IMPROVING OF SENSORY AND RHEOLOGICAL PROPERTIES OF ARTIFICIALLY SWEETENED PAPAYA-APRICOT NECTAR WITH SOME HYDROCOLLOIDS

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ABSTRACT

Sensory and rheological properties of artificially sweetened papaya-apricot nectar (aspartame or stevioside) were improved with some hydrocolloids (guar gum, xanthan gum or arabic gum). Concentration of artificial sweeteners and hydrocolloids were 1.2 g/L and 0.5% respectively. Using artificial sweeteners instead of sugar leads to decrease the sensory properties of papaya-apricot nectar. There was no significant difference ($p>0.05$) between aspartame and stevioside. Using hydrocolloids leads to increase the sensory properties of papaya-apricot nectar. There was no significant difference ($p>0.05$) between the used hydrocolloids. Rheological behaviour of nectar samples were studied using Brokfield rotational viscometer applying Herschel-Bulkley and Bingham models at four temperatures. Yield stress, consistency coefficient, flow behavior index and apparent viscosity were obtained. They increased and decreased at using hydrocolloids or artificial sweeteners, respectively. Effect of temperature on viscosity of nectar was studied applying Arhenious equation. Activation energy increased and decreased at using hydrocolloids or artificial sweeteners, respectively. The rheological properties confirmed the sensory properties that consistency index (Herschel-Bulkley equation) or viscosity (Bingham equation) was decreased by artificial sweeteners while there were increased by hydrocolloids. The obtained results could be help in establishing of quality control programs of such artificially sweetened nectars.

Key words: Sweeteners; Hydrocolloids; papaya-apricot nectar; flow behavior; rheological characteristics, sensory evaluation**.**

Nomenclature

Symbol	Term	Unit or definition	Symbol	Term	Unit or definition
A_{TH}	Thixotropy	Pa/s	LSD	Least significant difference	-
B1 to B12	Blend nectar numbers	-	S.E.	Standard error	-
E_a	Activation energy for flow	kJ/mol	T	Temperature	K
HB	Herschel-Bulkley Model	-	t	Temperature	°C
K	Consistency index	$Pa.s^n$	τ	Shear stress	Pa
n	Flow behavior index	Dimensionless	τ_0	Yield stress	Pa
R	Gas constant	8.314 kJ/ kg mol. K	$\dot{\gamma}$	Shear rate	s^{-1}
r	Correlation coefficient	-	η	Viscosity	Pa.s
r^2	Determination coefficient	-	η_∞	Constant in eqn. (3)	Pa.s
PAN	Papaya-apricot nectar	-			

INTRODUCTION

Papaya ranks highest per serving among fruit for carotenoids, potassium, fiber, and ascorbic acid content (**Liebman, 1992 and USDA 2008**). Papaya contains 108 mg ascorbic acid per 100 g of fresh fruit, which is higher than oranges 67 mg/100 g, **Lim *et al.* (2007)**.

The papaya industry capacity is underutilized. First, fresh whole papaya fruit does not transport well; bruising due to a soft skin and a short shelf life. Fruit is often soft, wrinkled and/or bruised, significantly decreasing consumer acceptance in an environment where unblemished fruit is expected. Second, a processed papaya product that maintains its fresh flavor does not currently exist. Research on processing of papaya fruit has resulted in a sweet (non-bitter), stable product; traditional pasteurization treatment leads to cooked flavor development (**Argaiz and Lopez-Malo, 1995**). Other heat processed fruits, including apples, oranges and tomatoes, do not suffer such an extreme alteration from their fresh fruit flavor after processing. This has led to papaya products that are mixed with other fruits to dilute or mask the off-flavors (**Tiwari, 2000**).

In order to improve the cloudy stability of juices for prolonged periods, hydrocolloids have been added (**Koksoy and Kilic, 2004 and Paraskevopoulou *et al.*, 2005**).

Arabic gum is the dried gummy exudate from the stems and branches of Acacia Senegal Willdenow or of other related species of Acacia (Fam. Leguminosae) (**Dondain and Phillips, 1999**). Arabic gum is approved for use as food additives by the US Food and Drug Administration and is on the list of substances that is a generally recognized as safe (GRAS) with specific limitations (**FDA, 1974**). Gum arabic is the oldest and best known of all the tree gum exudates from certain species of Acacia, family leguminosae. The chemical and physicochemical properties of this gum can vary significantly depending on the source, tree age, time of exudation, type of storage and climatic conditions (**Islam *et al.,* 1997**).

Arabic gum is widely used in the food industry, mainly to impart desirable qualities through its influence over viscosity, body and texture. In aqueous systems, it is used as an emulsifier, stabilizer, thickener, adhesive, and to prevent crystallization of sugar and the formation of ice crystals. Other hydrocolloids are also used for these purposes (**Mothe and Raob, 1999**).

Xanthan gum has been used in a wide variety of foods for a number of important reasons, including emulsion stabilization, temperature stability, compatibility with food ingredients, and its pseudoplastic rheological properties (**Garcia-Ochoa *et al.,* 2000**).

Guar gum is used as a gelling and thickening agent in many food products such as sauces, syrups, ice cream, instant foods, beverages, and confectionaries (**Dogan *et al.,* 2007 and Miyazawa and Funazukuri, 2006**). Guar gum and its derivatives are also extensively used in various industries such as mining, paper, textile, ceramic, paint, cosmetic, pharmaceutical and explosives (**Miyazawa and Funazukuri, 2006**).

Stevia rebaudiana Bertoni, belonging to the Compositae family, is a sweet herb native to Brazil and Paraguay. Stevia sweeteners, extracts from the leaves of this herb, are commercially available in Japan, Korea, China, South-East Asia and South America, where they have been used for some decades to sweeten a variety of foods including beverages, confectionery, pickled vegetables and seafoods. Recently, stevia extracts have been extensively used as the dietary supplements in USA (**Koyama *et al.,* 2003**).

The high-intensity sweetener aspartame has been consumed in more than 6000 products by hundreds of millions of people in countries around the world (**Butchko and Stargely, 2001**). Aspartame and mixtures of aspartame + acesulfame K are used instead of sucrose to sweeten many beverages and dairy products aimed at weight-conscious consumers. Many authors have studied the sensory properties of these high intensity sweeteners, especially with respect to their aftertaste (**King *et al.,* 2003**).

In fruit juice and beverage, sensory properties and organoleptic attributes of the final products are influenced by the several factors such as type and amount of acids and sweeteners (**Mirhosseini *et al.*, 2008).**

Flow properties of fruit purees are of considerable interest in the development of fruit products for technological and marketing reasons. Together with others, they provide the information necessary for the optimum design of unit processes; contribute to the quality control in both manufacturing processes and final product; limit the acceptability and the field of application of a new product; and finally, they are a powerful tool into understanding molecular structure changes (**Mizrahi, 1979; Holdsworth, 1993 and Guerrero and Alzamora, 1998**).

Sharoba *et al.* (2007) reported that blendes of papaya and apricot nectar appear that the nectar blends containing equal percentage of papaya puree and apricot juice had the higher score in all attributes and acceptable to panelists due to better consistency and flavor.

Accordingly, this work was carried out to study improving of sensory and rheological properties of artificially sweetened papaya-apricot nectar with some hydrocolloids

MATERIALS AND METHODS

Materials:

Apricot fruits (*Prunus armeniaca*) variety Amar were picked at the ripe stage from Amar village, Qalyoubia Governorate, Egypt, during season of 2008.

Papaya fruits (*Carica papaya* L.cv. Sunrise Solo) are usually collected green mature from the farm of Moshtohor Faculty of Agric. Benha Univ., Egypt. The fruits weight ranged from g 750 to 1750 g. The fruit surface was treated by H_2O_2 5% as disinfectant. It ripened under storage at room temperature for 3-4 days.

Hydrocolloids:

- **Guar gum and Xanthan gum** were obtained from CP Kelco Germany GmbH, 23755 Grossenbrode, Germany.
- **Arabic gum** was obtained from Hortimex, 62-510 Konin, Poland.

Sweeteners:

- **Aspartame** was obtained from Hortimex, 62-510 Konin, Poland.
- **Stevioside** was obtained from Jining Yunhe Stevioside Co., Ltd, Shandong, China.

Methods:

Processing:

Preparation of papaya-apricot nectar samples:

The papaya puree and apricot juice (1:1) were mixed together as recommended by **Sharoba *et al.* (2007)**. This mixture was used to prepare the formulas indicated in Table (A). Nectars pH was adjusted to

3.5 by adding citric acid solution (50% w/v), (**Tressler and Joslyn, 1971 and Brekke *et al.*, 1976**).

Sensory evaluation

Sensory evaluation was carried out by a properly well trained panel of 12 panelists. They were selected if their individual scores in 10 different tests showed a reproducibility of 90%. The 12 members internal panel evaluated the different papaya and apricot nectar blends for color, texture, taste, flavor, mouthfeel (smoothness, consistency, spread ability) and overall acceptability. Mineral water was used by the panelists to rinse the mouth between samples, according to **Onweluzo *et al.* (1999).**

The sensory evaluation of papaya-apricot nectar was carried out at two phases. The first phase was done to select the best concentration of adding each hydrocolloids or sweeteners in papaya-apricot nectar. The second phase was done to know the best blends of hydrocolloids and sweeteners in papaya-apricot nectar.

Rheological measurements:

Viscosity measurement was carried out by the Brookfield Digital Viscometer Model DV-II+ (USA) 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 Brookfield small sample adapter spindle was used. Data was analyzed by using Universal Software US200, Physica, Germany. Herschel-Bulkley and Bingham plastic math models provide a numerically and graphically analyze the behavior of data sets.

Herschel-Bulkley model describes the flow curve of a material with a yield stress and shear thinning or shear thickening behavior at stresses above the yield to calculate the viscosity and yield point of ideal-viscous fluids.

$$\tau = \tau_{OHB} + K\,\dot{\gamma}^{n} \qquad (1)$$

where:

τ =Shear stress (Pa), τ_{OHB}=Yield stress, shear stress at zero shear rate (Pa), **K** = Consistency index (Pa.s^n), $\dot{\gamma}$ = Shear rate (sec^{-1}), n = Flow index (dimensionless)

The calculated parameters for this model are: Herschel-Bulkley yield stress (τ_{OHB}**),** Consistency index (K) and Flow index (n).

Bingham Plastic: The Bingham equation is

$$\tau = \tau_{OB} + \eta_B\,\dot{\gamma} \qquad (2)$$

where:

τ = Shear stress (Pa), τ_{OB}=Yield stress, shear stress at zero shear rate (Pa), η_B = Plastic viscosity (Pa.s), $\dot{\gamma}$ = Shear rate (sec^{-1})

The calculated parameters for this model are: Plastic (apparent) viscosity (η_B) and Bingham yield stress (τ_{OB}).

The effect of temperature on viscosity and flow activation energy:
Activation energy was calculated using Arrhenius-type equation as mentioned by **El-Mansy *et al.* (2000 a, b)**:

$$\eta = \eta_\infty \exp (E_a / RT) \qquad (3)$$

Where η is the viscosity, η_∞ is a constant, E_a is the activation energy of flow (J/mol) R is the gas constant, and T is the absolute temperature in K.

Thixotropic area: thixotropic area calculates the area between two curves, commonly the up and down curves of a shear rate sweep (the gab area between the ascending and descending rheogram curves). This area is given in ($Pa.s^{-1}$) and is often used as a measure of a sample's thixotropy. Also the thixotropic area is a measure for the destruction (viscosity decrease at thixotropic samples) or construction (at rheopectic samples) of structures at inclining and declining load.

Statistical analysis:

Data for the sensory evaluation of all nectar preparations were subjected to the analysis of variance (ANOVA) followed by multiple comparisons using least significant difference, ($L.S.D._{0.05}$) (**Gomez and Gomez, 1984).**

RESULTS AND DISCUSSION

Selection of the best concentration of hydrocolloids and sweeteners:

Many samples of papaya-apricot nectars, in preliminary experiment were prepared containing different concentrations of guar gum, xanthan gum and arabic gum as hydrocolloids and aspartame and stevioside as sweeteners. Each additive was added alone in papaya-apricot nectar. All samples of papaya-apricot nectar were subjected for sensory evaluation to know the best concentration of additives had high acceptability in sensory attributes. The concentration of additives which had high score in sensory evaluation was used for preparing finished papaya-apricot nectars samples which were used to complete this study.

Effect of mixing some sweeteners and hydrocolloids blends in sensory properties of apricot-papaya nectar:

In this study we used (aspartame and stevioside) to produce low-calorie fruit nectars. Aspartame has a clean, sugar-like taste, enhances fruit and can be safely used under heat with some loss of sweetness at higher temperatures. It is primarily responsible for the growth of the low-calorie and reduced-calorie product market in the past two decades and is today an important component of thousands of foods and beverages. Because aspartame helps impart a good, sweet-tasting flavor to low-calorie and reduced-calorie foods and beverages, it is helpful to diabetics and beneficial in weight control by managing caloric intake while still maintaining a healthful diet. In the other hand stevioside is a low-calorie sweetener derived from *Stevia rebaudiana*, is 300 times sweeter than sucrose. The plant leaves have been used for centuries in Paraguay to sweeten bitter beverages and to make tea. Stevioside is highly soluble in water, very sweet in taste, and synergistic with other sweeteners (**Saulo, 2005**).

Color, texture, taste, flavor, mouthfeel and overall acceptability of papaya-apricot nectar with different blends of sweetness and hydrocolloid were organoleptically evaluated, the results are indicated in Table (1).

Non tabulated results for sensory evaluation of papaya-apricot nectar indicated that the best percentage additive of hydrocolloids for enhanced the texture of nectar was 0.5% for either guar, arabic or xanthan gum. Concerning for sweeteners, the best percentage additive of sweeteners was 1.2 g/L for either aspartame or stevoside. Nearly, the acceptable percentages of adding hydrocolloids and sweeteners were in agreement with those obtained by **Askar and El-Zoghbi (1991)**, **Matysiak and Noble (1991) and Pastor *et al.* (1996)** whom were used hydrocolloids and sweeteners in other fruits and vegetables products. So, samples of papaya-apricot nectar were prepared containing each acceptable percentage of hydrocolloids and sweeteners or blends of some of them.

Sensory evaluation of papaya-apricot nectar:

Data in Table (1) indicated that papaya-apricot nectar containing guar gum, xanthan gum or arabic gum had high score in overall acceptability. All papaya-apricot nectar containing hydrocolloids were acceptable more than control papaya-apricot nectar which is free from hydrocolloids. Also statistical analysis of overall acceptability data indicated that it could divide the different papaya- apricot nectar blends into three groups. Group one, mentioned before and had superscript letter "a", contained hydrocolloid only and had the highest scores (93.18 - 96.14). Second group, had superscript letter between "b to d", included control blend and blends contained hydrocolloid with sweetener. The overall acceptability scores of this group ranged between 81.17 and 88.17. Third group had superscript "e", included blends containing

sweetener only. This group had the lowest scores (69.10 and 71.16) Mouth feel is important property in sensory evaluation. Data in Table (1) indicated that all nectar samples can divide to two groups. First group had superscript letter "a", included control nectar sample and nectars containing any hydrocolloid without artificial sweetener. Second group, had superscript letter "b", and included other nectars containing hydrocolloid with sweetener or sweetener only. Color, texture, taste and flavor scores of artificially sweetened blends were the lowest scores. The scores of these parameters were improved by adding any hydrocolloid so, it could recommend to use hydrocolloid when prepare nectar fruits either naturally or artificially sweetened.

Selection of rheology models:

Nindo *et al.* (2007) mentioned that choice of an appropriate model to relate product viscosity to brix number and shear rate depends essentially on the intended application and use of a suitable instrument to determine the model parameters. During experiments, laminar flow conditions are necessary for accurate measurements; and for fruit purees containing particles with nonuniform sizes and shapes, stability may sometimes be difficult to achieve at either very low or high shear rates. At high shear rates, turbulent flow conditions are likely to be induced by the dispersed particles, resulting in structural breakdown of the sample. Even with these complexities, most purees generally exhibit non-Newtonian flow patterns. Therefore, the non-Newtonian models in Eqs. (1)–(2) were considered for their suitability in describing the flow of papaya-apricot nectar. The Herschel-Bulkley model has been used extensively in studies on handling and heating/cooling of foods because it gives good description of fluid flow behavior in the shear rate range that is easily measured by most rheological instruments.

Most fruit purees and nectars show shear-thinning behavior ($0<n<1$), a situation that may be regarded as an indication of breakdown of structural units in a food due to the hydrodynamic forces generated during shear (**Rao, 1999**). Quantification of flow parameters within some defined shear rate ranges may be a good way of studying these changes in product structure. If the foodstuff has a finite yield stress, the yield term can be included in the Power Law model to yield the Herschel-Bulkley (HB) model: The yield stress can be determined experimentally, graphically as explained by **Steffe (1996)**, or calculated by a separate model.

The HB model is convenient because Newtonian, Power law and Bingham Fluids can be considered as special cases obeying this generalized model (**Ditchfield *et al.*, 2004**). However, the yield stress obtained by fitting the three parameter HB model is strongly dependent on the selected shear rate range (**Steffe, 1996**).

The Correlation coefficients was used to determine how good the models fit the data. Based on Correlation coefficients and overall suitability of the models considered, the Herschel-Bulkley and Bingham models were selected to describe the rheological behavior of papaya-apricot nectar samples.

Effect of mixing some hydrocolloids and sweeteners blends on rheological characterisation of apricot-papaya nectar:

The rheological behavior of hydrocolloids is special importance when they are used to modify flow behavior. It is also, well recognized that rheological properties play a role in process design, evaluation and modeling. These properties are sometimes measured as an indicator of product quality (e.g. indication of total solids or change in molecular size). Rheological data are required for calculation in any process involving fluid flow (e.g. pump sizing, extraction, filtration, extrusion and purification) and play an important role in the analyses of flow conditions in food processes such as pasteurization, evaporation, drying and aseptic processing.

In this study three hydrocolloids (guar gum, xanthan gum and arabic gum) were used in papaya-apricot nectar due to improve the rheological properties.

Share rate–share stress curves (recorded by Brookfield Digital Viscometer) and data in Tables (2 and 3) for nectar samples showed non-Newtonian pseudoplastic with yield stress fluids as the apparent viscosity decreases with increasing shear rate, therefore they exhibit a shear-thinning behavior.

Several models have been used to characterize the flow behavior of papaya-apricot nectars mixed with gums and sweeteners and among them Herschel-Bulkley model has been frequently used for the determination of rheological properties of the fruit juices and nectars. In addition, Bingham model has been also used for the characterization of fluid foods such as fruit juices and nectars.

The parameters obtained for the Herschel-Bulkely and Bingham models are summarized in Tables (2 and 3). The correlation coefficients, for all cases, were higher than 0.964. Higher measure temperatures showed slightly lower values (K, η_B τ_{0HB} and τ_{0B}), this trend of results are in according to **Steffe (1996) and Marcotte *et al.* (2001)**.

Higher yield stress values were observed due to addition of gums and lower temperatures. This is in agreement with **Marcotte *et al.* (2001),** it has been recognized that the yield stress is a useful property of gums when they are used as binders, because it helps keep various components of the food formulation in place.

Gums addition showed that guar gum had generally higher synergistic effect than xanthan and arabic gums when used with papaya-apricot, this trend is similar with **Juszczak *et al.* (2004)** they found that guar gum had high flow behavior parameters than arabic gum. It could be concluded in the view of the results that guar gum particularly was more effective in increasing "K" values of papaya-apricot nectar. In the case of guar gum its molecular mass and galactose : mannose ratio strongly depended on the origin of the gum. In addition, the branching degree of the hydrocolloid, which is higher for guar gum, can also play an important part in the galactomannan-nectar compound interactions according to **Juszczak *et al.* (2004).** Similar trends were observed for other nectars content gums. The "K" values were increased with adding gum suggesting better synergy when they used to combined with papaya-apricot nectar. Combined of papaya-apricot nectar and guar gum may help attaining desired consistency. Guar gum is used in food industry for thickening purpose since it is more economical compared to other stabilizers. Since the synergy between guar gum and papaya-apricot nectar in terms of increasing the consistency of nectars was found better in this study, therefore the combined of guar- papaya-apricot nectar mix could be recommended in different fruit nectars formulations. Flow behavior index of nectar samples decreased with temperature.

Addition of sweeteners to the papaya-apricot nectar caused a decreased in values (K, η_B τ_{0HB} and τ_{0B}). The "n" values increased sharply with adding gums to papaya-apricot nectar, while they decreased with adding sweeteners. Both demonstrated non-Newtonian flow.

Thixotropy behavior of papaya-apricot nectar and effect of addition of some hydrocolloids and sweeteners:

From the shear rate-shear stress curves, nectar samples exhibited thixotropy, exhibit time dependent properties, which mean that the apparent viscosity or consistency will decrease with time. The area enclosed by the hysteresis loop signifies the degree of structural breakdown during steady shearing. The upper curve of the rheogram was found to be higher compared to the down ward curve which indicated a thinning of nectar samples with shearing. Similar behavior was observed by **Bhattacharya (1999); Singh** and **Eipeson (2000)**; **El-Mansy *et al.***

(2000a, b); Nindo *et al.* (2005) and **Ahmed *et al.* (2005).** The thixotropy (Pa/s) values increased with increasing total solids nectar samples. All hydrocolloids decrease the thixotropy.

Effect of temperature on flow behavior of nectar samples:

Temperature has an important influence on the flow behavior of nectar samples content hydrocolloids. Since different temperatures are usually encountered during processing of hydrocolloids, their rheological properties are studied as a function of temperature. The effect of temperature on the apparent viscosity at a specified shear rate is generally expressed by an Arrhenius-type model. The Arrhenius equation to a great extent explains the relationship between the temperature and viscosity. The viscosity is dependent up on the intermolecular distances. As the temperature is increased, the in-termolecular distances increase and therefore the viscosity will decrease for these main reasons. The viscosity is a function of temperature and the dissolved solid concentration.

Results presented in Table (4) showed the variation in viscosity with temperature described by an Arrhenius-type. The activation energy of nectar samples ranged between 5.13 to 16.48 kJ/mol. The activation energy increased with addition hydrocolloids and decreased with addition sweeteners. The same trend was observed for η_{∞} factors were increasing with increasing total solids and increased with addition hydrocolloids while decreased with addition sweeteners. From the obtained results it can be concluded that the hydrocolloids were the most effective to improve the viscosity of nectar samples. The effective and best increased of the viscosity was done by addition guar gum.

Conclusions

Obtained data indicated that thickened nectars showed a shear-thinning behavior, and their viscosity increased with adding thickeners with sugar. So, guar gum, xanthan gum or arabic gum must be used to improve sensory and rheological properties of artificially sweetened papaya-apricot nectar. Herschel-Bulkley and Bingham rheology models could be recommended that adequately described the stress-rate relationships for the thickened fluids. The parameters of the models can be used to estimate the viscosity of fruits nectar.

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Nomenclature

Symbol	Term	Unit or definition	Symbol	Term	Unit or definition
A_{TH}	Thixotropy	Pa/s	LSD	Least significant difference	-
B1 to B12	Blend nectar numbers	-	S.E.	Standard error	-
E_a	Activation energy for flow	kJ/mol	T	Temperature	K
HB	Herschel-Bulkley Model	-	t	Temperature	°C
K	Consistency index	$Pa.s^n$	τ	Shear stress	Pa
n	Flow behavior index	Dimensionless	τ_0	Yield stress	Pa
R	Gas constant	8.314 kJ/ kg mol. K	$\dot{\gamma}$	Shear rate	s^{-1}
r	Correlation coefficient	-	η	Viscosity	Pa.s
r^2	Determination coefficient	-	η_∞	Constant in eqn. (3)	Pa.s
PAN	Papaya-apricot nectar	-			

Table (A): Formulas of papaya-apricot nectar samples.

Blends No.	Mixed papaya puree+apricot juice	Sugar solution or water	Hydrocolloids	Sweeteners
B* (1) Control	25% mixed papaya puree + apricot juice	75% sugar solution (18±0.5 º brix)	-	-
B (2)	25% mixed papaya puree + apricot juice	75% water	-	1.2 g/L aspartame**
B (3)	25% mixed papaya puree + apricot juice	75% water	-	1.2 g/L stevioside
B (4)	25% mixed papaya puree + apricot juice	75% sugar solution (17.5±0.5 º brix)	0.5% guar gum	-
B (5)	25% mixed papaya puree + apricot juice	75% sugar solution (17.5±0.5 º brix)	0.5% arabic gum	-
B (6)	25% mixed papaya puree + apricot juice	75% sugar solution (17.5±0.5 º brix)	0.5% xanthan gum	-
B (7)	25% mixed papaya puree + apricot juice	74.5% water	0.5% guar gum	1.2 g/L aspartame
B (8)	25% mixed papaya	74.5% water	0.5% arabic gum	1.2 g/L

	puree + apricot juice			aspartame
B (9)	25% mixed papaya puree + apricot juice	74.5% water	0.5% xanthan gum	1.2 g/L aspartame
B (10)	25% mixed papaya puree + apricot juice	74.5% water	0.5% guar gum	1.2 g/L stevioside
B (11)	25% mixed papaya puree + apricot juice	74.5% water	0.5% arabic gum	1.2 g/L stevioside
B (12)	25% mixed papaya puree + apricot juice	74.5% water	0.5% xanthan gum	1.2 g/L stevioside

** B =Blend* ***Sweeteners were added 1.2g/L of final prepared nectar*

Table (1): Sensory properties of papaya and apricot nectar (PAN) blends.

Products (Nectar Blends)	Sensory attributes					
	Color (20)	Texture (20)	Taste (20)	Flavor (20)	Mouthfeel (20)	Overall acceptability (100)
Papaya-apricot nectar (control) (B1)	$19.81^{a}\pm0.38$	$16.92^{c}\pm0.64$	$18.07^{a}\pm0.54$	$19.48^{a}\pm0.34$	$18.21^{a}\pm0.28$	$83.17^{cd}\pm2.45$
PAN with aspartame (B2)	$11.27^{e}\pm0.08$	$8.22^{d}\pm0.86$	$10.15^{d}\pm0.47$	$11.08^{e}\pm0.83$	$13.65^{b}\pm0.84$	$71.16^{e}\pm1.07$
PAN with stevioside (B3)	$11.64^{e}\pm0.42$	$8.34^{d}\pm0.99$	$9.63^{d}\pm0.83$	$10.39^{e}\pm0.71$	$13.84^{b}\pm0.57$	$69.10^{e}\pm2.08$
PAN with guar gum (B4)	$18.57^{b}\pm0.39$	$19.41^{a}\pm0.14$	$17.64^{ab}\pm1.23$	$17.82^{b}\pm0.35$	$18.94^{a}\pm0.61$	$96.14^{a}\pm1.83$
PAN with arabic gum (B5)	$18.31^{b}\pm0.48$	$17.86^{abc}\pm0.53$	$16.81^{ab}\pm0.85$	$17.21^{b}\pm0.96$	$18.04^{a}\pm0.34$	$93.18^{a}\pm0.97$
PAN with xanthan gum (B6)	$18.94^{b}\pm0.24$	$18.87^{ab}\pm0.67$	$17.52^{ab}\pm0.62$	$17.91^{b}\pm0.67$	$19.01^{a}\pm0.81$	$95.53^{a}\pm0.84$
PAN with (aspartame + guar gum) (B7)	$15.41^{cd}\pm0.19$	$18.60^{abc}\pm1.04$	$15.99^{bc}\pm0.97$	$15.86^{c}\pm0.96$	$14.58^{b}\pm0.70$	$88.17^{b}\pm1.27$
PAN with (aspartame + arabic gum) (B8)	$14.87^{d}\pm0.54$	$17.39^{bc}\pm0.82$	$14.86^{c}\pm1.28$	$15.44^{d}\pm0.51$	$14.33^{b}\pm0.93$	$83.11^{cd}\pm1.36$
PAN with (aspartame + xanthan gum) (B9)	$15.68^{c}\pm0.61$	$18.12^{abc}\pm0.32$	$15.64^{bc}\pm0.25$	$15.91^{c}\pm0.28$	$14.61^{b}\pm0.82$	$86.17^{bc}\pm1.57$
PAN with (stevioside + guar gum) (B10)	$15.36^{cd}\pm0.27$	$18.43^{abc}\pm0.55$	$15.68^{bc}\pm0.31$	$14.79^{d}\pm0.37$	$14.47^{b}\pm0.71$	$84.75^{bcd}\pm1.25$
PAN with (stevioside + arabic gum) (B11)	$14.81^{d}\pm0.69$	$17.11^{bc}\pm0.36$	$14.77^{c}\pm0.52$	$14.68^{d}\pm0.68$	$14.32^{b}\pm0.68$	$81.17^{d}\pm2.04$
PAN with (stevioside + xanthan gum) (B12)	$15.54^{c}\pm0.40$	$18.04^{abc}\pm0.75$	$15.65^{bc}\pm0.61$	$14.89^{d}\pm0.72$	$14.58^{b}\pm0.94$	$83.19^{cd}\pm1.67$
L.S.D at P<0.05	0.67	1.81	1.76	0.81	1.64	4.57

[a,b] ***There is no significant different (P > 0.05) between any two means, within the same attribute have the same letter.***

Table (2): Effect of addition some sweetness or hydrocolloids on rheological parameters of papaya and apricot nectar.

Nectar samples	t °C	Parameters for different rheology models							Thixotropy ($Pa.s^{-1}$)
		Herschel-Bulkley				Bingham			
		τ_{0HB}	K	n	r	η_B	τ_{0B}	r	
Papaya-apricot nectar (control) (B1)	5	4.89	4.79	0.159	0.999	22.31	4.83	0.996	138.01
	25	4.14	4.55	0.153	0.999	19.11	4.24	0.996	124.15
	50	3.82	4.28	0.148	0.999	15.87	3.94	0.992	116.81
	75	3.51	3.96	0.139	0.998	12.12	3.75	0.990	107.46
PAN with aspartame (B2)	5	0.91	2.33	0.122	0.984	13.46	1.21	0.984	38.11
	25	0.63	2.09	0.121	0.986	10.83	1.05	0.986	31.67
	50	0.42	1.93	0.119	0.975	9.14	0.91	0.976	25.08
	75	0.19	1.77	0.120	0.972	7.25	0.78	0.971	18.40
PAN with stevioside (B3)	5	0.68	2.28	0.113	0.996	13.27	0.89	0.988	38.45
	25	0.49	2.04	0.112	0.997	10.75	0.74	0.982	31.27
	50	0.32	1.86	0.112	0.991	9.21	0.65	0.965	25.19
	75	0.17	1.65	0.109	0.985	7.34	0.55	0.966	18.15
PAN with guar gum (B4)	5	8.12	15.83	0.603	0.999	49.83	8.96	0.995	74.34
	25	7.54	14.77	0.582	0.999	46.81	8.40	0.997	71.81
	50	5.84	12.46	0.531	0.997	44.31	8.03	0.991	68.50
	75	5.12	9.11	0.485	0.990	42.10	7.79	0.990	64.39
PAN with arabic gum (B5)	5	7.15	11.65	0.335	0.999	43.12	7.74	0.999	81.07
	25	6.28	8.93	0.333	0.999	41.08	7.09	0.996	75.45
	50	5.20	7.58	0.321	0.999	38.91	6.73	0.991	70.29
	75	4.06	6.42	0.310	0.999	35.67	6.14	0.979	66.49
PAN with xanthan gum (B6)	5	7.78	13.08	0.589	0.999	46.34	8.41	0.993	78.64
	25	6.34	10.67	0.551	0.999	44.09	8.12	0.991	74.38
	50	5.83	10.11	0.501	0.998	42.33	7.76	0.991	71.12
	75	5.04	8.63	0.480	0.999	40.46	7.31	0.988	67.34

Table (3): Effect of addition some sweetness and hydrocolloids on rheological parameters of papaya and apricot nectar.

Nectar samples	t °C	Parameters for different rheology models							Thixotropy ($Pa.s^{-1}$)
		Herschel-Bulkley				Bingham			
		τ_{0HB}	K	n	r	η_B	τ_{0B}	r	
PAN with aspartame + guar gum (B7)	5	6.63	12.54	0.491	0.999	42.10	7.33	0.998	68.15
	25	5.46	11.29	0.443	0.999	39.89	6.79	0.973	65.47
	50	4.62	10.74	0.399	0.998	37.82	6.27	0.968	61.33
	75	3.95	10.06	0.379	0.995	34.43	5.76	0.967	58.94
PAN with aspartame + arabic gum (B8)	5	4.92	10.11	0.294	0.999	36.84	5.68	0.999	78.19
	25	3.98	8.24	0.259	0.999	35.01	5.13	0.998	70.01
	50	3.35	6.71	0.244	0.999	32.54	4.65	0.991	67.87
	75	2.96	5.94	0.225	0.996	28.49	4.18	0.986	64.28
PAN with aspartame + xanthan gum (B9)	5	5.51	11.37	0.479	0.999	40.22	6.28	0.997	75.28
	25	4.43	9.14	0.431	0.997	37.85	5.81	0.992	71.14
	50	3.89	8.58	0.397	0.994	34.99	5.34	0.988	69.34
	75	3.05	7.86	0.374	0.990	32.41	4.79	0.964	66.11
PAN with stevioside + guar gum (B10)	5	6.43	12.21	0.474	0.999	41.35	7.26	0.995	69.74
	25	5.37	11.03	0.431	0.995	39.15	6.73	0.994	65.96
	50	4.51	10.40	0.394	0.995	37.14	6.16	0.987	62.14
	75	3.86	9.81	0.368	0.991	33.74	5.71	0.976	59.81
PAN with stevioside + arabic gum (B11)	5	4.79	9.86	0.287	0.999	36.16	5.65	0.988	78.37
	25	3.88	8.06	0.253	0.993	34.57	5.09	0.983	73.15
	50	3.13	6.63	0.235	0.995	31.90	4.54	0.971	70.13
	75	2.74	5.71	0.213	0.987	27.61	4.11	0.972	67.81
PAN with stevioside + xanthan gum (B12)	5	5.21	11.08	0.461	0.999	40.01	6.22	0.985	77.11
	25	4.17	9.02	0.417	0.991	37.28	5.73	0.982	73.21
	50	3.66	8.34	0.391	0.989	34.32	5.22	0.982	71.14
	75	2.89	7.56	0.366	0.990	31.74	4.71	0.979	68.27

Table (4): Parameters for the Arrhenius equation to predict the variation of viscosity of papaya-apricot nectar blended with some sweeteners and hydrocolloids.

Nectar sample	E_a (kJ/mol.)	η_∞ (mPa.s)	Determination coefficient (r^2)	Temperature range (°C)
Papaya-apricot nectar (control) (B1)	9.34	3.11	0.999	5-75
PAN with aspartame (B2)	5.84	1.95	0.956	5-75
PAN with stevioside (B3)	5.13	1.87	0.943	5-75
PAN with guar gum (B4)	16.48	4.20	0.999	5-75
PAN with arabic gum (B5)	14.39	4.12	0.999	5-75
PAN with xanthan gum (B6)	15.96	4.16	0.999	5-75
PAN with (aspartame + guar gum) (B7)	11.23	6.24	0.994	5-75
PAN with (aspartame + arabic gum) (B8)	10.55	6.08	0.995	5-75
PAN with (aspartame + xanthan gum) (B9)	10.98	6.13	0.991	5-75
PAN with (stevioside + guar gum) (B10)	11.01	6.19	0.986	5-75
PAN with (stevioside + arabic gum) (B11)	10.37	5.91	0.968	5-75
PAN with (stevioside + xanthan gum) (B12)	10.63	5.64	0.974	5-75