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Replacing Sucrose by Stevioioside and Adding Arabic Gum: investigation of Rheological Properties of Apple Jam

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ABSTRACT

Obesity and gaining weight is one of the current problems which arose from high calories diets. It causes to obesity as one of the dangerous diseases in the world. The aim of this study was to produce free sugar Apple Jam by replacing it with Stevioside and evaluating its rheological properties by adding Arabic Gum in 3 levels including 0.25 % , 0.5% and 2 %. It caused to reduce hardness , sample has 2 % Arabic Gum showed the least hardness. Color measurement exhibits the increase of lightness, the decrease of redness and yellowness ,reduction in browning index by the increase of replacing ($p<0.05$).TPA results displayed a pseudo plastic behavior of apple jam which fitted to Hershel Bulkley model . increasing Gum results in decreasing flow index (N) consistency index and yield stress decreased by replacing sucrose with Stevioside ,while increase by their increasing. Sensory evaluation results showed that this replacing with Stevioside and Arabic Gum produce an after taste cause to reduce in panelists' evaluation, with respect to achieved results, we understand that complete replacing of sucrose by Stevioside to produce apple jam is not impossible.

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INTRODUCTION

Both full calorie diets and no exercising can lead to gain weight which redound to diseases including obesity, cardiovascular, non insulin dependent diabetic etc. diabetics is the most widespread disease arose from metabolism disorders in which sick people unable to digest glucose (Mahan and Escott, 2004). Statistical assessments exhibits that diabetics is growing in nations. Today, more than 230 millions people suffer from diabetes in the world and WHO has predicted that there will be more than 6.4 million sick people by 2025 (Iranian diabetes society, 2006), 90-95 % of afflicted people related to 2nd diabetes (Mahan and Escott, 2004). Besides, based on WHO researches, more than 30% of Middle East residents suffer from overweight, obesity incidence in Iran among children and teens are 8.8 % and 4.5 % respectively (Farahzad and Bagheri, 2004). People's knowledge of healthy food have caused to create a viewpoint of producing with less fat, salt, sugar and more fiber (Ignaro *et al*, 2007). Although sucrose replacing by synthetic sweetener such as aspartame and Sucralose has been considered (Chapello, 1998). Creating of functional properties of sucrose in sugar free products is difficult (Martinez *et al*, 2012). Currently, tendency to use Stevioside as a natural sweetener causes not to produce more calories, suitable replacing of sugar, with no adverse effects (Cardello *et al*, 1997 and Clos *et al*, 2008). Findings display that diterpene glycosides describes as the most important sweet taste in Stevia extraction (Hamzeloee, 2004). Rbaudioside A, Ribadioside C, Stevioside and Dudoside are common stevia's glycosides .their sweetness is 200-300 times more than sugar (Morga and Dashora, 2009). Stevia use to treat diabetes, cancer, high blood pressure (Curry and Roberts 2008 and Ghosh *et al*, 2008), inhibit microbial growth in mouth (Fatemi, 2008). Steviol, non sugar part of Stevioside, contains a hydroxyle group on 13th carbon which bonds α1→13 to a disaccharide sufrose and a carboxyl group on 4th carbon where bonds to an α-diglucose unit (Ahmad *et al*, 2011). In recent decades, Stevioside has used in confectionary and seafood in countries such as Japan, China…. (Koyma *et al*, 2003). Jam produces by mixing one or more fruit pulp, sugar or other sweetener like honey or synthetic sweetener and adding water or not (National Iran Standard, 1978). High level of sugar and its adverse effects in the body have led consumers to use low calorie jam .The role of sugar

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in consistency cause to consider using hydrocolloids as sugar replacer that contain emulsifier properties and gelling agent (Dickinson, 2009). Arabic Gum secretes commonly when tree undergoes dryness, inimical conditions of soil or injured (Dror *et al*, 2006). Arabic Gum, a neutral or low acid salt, composed of a polysaccharide complex with calcium, magnesium and potassium. Its molecules create a hard compressed spring with lots of side chains and high molecular weight (more than 3000D) . They also have 4 different sugars including Larabinose, L Ramnose, D Galactose, D Glucoronic acid. To produce high viscosity, high concentration of Arabic Gum is required (Keramat, 2008). Arabic Gum uses to inhibit sugar crystallization in confectionary, uniform distribution of fats, emulsification in beverages, encapsulation and fixing flavor .Studying on replacing Stevia and Sucralose on physiochemical properties of mango jam revealed that yield stress and consistency decreased as a result of reduction in total soluble solid (Basu *et al*, 2013). Optimizing production of low calorie jam by mixture of tropical fruits and using Acesulafam or Sorbitol as replacer lead to a final formulation containing 106/100g of jam (Abdullah and Chang, 2001). Studying on physiochemical and sensory properties of dietary Guava jam in which sodium saccharin and sodium siclamat used as replacer displayed similarity of common jam with dietary jam (Correa *et al*, 2011). The target of present study is to evaluate production of dietary apple jam by Stevioside.

Methodology:

Apple Jam Production Procedure:

To prepare samples, apples purchased from Isfahan Market, washed, peeled and cut into cube segment, soaked in water to prevent blacken and heated to boil. Apple cooked under atmosphere pressure and in stainless steel container. Cooked apples brought out of water, remained water mixed with sugar, filtered, citric acid and pectin added, heated lightly to set the syrup. Cooking stage finished when BX came to 65-66. Hot jams poured in glass and cooled to ambient temperature in 2 stages. To provide low calorie treatment, sucrose replaced by Stevioside with 200:1 ratio and Arabic Gum added in 3 different concentrations including 0.25% 0.5% and 2%. The levels of other ingredients were stable.

Table 1: Basic formulation of apple jam.

Ingredients per 500g of fruit	Amount
Apple	500g
sucrose	500g
Pure pectin (high metoxyle pectin)	3g
Citric acid (solution (5 % w/v)	2.5 ml

Color Measurement:

To investigate color, samples placed in a Petri dish with white walls. Two lamps (18 w, with a 30˚ as angle of radiation) used to take photos of samples. Pictures analyzed by Image Pro software through selecting 10 random points, then RGB determined and converted to *L,*a and *B.*L. Positives values of *a and *b index are related to red and yellow, negative values to green and blue respectively (Mohebi, 2008). Browning index calculated by equation 1 and 2 in which determined factors including *L ,*a and *b. In fact ΔE, ratio of color changes of control to browning index, displays browning level (Saricoban and Yilmaz 2010).

Evaluation of Jam's Sap Color:

Hunter lab (Colorflex EZ,Virginia, USA) used to conduct *L ,*a and *b factors. browning level and color changes determined by Equation 1 and 2.

$$1)E = \sqrt{(L° - L)^2 + (a° - a)^2 + (b° - b)^2}$$

$$2)BI = \frac{100 \times (X - 0/31)}{0/17}$$

Evaluation of Fruit Texture:

Texture analyzer (Brookfield Engineering middle base, CT3-4500, USA) used to conduct penetration test with TA44 PROBE in which probe race was 0.5mm/s and penetration diameter 10mm.

Evaluation of Syrup Texture:

Rheometer model (Brookfield Engineering middle base, RVD3, USA) equipped with ULA spindle used , torque range adjusted between 10-60 % used to assess texture properties and results fit to Hershel Bulkley model (equation 3).

3)$\tau \cdot + myn = \tau$

Sensory Evaluation:

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Sensory evaluation conducted by one property intensity scoring test, performed by 6 panelists in the field of taste and texture, each bowl numbered by 3 random digit numbers.

Statistical Analysis:

LSD test was used to conduct significant differences ($p<0.05$) using SAS9 software and plot designing by EXCEL 2007.

RESULTS AND DISCUSSION

Fruit and syrup color evaluation:

As it has shown in table 2, by replacing sucrose with Stevioside and Arabic Gum *L,*a and *b Decreased significantly as dietary treatment containing 2 % Gum displayed the most amount of *L , color changes and the least *a ,*b and browning . The importance of relation between browning index and lightness consider as the increase of *L and the decrease of *a and *b cause to reduction of browning occurrence (Hmazeloee *et al*, 2004).

Reduction of browning occurs obviously as a result of fewer tendencies of stevioside and Arabic Gum to browning reaction, beside hygroscopic properties of Arabic Gum causes to more water absorption, aw increases. In fact browning reaction increases in a wide range of moisture (Keramat, 2008).

Table.2: Evaluation of saccharose replacement by Stevia and Arabic Gum on color properties of fruit and syrup of jam.

Treatment	BI	ΔE	b*	a*	L*
Control					
(fruit)	79/82±3/86^{a}	-	51/69±1/28^{a}	-8/06±0/78^{a}	78/5±0/66^{ab}
Treatment including 0.25 % Arabic Gum	47/81±7/15^{b}	14/81±2/66^{a}	35/28±3/21^{b}	-10/11±0/44^{b}	77/32±0/30^{b}
Treatment including 0.5% Arabic Gum	40/13±4/42^{c}	19/76±2/66^{b}	32/8±2/38^{b}	-11/4±0/40^{c}	79/15±0/18^{bc}
Treatment including 2% Arabic Gum	38/27±1/95^{c}	20/19±1/31^{b}	32/69±1/01^{b}	-12/2±0/83^{d}	79/84±0/73^{c}
Jam syrup (control)					
	77/02±12/46^{a}	-	11/72±44/01^{a}	0/36±0/19^{a}	21/49±0/78^{a}
Treatment including 0.25 % Arabic Gum	12/65±2/19^{b}	16/83±3/18^{a}	5/63±0/51^{b}	-1/82±0/10^{b}	36/48±2/10^{b}
Treatment including 0.5% Arabic Gum	4/41±0/15^{b}	19/41±2/67^{a}	3/36±0/23^{b}	-2/08±0/12^{bc}	38/30±1/89^{c}
Treatment including 2% Arabic Gum	2/64±0/30^{b}	23/41±0/39^{a}	2/85±0/07^{c}	2/36±0/1^{c}	42/44±0/79^{c}

Numbers including common letters have no significant difference in ($p<0.05$).

Fruit Texture Evaluation:

Required force for penetrating a piston in food stuff refers to penetration test .Hardness of texture needs a direct ratio with force amount (Borne, 2002). Texture softened by replacing sucrose with Stevioside and Arabic Gum ($p\leq0.5$) as a result of sugar decreasing, less water binding capacity, loosen pectin gel (figure 1). Similar result found in the study by Santanu Basu in replacing sucrose with Sorbitol in mangos jam (Basu and Shivhare 2012).

Evaluation of Syrup Texture:

Figure 2 displays shear rate changing versus shear stress in low calorie treatment and control, the results fitted with Hershel Bulkley model. Table 3 exhibits determined factors including yield stress (τy), flow index (n) and consistency coefficient (m). Correlation coefficient amounts range from 0.987-0.999 which exhibits the coincidence of results with model the most and the least yield stress related to control and sample containing 0.25 % Gum. In fact, yield stress decreased by replacing sucrose with Stevioside, however it increased by adding more Gum. The most consistency coefficient related to sample containing 2 % Gum, although its viscosity reached to the least viscosity by increasing shear rate, increasing Gum resulted in more water absorption and gelling formation , water removed when shear rate destroy gel network and viscosity decreased. Flow index was less than 1 displaying a pseudo plastic shear thinning behavior (figure 2). A similar result was found in the study by Basu and Shivhare (Basu and Shivhare 2010 and 2012).

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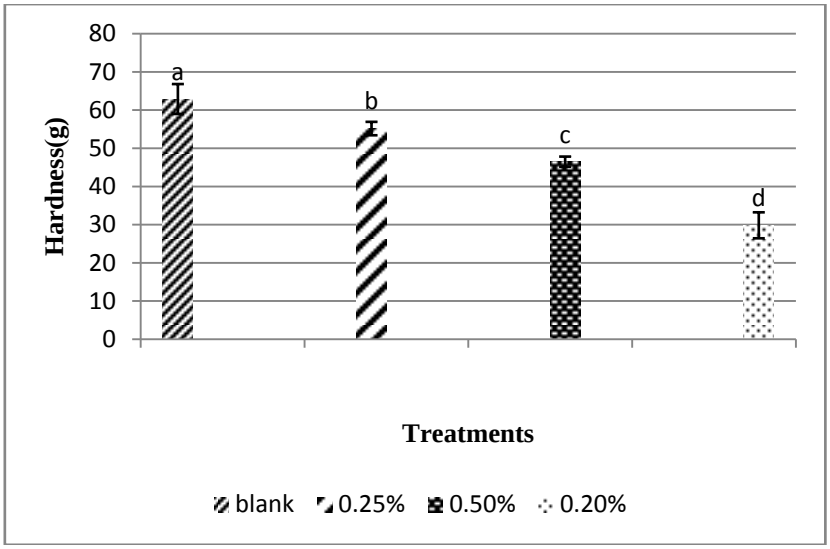

Fig. 1: Evaluation of saccharose replacement by Stevia and Arabic Gum on hardness of fruit.

Table 3: Evaluation of Saccharose replacement by Stevia and Arabic Gum on yield stress, consistency coefficient, flow index.

Treatments	r^2	N	*m* (Pa.s^n)	τy (Pa)
Control	0/999	0/444	1/95	27/25
Treatment including 0.25 % Arabic Gum	0/998	0/381	1/62	18/26
Treatment including 0.5% Arabic Gum	0/987	0/222	5/46	20/23
Treatment including 2% Arabic Gum	0/994	0/226	7/06	26/33

Numbers including common letters have no significant difference in (p <0.05)

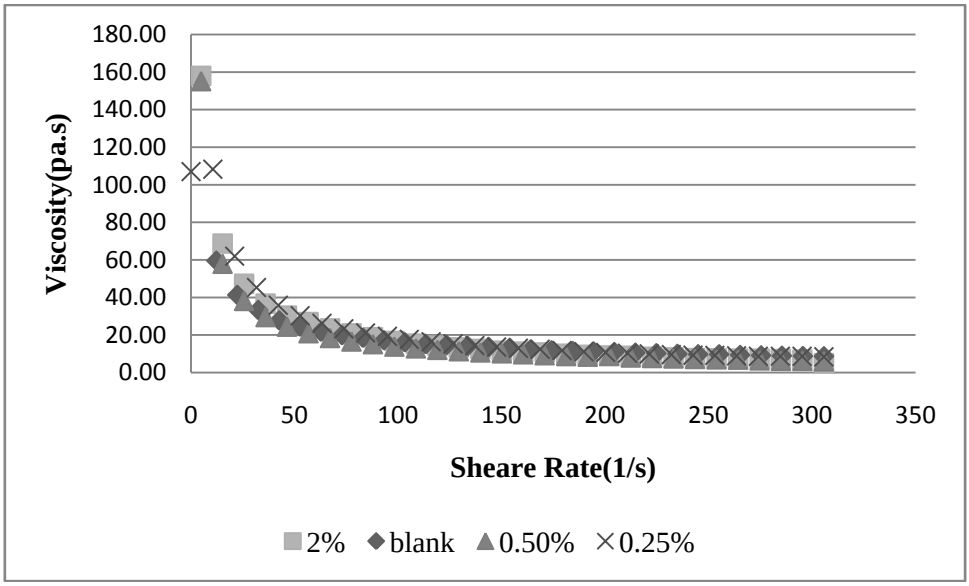

Fig. 2: Evaluation of Saccharose replacement by Stevia and Arabic Gum on viscosity of Jam.

Sensory Evaluation:

Replacing sucrose with Stevioside and Arabic Gum resulted in a significant unsuitable aftertaste. While no aftertaste evaluated by panelist in adding Arabic Gum in different levels, it can attribute to Stevioside responsible for bitter flavor (Morga and Dashora, 2009 and Keramat, 2008). This aftertaste relates to some compounds including essential oils, Tannin, Flavonoids and in recent researches Ribaudioside A, Stevioside. however former effects are less than the second one (Morga and Dashora, 2009). Panelists' determination displayed a significantly reduction in hardness and total quality while adding 2 % Arabic Gum supporting experimental result.

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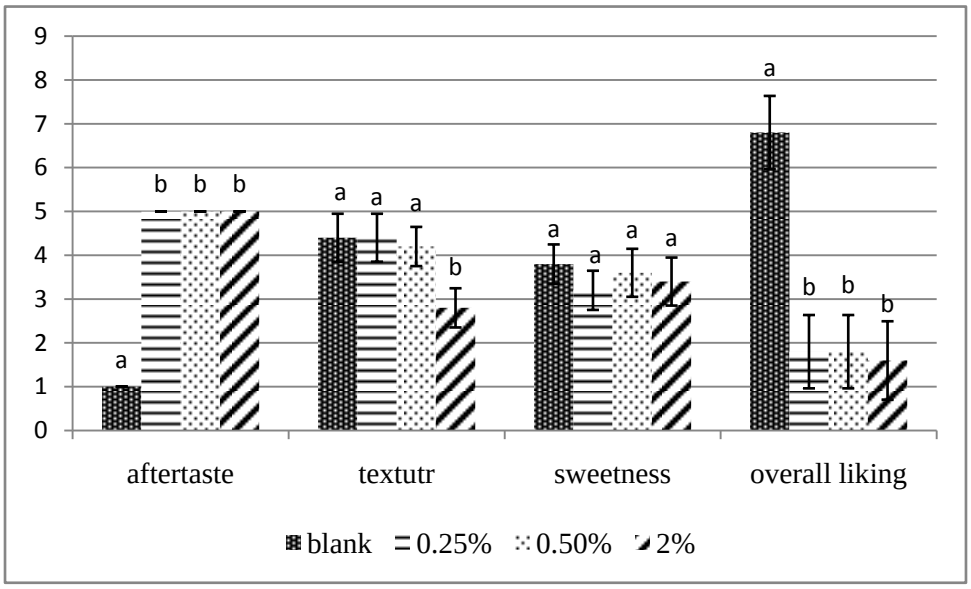

Fig. 3: Evaluation of Saccharose replacement by Stevia and Arabic Gum on sensory properties of apple jam.

Conclusion:

Considering Stevioside as a sweetener is impossible due to its bitter aftertaste , although Arabic Gum appropriately can be an option to produce better sensory properties for sugar free jam if uses along with a suitable sweetener.

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