$\text{Prandtl number (Pr)} = \upsilon/\alpha$$

Water activity is the major factor that influence the keeping quality or storability of fruits puree and nectars.

3.2. Sensory properties of mango and papaya nectar blends:

Blending of fruit nectars could be an economic requisite and also needed to improve the appearance, nutrition and flavor. Sensory evaluation is generally the final guide of the quality from the consumer's point of view. Thus, it is beneficial to make a comparison between the nectars blends, which were applied, also organoleptic parameters, indicate the possibility of nectar for acceptability. Consistency, color, taste, odor and overall acceptability of different papaya and mango nectars blends were organoleptically evaluated, the results are presented in Table (2) and Fig.(1). Significant differences among the 10 tested nectars. Regarding the consistency of papaya and mango nectars, results in Table (2) reflect that the consistency of nectars (P10% +M90%) and (P20% +M80%) had the highest scores compared with the other nectars.

Table (2): Sensory Properties of Mango and Papaya Nectar Blends

Products (Nectar blends)	Sensory attributes				
	Consistency (Texture) (25)	Color (25)	Taste (25)	Odor (25)	Overall acceptability (100)
Mango nectar	$21.91^{abc}\pm0.311$	$21.57^{cd}\pm0.401$	$21.58^{b}\pm0.55$	$21.02^{bc}\pm0.299$	$90.07^{ab}\pm1.57$
P10 +M 90%	$22.45^{ab}\pm0.407$	$23.50^{a}\pm0.344$	$23.35^{a}\pm0.39$	$23.30^{a}\pm0.317$	$93.00^{a}\pm1.28$
P20 +M 80%	$22.80^{a}\pm0.367$	$23.25^{a}\pm0.403$	$23.40^{a}\pm0.39$	$23.25^{a}\pm0.390$	$93.10^{a}\pm1.30$
P30 +M 70%	$22.25^{ab}\pm0.339$	$22.95^{ab}\pm0.359$	$21.50^{bc}\pm0.49$	$22.10^{ab}\pm0.475$	$90.00^{ab}\pm1.06$
P40 +M 60%	$21.50^{bcd}\pm0.380$	$22.00^{bc}\pm0.355$	$21.10^{bc}\pm0.55$	$20.95^{bc}\pm0.489$	$87.70^{bc}\pm1.08$
P50 +M 50%	$20.85^{cde}\pm0.379$	$21.55^{cd}\pm0.387$	$20.85^{bcd}\pm0.48$	$20.35^{cd}\pm0.634$	$84.65^{cd}\pm1.49$
P60 +M 40%	$20.00^{e}\pm0.391$	$21.05^{cde}\pm0.352$	$20.20^{cde}\pm0.51$	$19.60^{cd}\pm0.596$	$82.40^{de}\pm1.51$
P70 +M 30%	$20.30^{de}\pm0.539$	$20.65^{de}\pm0.437$	$19.65^{de}\pm0.45$	$19.05^{de}\pm0.564$	$80.80^{def}\pm1.67$
P80 +M 20%	$20.15^{e}\pm0.539$	$20.25^{e}\pm0.528$	$19.25^{ef}\pm0.58$	$17.60^{ef}\pm0.596$	$79.05^{ef}\pm1.99$
P90 +M 10%	$19.05^{f}\pm0.613$	$19.75^{f}\pm0.598$	$18.15^{f}\pm0.58$	$17.10^{f}\pm0.680$	$77.05^{f}\pm2.17$
L.S .D at P<0.05	**1.24**	**1.18**	**1.37**	**1.49**	**4.29**

Values represent of 20 panelists (Mean $\pm$S.E.)

a, b, c There is no significant difference ($p\geq0.05$) between any two averages of different nectar blends have the same superscripts, within the same acceptaptability attribute.

Generally the higher scores in all attributes were for papaya and mango nectars (P10% +M90%) and (P20% +M80%), and the lower scores in all attributes were for nectars (P80% +M20%) and (P90% +M10%). Also the blends (P10% +M90%) and (P20% +M80%) were recorded as excellent with consistency, color, taste, odor and overall acceptability. The means increased by increasing the percentage of mango. So, in conclusion, results for papaya and mango nectar blends appeared that the nectars blends containing more mangos puree had the higher score in all attributes. These results were agreed with Mostafa *et al.* (1997) they found increasing mango percentage enhanced the means of all properties.

Rheological behavior of mango and papaya puree at different temperatures:

Viscosity is usually considered an important property related to the quality of food products. Viscometric data are also essential for the design evaluation of food processing equipment such as pumps, piping, heat exchangers, evaporators, sterilizers filters and mixtures. Table (3) lists the magnitudes parameters of Bingham (BP) model, Power law (PL) model, IPC Paste model and Casson (CA) model for mango and papaya purees at all assay temperatures. All parameters decreased with temperature increasing.

The τ_{0BP} and τ_{0CA} values: The τ_{0BP} for mango puree and papaya puree decreased with temperature increasing. It was 7.59 Pa at 5 °C and decreased to 3.43 Pa at 100 °C. The same results were obtained also by using Casson model. The yield stress τ_{0CA} values for CA model were lower than those obtained by BP model for mango puree and papaya puree. The yield stress values dependence of fruit puree A_w, it were higher at the highest A_w value. Guerrero and Alzamora (1998) reported the same results.

The flow index values (n) for the mango puree and papaya puree given in Table (3) were less than one indicating that the rheological behavior is non-Newtonian fluid. On the other hand, the flow index values for mango puree (n) ranged between 0.18 to 0.31, while n for papaya puree ranged between 0.30 to 0.40. These results indicated that mango and papaya puree behaved as a non-Newtonian fluids (pseudoplastic fluid). The flow index values decreased with increasing total solids and pectin content, same results also obtained by Abd El-Salam (1999); El-Mansy *et al.*(2000b). The PL model equation was found a good model to describe the flow behavior of puree. These results were in agreement with Saravacos and Kostaropoulos (1995) who reported that most fruit and vegetable fluids and pastes are pseudoplastic, where the flow behavior index varies between 0 and 1.

The consistency index (k) values decreased with increasing temperature. It were 25610, 15194, 8663, 5582 and 3115 mPa.s^n for papaya puree and 8996, 7621, 7390, 5660 and 4299 mPa.s^n for mango puree at temperature 0, 20, 40, 60 and 100 °C, respectively. The consistency index decreases sharply at higher temperatures.
η_{BP}, η_{CA} and η_{10} values decreased with increasing temperature while shear sensitivity factor increased with increasing temperature.

The rheological parameters of mango puree exhibited much lower values than papaya puree in all parameters. The confidence of all models (%) was higher than (95.1%) and the confidence of PL and IPC Paste models were equal at all temperature.

Rheological behavior of mango and papaya nectar:

The rheological properties of fluid foods are key parameters required to solve food industry problems in numerous areas: quality control, evaluation of consumer acceptance or texture. Regarding the flow data fitted to the power law model in all cases the confidence of model (%) was higher than 95% in all cases. Thus the power law model is the best fitted experimental data for these nectars.

Yield stress: the τ_{0BP} and τ_{0CA} values ranged between 6.70 to 3.19 mPa and 6.01 to 2.93 mPa, respectively, for papaya nectars while the τ_{0BP} and τ_{0CA}

values for mango nectar ranged between 6.70 to 5.00 mPa and 5.94 to 4.53 mPa, respectively. Yield stress of the papaya nectar was sensitive to temperature and decreased rapidly as temperature increased.

Table (3): Rheological Parameters at Different Temperatures for Mango Puree and Papaya Puree.

Products	T (°C)	Parameters for different models											
		Bingham Plastic			Power Law			IPC Paste			Casson		
		η_{BP}	τ_{0BP}	Con. %	K	n	Con. %	η_{10}	S	Con. %	η_{CA}	τ_{0CA}	Con. %
Mango Puree	5	970.7	7.59	95.7	8996	0.31	99.3	4739	0.69	99.3	479.5	6.37	96.0
	10	854.0	7.51	98.0	8345	0.31	99.6	4062	0.69	99.6	380.2	5.68	96.5
	20	750.1	7.01	95.8	7621	0.30	98.9	3842	0.70	98.9	330.4	5.07	95.7
	30	715.4	6.84	95.9	7536	0.27	98.9	3685	0.73	98.9	305.5	4.67	95.7
	40	689.6	6.35	97.2	7390	0.25	97.7	3547	0.75	97.7	288.7	4.57	97.6
	50	660.5	5.29	98.2	6597	0.25	98.2	2867	0.75	98.2	279.4	3.49	95.7
	60	595.3	4.90	95.5	5660	0.25	98.5	2692	0.75	98.5	263.9	3.52	99.1
	70	537	4.79	95.7	5484	0.21	99.1	2310	0.79	99.1	247.3	3.17	95.9
	80	535.1	4.50	96.6	5318	0.21	97.3	2228	0.79	97.3	246.5	2.94	95.4
	90	513.1	3.67	95.4	4512	0.20	98.8	2170	0.81	98.8	165.3	2.28	95.3
	100	412.2	3.43	97.6	4299	0.18	98.0	2078	0.83	98.0	124.5	2.09	98.0
Papaya Puree	5	2642	22.0	97.3	25610	0.40	97.5	14102	0.60	97.5	1365	13.6	98.0
	10	1888	19.9	95.9	22444	0.39	99.7	12031	0.61	99.7	887.1	13.2	97.6
	20	1668	13.7	95.2	15194	0.38	98.9	8595	0.62	98.9	866.1	8.2	98.0
	30	1442	8.05	96.6	10246	0.38	99.2	5839	0.62	99.2	803.7	4.57	97.4
	40	1216	6.60	99.7	8663	0.37	98.2	4808	0.64	98.2	632.7	3.96	98.5
	50	854.8	5.63	97.2	7208	0.36	98.0	3891	0.64	98.0	407.6	3.64	99.3
	60	654.6	3.49	95.5	5582	0.36	99.4	2560	0.65	99.4	340.9	2.09	98.9
	70	634.4	3.33	95.2	4421	0.35	98.2	2448	0.65	98.2	326.9	2.01	97.8
	80	571.9	2.56	95.2	3177	0.33	95.1	1972	0.67	95.1	367	1.68	98.4
	90	462.1	2.56	96.0	3262	0.32	97.5	1857	0.68	97.5	255.4	1.76	98.1
	100	443.4	2.53	95.9	3115	0.30	96.7	1795	0.70	96.7	247.7	1.40	95.7

Flow index values ranged between 0.12 to 0.07 for mango nectar and between 0.15 to 0.07 for papaya nectar. All these values indicated the pseudoplasticity of the analyzed fruit nectars. In general, the flow index of fruit nectars were related to temperature. Increasing temperature led to decrease the n values slightly. These values are in agreement with those previously reported (Guerrero and Alzamora, 1998).

The consistency index decreased sharply at higher temperatures. Decrease in K with increased temperature has been commonly reported by researchers (Ibarz *et al.,* 1995 and 1996 a,b) who reported that temperature was found to have a large effect on the consistency index but with a little effect on the flow behavior index

Table (4): Rheological Parameters at Different Temperatures for Mango and Papaya Nectar

Products	T (ºC)	Parameters for different models											
		Bingham Plastic			Power Law			IPC Paste			Casson		
		η_{BP}	τ_{0BP}	Con. %	K	n	Con. %	η_{10}	S	Con. %	η_{CA}	τ_{0CA}	Con. %
Mango Nectar	5	31.0	6.70	97.6	5778	0.12	97.7	576.1	0.89	97.7	5.99	5.94	97.3
	10	30.3	6.55	97.7	5671	0.12	97.4	562.8	0.90	97.4	5.78	5.82	97.4
	20	24.4	6.36	98.4	5551	0.11	96.9	534.7	0.91	96.9	4.84	5.74	98.3
	30	23.3	6.17	98.6	5500	0.10	97.3	514.9	0.92	97.3	4.60	5.64	98.3
	40	22.7	5.97	97.9	5371	0.09	97.7	503.0	0.92	97.7	4.11	5.46	98.7
	50	21.2	5.79	97.1	5128	0.09	97.8	492.4	0.94	97.8	3.98	5.22	98.4
	60	20.6	5.72	98.7	5107	0.08	97.8	479.4	0.94	97.8	3.52	5.23	98.7
	70	19.2	5.50	99.9	4919	0.08	95.6	463.6	0.96	95.6	2.72	5.00	97.1
	80	18.5	5.15	95.7	4660	0.08	97.2	435.2	0.95	97.2	2.66	4.71	97.1
	90	16.2	5.11	95.8	4436	0.08	96.2	432.8	0.96	96.2	2.64	4.66	98.9
	100	15.4	5.00	96.7	4295	0.07	95.7	425.5	0.96	95.7	2.44	4.53	99.0
Papaya Nectar	5	27.9	6.70	98.4	5832	0.15	96.9	569.6	0.87	96.9	7.10	6.01	99.5
	10	25.2	6.55	98.2	5827	0.13	97.8	540.9	0.88	97.8	6.90	6.01	99.2
	20	22.8	6.03	99.5	5280	0.11	96.9	507.8	0.89	96.9	5.24	5.43	95.1
	30	22.8	5.60	99.4	4801	0.10	95.1	474.4	0.90	95.1	4.60	4.97	98.5
	40	19.4	5.48	99.2	4791	0.09	96.8	459.0	0.91	96.8	4.68	4.95	99.4
	50	17.9	4.81	96.2	4390	0.09	98.1	400.0	0.91	98.1	3.95	4.44	98.0
	60	16.1	4.32	98.9	3940	0.08	96.6	362.3	0.92	96.6	3.88	3.96	97.1
	70	15.9	3.84	98.2	3408	0.09	97.2	326.3	0.92	97.2	3.25	3.46	99.8
	80	15.2	3.53	99.0	3162	0.09	97.3	300.6	0.92	97.3	3.08	3.19	97.6
	90	12.2	3.38	99.2	3024	0.08	97.5	283.2	0.93	97.5	3.06	3.08	96.5
	100	10.6	3.19	98.7	2886	0.07	96.7	265.2	0.93	96.7	2.91	2.93	96.3

Rheological Parameters of Mango and Papaya Nectar Blends:

Measurements of rheological parameters of nectar blends were not found in the literature. In this part the rheological behavior were studied at different industrial temperatures for different blends. Mango and papaya nectars blends showed non-Newtonian fluids characters. It showed plastic behavior at all assayed temperatures. In “plastic materials” the apparent viscosity decrease as the rate of shear at which the material is tested increase. This plastic behavior is the result of a complex interaction among the pulp, soluble pectin, organic acids and soluble solids. The viscosity curve exhibited shear thinning (Structure viscous) behavior: the viscosity η fall with increasing shear rate.

The experimental values of shear stress τ in mPa and shear rate $\dot{\gamma}$ in s^{-1} have been fitted by equations (1-4). η_{BP}, τ_{0BP}, K, n, η_{10}, S, η_{CA}, τ_{0CA} were calculated, using Brookfield Software Rheocalc version (1.1), and tabulated in Table (5) .

Table (5): Rheological Parameters of Papaya and Mango Nectar Blends.

(Nectar Blends)	T (°C)	Parameters for different models											
		Bingham Plastic			Power Law			IPC Paste			Casson		
		η_{BP}	τ_{0BP}	Con. %	K	n	Con. %	η_{10}	S	Con. %	η_{CA}	τ_{0CA}	Con. %
P10 +M 90%	5	23.9	6.08	98.2	5282	0.19	97.5	516.6	0.90	97.5	6.53	5.45	98.3
	10	24.7	6.06	97.5	5147	0.18	99.1	514.4	0.89	99.1	5.99	5.37	97.5
	20	20.1	5.93	97.7	5106	0.16	99.3	495.2	0.90	99.3	5.62	5.34	96.2
	30	29.4	4.30	98.3	3497	0.15	99.3	388.0	0.91	99.3	5.53	4.60	96.9
	40	28.3	4.20	99.0	3488	0.14	98.5	378.7	0.91	98.5	5.09	4.56	94.8
	50	25.5	4.06	99.3	3403	0.13	99.5	371.3	0.92	99.5	5.02	3.92	95.0
	60	58.5	3.88	98.6	3322	0.12	98.0	362.7	0.93	98.0	4.70	3.48	97.9
	70	20.7	3.41	97.8	3304	0.12	96.0	339.4	0.93	96.0	4.11	3.40	98.0
	80	19.2	3.24	96.5	2890	0.11	98.4	247.1	0.95	98.4	3.70	3.09	97.0
	90	15.23	2.93	98.9	2565	0.10	99.3	234.6	0.95	99.3	3.58	2.71	96.8
	100	14.65	2.68	98.9	2376	0.10	99.0	216.7	0.95	99.0	3.61	2.48	96.7
P20 +M 80%	5	24.5	5.57	98.9	4894	0.17	99.5	472.0	0.89	99.5	5.23	4.85	96.3
	10	22.3	5.53	98.3	4807	0.17	98.9	465.6	0.90	98.9	4.10	4.47	98.4
	20	21.7	5.34	97.9	4738	0.15	99.7	455.2	0.91	99.7	4.00	4.13	95.1
	30	21.0	5.21	97.5	4508	0.14	99.2	441.6	0.93	99.2	3.76	4.06	98.4
	40	20.2	4.91	98.0	4269	0.13	99.1	415.7	0.94	99.1	3.59	3.95	96.2
	50	20.2	4.83	98.3	4285	0.12	97.3	405.2	0.96	97.3	3.48	3.79	95.5
	60	19.5	4.29	98.1	3664	0.11	99.3	369.8	0.99	99.3	3.37	3.78	98.6
	70	18.6	4.02	98.3	3430	0.12	98.1	350.0	0.98	98.1	3.12	3.54	97.7
	80	17.7	3.85	97.3	3303	0.11	98.9	339.0	0.99	98.9	3.07	3.41	98.4
	90	17.4	3.84	99.4	3281	0.11	99.0	332.9	1.02	99.0	3.03	3.38	98.9
	100	17.2	3.66	98.7	3166	0.11	98.8	317.2	1.04	98.8	3.01	3.25	95.4
P30 +M 70%	5	24.1	5.38	97.1	4600	0.14	99.2	460.6	0.89	99.2	6.86	4.77	96.4
	10	24.0	5.28	96.9	4504	0.13	99.0	452.7	0.89	99.0	5.93	4.67	96.2
	20	24.0	5.10	97.4	4349	0.13	96.7	439.4	0.89	96.7	5.05	4.49	94.3
	30	23.7	4.83	96.5	4070	0.12	98.6	420.0	0.91	98.6	5.00	4.21	97.7
	40	22.4	4.58	98.9	3920	0.11	97.0	395.7	0.91	97.0	4.89	4.02	98.9
	50	21.3	4.49	97.2	3863	0.09	97.8	382.5	0.91	97.8	4.83	4.04	96.4
	60	20.7	4.24	94.7	3734	0.10	97.2	366.7	0.93	97.2	4.16	3.79	96.8
	70	19.6	4.05	96.4	3442	0.10	97.1	355.5	0.94	97.1	4.09	3.53	98.1
	80	17.5	4.01	97.9	3421	0.10	99.1	348.6	0.95	99.1	3.79	3.53	98.5
	90	16.5	3.83	96.7	3278	0.09	98.0	335.0	0.99	98.0	3.57	3.36	98.5
	100	15.7	3.78	97.9	3241	0.09	98.3	331.3	0.99	98.3	3.16	3.31	98.8

Table (5) Cont.

Nectar Blends	T (ºC)	Parameters for different models											
		Bingham Plastic			Power Law			IPC Paste			Casson		
		η_{BP}	τ_{0BP}	Con. %	K	n	Con. %	η_{10}	S	Con. %	η_{CA}	τ_{0CA}	Con. %
P40 +M 60%	5	28.7	5.79	95.7	4950	0.14	97.1	490.2	0.90	97.1	6.53	5.16	96.9
	10	25.0	5.70	97.3	4939	0.14	99.8	480.5	0.90	99.8	6.10	5.12	97.2
	20	24.5	5.48	99.1	4552	0.13	98.9	469.4	0.92	98.9	5.42	4.78	98.0
	30	24.4	5.24	97.6	4525	0.12	98.3	447.7	0.94	98.3	4.57	4.67	98.6
	40	23.2	4.91	98.7	4222	0.12	99.4	426.0	0.94	99.4	4.26	4.32	97.9
	50	23.1	4.68	97.7	3952	0.12	99.7	415.6	0.97	99.7	4.18	4.03	95.2
	60	22.8	4.62	95.6	3917	0.12	99.3	402.6	0.98	99.3	4.11	4.04	96.9
	70	21.5	4.50	97.4	3814	0.12	99.9	390.7	0.99	99.9	4.05	3.93	97.1
	80	19.5	4.20	95.1	3530	0.12	99.2	361.2	1.04	99.2	3.85	3.69	98.7
	90	19.2	4.09	97.1	3471	0.11	96.9	353.6	1.07	96.9	3.75	3.60	98.5
	100	17.8	4.03	98.9	3441	0.11	96.0	346.7	1.08	96.0	3.52	3.57	98.2
P50 +M 50%	5	25.2	5.81	96.2	4983	0.12	99.0	490.2	0.89	99.0	5.68	5.14	97.9
	10	22.4	5.70	97.1	4958	0.12	97.2	479.6	0.91	97.2	5.03	5.13	97.4
	20	21.0	5.57	97.1	4924	0.11	99.1	466.5	0.93	99.1	4.68	5.13	99.9
	30	20.8	5.55	98.1	4898	0.11	99.9	462.9	0.95	99.9	4.39	5.05	95.1
	40	20.1	5.44	98.3	4842	0.10	98.4	457.6	0.95	98.4	4.13	4.95	96.7
	50	19.1	5.27	99.5	4758	0.10	99.7	445.7	0.96	99.7	3.70	4.88	95.3
	60	18.9	5.22	95.0	4542	0.09	99.0	438.1	0.97	99.0	3.57	4.72	98.8
	70	18.7	4.93	97.3	4387	0.08	99.7	411.2	0.99	99.7	3.08	4.50	98.6
	80	18.2	4.69	96.2	3995	0.09	99.1	410.1	0.99	99.1	3.03	4.37	97.7
	90	16.8	4.62	97.5	3975	0.09	96.2	388.2	1.03	96.2	2.98	4.14	98.7
	100	15.0	4.29	95.6	3746	0.09	99.3	358.7	1.07	99.3	2.97	3.87	97.5
P60 +M 40%	5	20.9	5.71	96.2	4911	0.13	99.3	475.3	0.91	99.3	5.71	5.14	96.3
	10	20.0	5.67	98.7	4860	0.11	98.0	475.0	0.91	98.0	4.76	5.12	98.0
	20	19.2	5.44	97.3	4775	0.10	97.9	460.8	0.92	97.9	4.12	4.96	97.0
	30	18.4	5.28	98.3	4720	0.10	98.4	452.0	0.92	98.4	4.19	4.91	95.2
	40	17.5	5.21	98.8	4693	0.10	99.0	442.2	0.92	99.0	4.13	4.87	96.4
	50	17.9	5.18	99.4	4619	0.09	99.3	430.2	0.93	99.3	3.98	4.80	96.6
	60	17.0	5.14	97.5	4541	0.09	97.3	428.4	0.95	97.3	3.73	4.68	95.6
	70	16.9	4.82	97.5	4263	0.09	99.4	406.1	0.95	99.4	3.51	4.36	98.3
	80	16.5	4.68	96.3	3992	0.08	99.7	401.6	0.99	99.7	3.50	4.13	97.1
	90	16.1	4.49	96.4	3903	0.08	98.4	380.6	0.99	98.4	3.43	4.02	99.9
	100	15.1	4.25	95.3	3799	0.08	99.1	352.4	0.99	99.1	3.42	3.88	97.9

Table (5) Cont.

Nectar Blends	T (°C)	Bingham Plastic			Power Law			IPC Paste			Casson		
		η_{BP}	τ_{0BP}	Con. %	K	n	Con. %	η_{10}	S	Con. %	η_{CA}	τ_{0CA}	Con. %
P70 +M 30%	5	23.2	5.46	98.5	4991	0.14	99.5	464.2	0.90	99.5	5.64	5.07	94.5
	10	22.7	5.39	98.6	4792	0.13	99.6	459.6	0.90	99.6	5.42	4.91	95.0
	20	20.3	5.33	97.0	4752	0.12	99.2	448.4	0.94	99.2	5.20	4.86	96.7
	30	20.0	5.31	97.5	4726	0.12	99.7	440.7	0.96	99.7	4.89	4.82	94.0
	40	20.1	5.23	97.9	4717	0.11	98.3	439.9	0.96	98.3	4.79	4.78	96.5
	50	18.5	5.20	96.2	4706	0.11	98.5	436.3	0.98	98.5	4.19	4.76	95.9
	60	18.1	5.09	98.4	4536	0.11	98.8	429.2	0.99	98.8	4.08	4.60	95.7
	70	17.4	5.07	97.7	4518	0.10	98.0	424.2	0.99	98.0	4.01	4.53	95.3
	80	17.3	4.89	97.7	4234	0.10	99.7	416.1	1.02	99.7	3.92	4.36	96.5
	90	17.2	4.79	98.4	4173	0.09	99.3	407.9	1.07	99.3	3.71	4.28	97.9
	100	13.6	4.50	94.7	4011	0.09	98.2	379.4	1.06	98.2	3.53	4.09	96.6
P80 +M 20%	5	23.4	6.05	97.1	5240	0.13	99.3	510.7	0.90	99.3	3.44	5.42	98.5
	10	23.0	5.94	97.5	5209	0.12	99.0	501.7	0.90	99.0	3.47	5.41	96.7
	20	20.9	5.94	96.9	5194	0.12	98.5	489.5	0.92	98.5	2.16	5.31	98.8
	30	20.3	5.75	95.8	5047	0.11	98.1	481.9	0.95	98.1	2.71	5.22	97.5
	40	19.4	5.49	96.1	4989	0.11	98.0	463.0	0.97	98.0	3.03	4.99	97.5
	50	19.0	5.43	97.1	4827	0.10	99.7	452.1	0.97	99.7	2.24	4.96	95.1
	60	17.8	5.11	97.7	4496	0.09	98.4	430.3	0.98	98.4	2.67	4.61	96.1
	70	17.4	5.02	96.6	4430	0.09	99.3	423.4	0.98	99.3	2.58	4.55	96.0
	80	17.0	4.92	97.7	4314	0.09	98.8	409.2	0.99	98.8	2.29	4.43	96.1
	90	15.6	4.88	96.6	4253	0.09	98.4	402.0	0.99	98.4	1.29	4.37	96.2
	100	12.7	4.39	97.3	3887	0.08	99.6	367.9	1.01	99.6	2.06	3.99	95.5
P90 +M 10%	5	29.6	9.06	98.2	5348	0.15	99.6	510.4	0.90	99.6	5.28	5.49	98.2
	10	29.0	6.07	97.2	5274	0.14	98.2	508.9	0.91	98.2	5.06	5.47	98.4
	20	26.6	5.63	96.8	4891	0.14	99.9	485.2	0.90	99.9	5.01	5.02	94.6
	30	24.4	5.58	97.6	4714	0.13	99.3	480.7	0.92	99.3	4.95	4.86	97.6
	40	22.9	5.52	98.7	4631	0.12	97.3	477.1	0.93	97.3	4.82	4.82	98.0
	50	22.6	5.38	97.3	4581	0.12	97.4	470.3	0.93	97.4	4.17	4.71	96.0
	60	21.7	5.16	96.4	4503	0.11	98.0	436.9	0.93	98.0	3.86	4.68	95.3
	70	18.1	5.14	97.7	4474	0.10	98.7	424.6	0.95	98.7	3.74	4.61	96.7
	80	17.6	5.02	98.1	4424	0.09	98.5	420.7	0.95	98.5	3.46	4.54	98.4
	90	17.4	4.95	96.6	4341	0.09	99.7	415.0	0.97	99.7	3.43	4.47	99.0
	100	15.1	4.84	98.5	4273	0.09	99.0	405.7	0.98	99.0	3.29	4.39	98.5

Yield stress τ_{0BP} and τ_{0CA}: The yield stress is related to the existence of a reticulated structure, which is generally due to the interaction between colloidal particles or the formation of links between the long chain molecules. Yield point τ_0 value was higher for blends that containing more papaya percent and lower for blends containing less papaya percent. The highest τ_0 value indicated that the forces of the interparticular link were greater than those of the other blends. Some authors consider that the τ_0 value in products of a similar composition is related to the factors which influence gel formation, such as pH, sugar, pulp content and pectin content (Alonso *et al.,* 1995). The "τ_0" decreased when the temperature increased for the different nectars blends under investigation.

Consistency index (K) Value was higher for nectar blend containing P90%:M10%. It ranged between 5348 to 4273 mPa.s^n at temperature ranged between 5 to 100 °C. The reason for such differences in the flow behavior constants between nectar blends might be referred to the variations in their content of mango puree, pectic substances and particles. The (K) consistency index (Pa.s^n) decreased with increasing temperature.

Flow behavior index (n) values for the nectar blends given in Table (5) were less than one indicating that the rheological behavior is pseudoplastic. The (n) values ranged between 0.07 and 0.17.

Effect of Temperature on Viscosity of Papaya and Mango Products:

The effect of temperature on the apparent viscosity can be described by the Arrhenius relationship (Giner *et al.,* 1996, and Sharoba 2004). In the case of non-Newtonian fluids, like fruit juices nectar and puree, the apparent coefficient of viscosity at a fixed shear rate is used instead of the coefficient of viscosity; for power law fluids, the consistency coefficients normally used.

The viscosity data at a shear rate at different temperatures are used in calculating the activation energy. The inverse of the absolute temperature plotted against the logarithm of viscosity permitted the verification of the application of the Arrhenius equation for fruit juices. The η_∞ and E_a parameters are determined by measuring η at several temperatures within constant shear rate. A temperatures change of just 1°C can change viscosity as much as 10% to 15%. It is essential to control the temperature of the material under test and to report the test temperature (Rizvi and Mittal, 1992).

The values η_∞ and E_a of described by Arrhenius-type. The activation energy of papaya puree and nectar were 5099.56 and 7717.97 J/mol and η_∞ were 0.4357 and 3.0989 mPa.s, respectively. On the other hand the activation energy of mango puree and nectar were 5099.59 and 3537.77 J/mol, respectively. These results are in agreement with Sharoba (1999) who found that activation energy of orange nectar and serum is higher than orange Juice. He mentioned that activation energy of flow decreased significantly when suspended particles were present in the product, as in cloudy juices and fruit puree. Also the same results and trend are agreement with Guerrero and Alzamora (1998).

Effect of Temperature on Viscosity of Papaya and Mango Nectar Blends:

The viscosity is depending upon the intermolecular distances. As the temperature is increased, the intermolecular distances increase and therefore the viscosity will decrease for these main reasons. The viscosity is a function of temperature and the dissolved solid concentration (Bayindirli, 1992). The Arrhenius equation to a great extent explains the relationship between the temperature and viscosity

The η_∞ and E_a parameters are determined by measuring η at several temperatures (5-100°C) within 10 RPM. Results presented in Table (6) and Fig.(2) showed the parameters of Arrhenius equation. The activation energy increased with increasing of mango puree in nectar but decreased with increasing of papaya puree in nectar. The activation energy E_a values were (8534.32 and 2649.34 J/mol.) for (P 10%+M 90% nectar) and (P 90%+M 10% nectar), respectively. On the other hand η_∞ factors increased with increasing of papaya puree in nectar but decreased with increasing mango puree in nectar. The η_∞ values were (2.6481 and 5.1603 mPa.s) for (P 10%+M 90% nectar and P 90%+M 10% nectar), respectively. The activation energy increased with the decreasing pulp content, pseudoplastic behavior and temperature. Therefore, temperature had a greater effect on the samples with higher pulp content. This tendency is similar to other juices (Ibarz *et al.,* 1994).

The temperature dependence of viscosity was studied using the Arrhenius relationship Eq.(5). A linear relationship of ln (η) vs. (1/T) was observed. The correlation coefficients (r) for each nectar blendes are presented in Table (6). Activation energy (E_a) ranged from 8534.32 to 2068.44 J/ mole. Activation energy indicates the sensitivity of the viscosity to the temperature change. Higher E_a means that the (P10% : M 90% nectar) viscosity is relatively more sensitive to temperature change.

Table (6): Arrhenius-Type Constsnts Relating the Effect of Temperature and Viscosity at 10 RPM on Mango and Papaya Nectar Blends

Products (Nectar Blends)	E_a (J/mol)	η_∞ (mPa.s)	Coefficient of Correlation (r)	Temperature range (°C)
P10 +M 90%	8534.32	2.6481	0.9997	5 – 100 °C
P20 +M 80%	3985.90	4.5159	0.9998	5 – 100 °C
P30 +M 70%	4233.49	4.3995	0.9994	5 – 100 °C
P40 +M 60%	2968.51	4.9155	0.9995	5 – 100 °C
P50 +M 50%	2068.44	5.3136	0.9996	5 – 100 °C
P60 +M 40%	2518.89	5.1149	0.9990	5 – 100 °C
P70 +M 30%	2201.55	5.2575	0.9998	5 – 100 °C
P80 +M 20%	2835.82	5.0410	0.9994	5 – 100 °C
P90 +M 10%	2649.34	5.1603	0.9999	5 – 100 °C

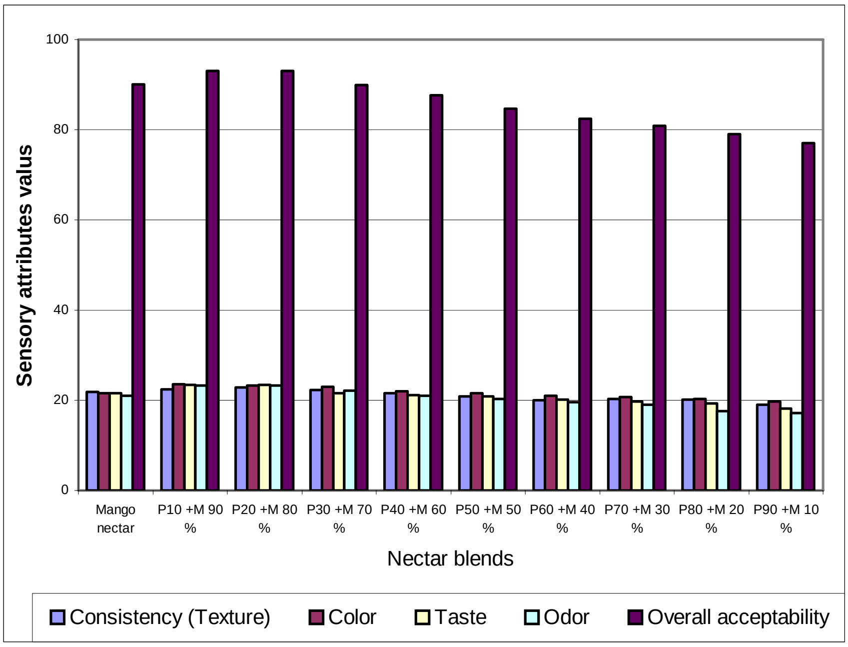

Fig. (1): Sensory Properties of Mango and Papaya Nectar Blends

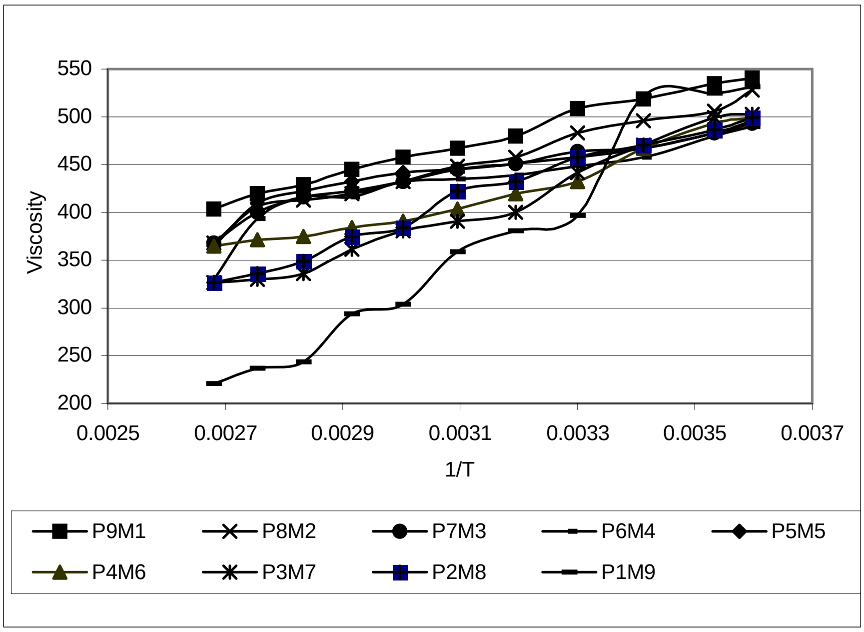

Fig. (2): Effect of Temperature on Mango and Papaya Nectar Blends

CONCLUSIONS

It was concluded that papaya, which is cheaper than mango, could be blended with mango in the preparation of purees, juices and nectars.

Within the temperature range of 5-100°C, nectar blendes investigated in this study were non-Newtonian. Data reported in the experiment should be useful for the nectar blendes processing industry. The effect of temperature on viscosity was very well correlated with the Arrhenius equation.

Sensory analysis of products indicated that nectar with M80: P20 were most acceptable to panelists.

Physico-chemical and rheological properties could then be applied to the control of composition of formulated nectars.

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