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Sensory Analysis of Sugar Reduced Jam Containing Gum Arabic from *Acacia senegal* var. *kerensis*

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Abstract

Reducing sugar in jam has an effect on the physico-chemical as well as sensory properties of the jam. To compensate for some of the functional properties lost, other co-solutes may be used. Therefore the objective of this study was to use gum Arabic from *Acacia senegal* var. *kerensis* in formulation of a reduced sugar jam from plums and pineapple fruits. The innovatively prepared jam was subjected to sensory evaluation by a semi-trained panel. Twelve formulations were prepared in factorial arrangement in a completely randomized design. The products were rated using a seven-point hedonic scale for colour, taste, texture/spreadability, mouth feel and general acceptability. Data were analysed using SAS, 2004 (version 9.1.3) to perform analysis of variance and determine the least squares means for each variable. The main effect of the study was the level of gum Arabic at 15% and 20% w/w, level of sugar content at 30 and 35% w/w, and the type of fruit. A control product was prepared for the two sugar levels but without gum Arabic. Significance was established at $p < 0.05$ level, while the means separation was done using Tukey's honestly significance difference (HSD). The results obtained showed that Fruit type significantly affected the color at $p < 0.05$, while gum Arabic and the interactions did not significantly affect the color (at $p < 0.05$). Fruit type, gum Arabic and their interactions with sugar affected the spreadability and it was highly significant at $p < 0.001$ while gum Arabic significantly affected the taste at $p < 0.001$. The best formulation for most attributes was 15% gum for the two fruits, 30% sugar for pineapple and 35% sugar for plum jam. It was therefore possible to reduce the amount of sugar by 50% of the commercially available jam while substituting it with 15% gum Arabic which qualifies the quantity necessary for an ingredient in food formulation. This is the first time that such work of innovatively preparing a jam with a sugar re-

duction of up to 50% via utilization of gum Arabic from *Acacia senegal* var. *kerensis* is being reported.

Keywords

Gum Arabic, Sucrose/Sugar, Reduced Sugar Jam, Sensory Evaluation

1. Introduction

Preparation of jams, marmalades and jellies are technologies that have been used over many years to preserve fruits for use during off season [1] [2]. This technology was initially done at household level but as sugar became more affordable and the chemistry of pectin was better understood, the practice was up-scaled to industrial levels [3]. This led to the development of quality standards vis-à-vis ingredients especially their quantities, processing techniques, and varieties of fruits and vegetables that can be used [1].

Apart from the different varieties of fruits that have been explored for use in jam making, alternative sweeteners have been evaluated in order to replace a portion or all of the sucrose. These innovations have been driven by the need for manufacturers to meet consumer demands for healthier food products that contain low calories without adversely affecting the sensory parameters such as taste and texture [1]. The alternative sweeteners that have been evaluated and utilized in jams include acesulfame potassium, aspartame, saccharin, fructose, sorbitol, maltitol, corn syrup and honey [4] [5] [6]. Use of fructooligosaccharides (FOS) as a mild sweetener, thickener and as a prebiotic has been reported by [6] [7] [8] [9]. However, the use of gum Arabic in sugar reduced jam has not been reported despite its application in other low sugar products like candies. Gum Arabic is used to substitute for the loss of texture, mouth feel and body which results from reduction of sugar content or replacement with other sweeteners.

Gum Arabic (E414) is defined as a dried exudation obtained primarily from the stems of *Acacia senegal* (L.) Willdenow and *Acacia seyal* Delile, trees of the *Leguminosae* family [10]. Gum Arabic from *Acacia senegal* var. *kerensis* exhibits some superior functionality properties compared to the gum from *Acacia senegal* var. *senegal* [11] [12]. For example, the emulsification property of var. *kerensis* gum is superior compared to the one from var. *senegal*. This is associated with the higher protein content (2.9%) for var. *kerensis as* compared to (1.9%) for var. *senegal*. The var. *kerensis* gum also gels at lower concentration due to the fact that variety *kerensis* has a higher intrinsic viscosity due to the longer gyration radius [11] [12] [13]. [12] reported a gyration radius (R_g) of 32 nm and 47 nm for the gum from var. *senegal* and var. *kerensis*, respectively.

Processing methods as well as ingredients used in jam making may influence the sensory characteristics of jam such as appearance, flavor (taste and aroma) and texture. Sensory quality for fruit jams can be based on the basic parameters

such as color, sweetness and natural fruit identity [14]. The current work reports the innovative preparation and sensory properties of a jam with reduced sucrose content but containing gum Arabic from *Acacia senegal* var. *kerensis*. This is the first study to report the use of gum Arabic from *Acacia senegal* var. *kerensis* in reduced sugar plum and pineapple jam.

2. Materials and Methods

2.1. Materials

The work was carried out at the Guildford Institute, Department of Dairy, Food Science and Technology in Egerton University and at the Kenya Forest Research Institute's Forest Product Laboratory at Karura, Nairobi, Kenya.

Fruits (plums and pineapple) and other ingredients were sourced from local supermarkets. The fruits were checked for peak ripeness, firm texture and with no wounds or pests. The respective food additives (High and low methoxyl pectin and sorbic acid) were procured from local distributors (Pradip Enterprises Products, Promaco Limited, and Kobian Scientific, Nairobi, Kenya). Gum Arabic was procured from Kennect Enterprises Limited, Kenya.

2.2. Preparation of Jams

The fruits were washed in chlorinated water and rinsed with clean running water. Pineapples were peeled and diced into small pieces. A blender was used to blend each of the fruits into a homogenous pulp. Plums were blanched, peeled, de-seeded and blended. Traditional open pan cooking was used for all treatments whereby the cooking temperature was in the range of 90˚C - 105˚C. The mixture of fruit pulp and the gum were boiled for about an hour while continuously stirring for the first 15 minutes and at 10 minutes intervals thereafter. The pH was maintained at a range of 2.9 - 3.2 while the Brix was maintained at a range of 55˚ - 65˚. Different formulations were used to determine the effect of gum Arabic at different quantities. Two levels of gum Arabic (15% and 20% w/w) and two levels of sugar (30% and 35% w/w) were used in a factorial arrangement. The control samples had no gum but retained the two levels of sugar content. Fruit pulp and pectin were maintained at 45% and 1%, respectively for all treatments. Citric acid was only added to the pineapple formulation to adjust the pH to 3.2. The formulation for the pineapple mixture was concentrated to 45˚ Brix. The gum Arabic was then added while stirring until it dissolved. Pectin was added when the jam preparation mixture attained 68˚ Brix. This was followed by the addition of citric and sorbic acids. The final brix attained was 65˚ for the jam with gum Arabic and 50˚ for the one without. All the treatments were carried out in triplicate. The jams were then filled in clean, sterilized and dry glass jars while hot and covered with sterilized lids. The jars with jam were cooled in water to room temperature. The effectiveness of vacuum sealing was checked by pressing the lids. If the lids popped after pressing, the container was emptied and the filling repeated after reheating.

2.3. Sensory Evaluation

Sensory evaluation was carried out at Guildford Institute sensory room. The room is fitted with eight isolated and white fluorescent lit booths. The panelists were served with slices of white sugarless bread to apply the jam on. The panel consisted of 30 semi-trained panelists with previous knowledge of what is expected in a sensory study. The panel consisted of 16 females and 14 males aged between 18 - 45 years. They were all picked from the department of Dairy, Food Science and Technology staff and students. A seven-point hedonic scale was used to rate the taste, color, texture/spreadability, mouth feel and overall acceptability of the two types of jam. The rating scale was as follows: 7 (like extremely), 6 (like moderately), 5 (like slightly), 4 (neither like nor dislike), 3 (dislike slightly), 2 (dislike moderately) and 1 (dislike extremely).

2.4. Statistical Analysis

The experiment employed a factorial experiment with three factors in a completely randomized design. The different sample treatments were analyzed using PROC GLM procedure of the statistical analysis system version 9.1.3 (SAS, 2004) to perform analysis of variance and determine the least squares means for each variable. The main effect of the study was the level of gum Arabic at 15% and 20%, level of sugar content, 30% and 35%, and the type of fruit. A control product was done for the two sugar levels but without gum Arabic. Significance was established at $p < 0.05$ level, while the means separation was done using Tukey's honestly significance difference (HSD).

3. Results and Discussion

Analysis of variance was done for the main effect and interactions. The results of the interactions are presented in Table 1. Fruit type significantly affected the

Table 1. Jam sensory parameters evaluated.

S.O.V	DF	Color	Spreadability	Taste	Mouth feel	Overall
Fruit	1	5.14*	14.80***	6.40*	0.47^{ns}	3.03^{ns}
Sugar	1	0.47^{ns}	0.34^{ns}	1.11^{ns}	1.46^{ns}	2.67^{ns}
Gum Arabic	2	2.19^{ns}	18.96***	9.16***	5.97*	8.66***
Fruit * sugar	1	0.003^{ns}	13.23***	6.40*	4.67^{ns}	3.40^{ns}
Fruit * gum Arabic	2	0.02^{ns}	2.99^{ns}	2.76^{ns}	3.80^{ns}	1.76^{ns}
Sugar * gum Arabic	2	1.69^{ns}	9.09****	4.80*	3.17^{ns}	3.85*
Fruit * sugar * gum Arabic	2	1.45^{ns}	4.06^{ns}	3.96^{ns}	2.64^{ns}	2.85^{ns}
Reps	29	2.77***	1.79^{ns}	2.00^{ns}	2.76^{ns}	2.74***
Error	319	1.09***	1.53***	1.37***	1.35^{ns}	1.16***
MSD	-	0.22	0.26	0.24	0.24	0.22

Key: S.O.V = Source of variations in the model, DF = Degree of freedom, MSD = Minimum significance difference. ns = Not significant, * = $p < 0.05$ and *** = $p < 0.001$.

color at $p < 0.05$, while gum Arabic and the interactions did not significantly affect the color (at $p < 0.05$). Fruit type, gum Arabic and their interactions with sugar affected the spreadability which was significant at $p < 0.001$ while gum Arabic significantly affected the taste at $p < 0.001$.

The means for the sensory attribute versus fruit type, sugar levels and gum levels are presented in **Table 2**. The fruit 2 (plum) had the highest liking compared to the fruit 1 (pineapple) in all parameters except the mouth feel. However, there was no significant difference in the general acceptability of the jam from the two fruits. This observation is similar to that reported by [15]. These workers reported that despite there being significant difference in various sensory attributes of different fruit formulations containing pineapple, papaya and carambola in varying ratios, the overall acceptability had no significant difference. The results indicate that there was no significant difference in the sensory attribute for the different levels of sugar used. A 5% difference is minimal and thus not noticeable in terms of sweetness but it could have a significant effect on the sugar acid balance that gives an overall acceptable product.

In terms of spreadability and mouth feel, the panel least liked the jam with 20% gum Arabic and overall they liked the one without gum Arabic. However, in a scale of 7 points a score of 5 can be termed as "good". Gum Arabic had an effect on mouth feel of the jam as the gum level increased as shown in **Table 2**. This is probably due to the increase in viscosity and adhesiveness as concentration of gum increased, an observation also reported by [16]. [13] also reported a decrease in expressible moisture in beef extension due to increase in water holding capacity as gum level increased. This observation by [13] could also explain the difference in mouth feel of the jam as gum level increased.

The means of different sensory attributes for interaction between the different fruits used and different levels of gum Arabic are presented in **Table 3**. Interaction between the fruit and the gum level did not affect how the color was scored as compared to control. Fruit 2 (plum) with 20% and the same fruit without gum scored 6.27 whereas fruit 1 (pineapple) scored 6.03 and 6.00 for 0% and 20% gum, respectively. For spreadability, fruit 2 with 0% and 15% and fruit 1 (pineapple) with 15% gum Arabic scored higher (5.88 to 6.07). Spreadability is a factor of rheology of the product. This observation is attributed partly by the

Table 2. Means ± std error for the sensory attribute versus fruit type, sugar levels and gum levels.

Sensory Parameter	Fruit Type		Sugar Levels		Gum Levels		
	1	2	30	35	0	15	20
Colour	$5.94^{b} \pm 0.09$	$6.18^{a} \pm 0.07$	$6.10^{a} \pm 0.08$	$6.03^{a} \pm 0.09$	$6.15^{a} \pm 0.11$	$5.91^{a} \pm 0.11$	$6.13^{a} \pm 0.09$
Spreadability	$5.52^{b} \pm 0.11$	$5.93^{a} \pm 0.09$	$5.76^{a} \pm 0.11$	$5.69^{a} \pm 0.09$	$5.93^{a} \pm 0.12$	$5.98^{a} \pm 0.11$	$5.27^{b} \pm 0.12$
Taste	$5.77^{b} \pm 0.10$	$6.03^{a} \pm 0.08$	$5.96^{a} \pm 0.09$	$5.84^{a} \pm 0.10$	$6.21^{a} \pm 0.11$	$5.82^{b} \pm$ o.11	$5.68^{b} \pm 0.12$
Mouth feel	$5.76^{a} \pm 0.09$	$5.68^{a} \pm 0.10$	$5.78^{a} \pm 0.09$	$5.66^{a} \pm 0.09$	$5.96^{a} \pm 0.11$	$5.68^{ab} \pm 0.12$	$5.52^{b} \pm 0.11$
Overall acceptability	$5.75^{a} \pm 0.10$	$5.93^{a} \pm 0.08$	$5.93^{a} \pm 0.09$	$5.76^{a} \pm 0.09$	$6.15^{a} \pm 0.10$	$5.72^{b} \pm 0.11$	$5.66^{b} \pm 0.11$

Key: Means with the same letters across the row for each factor are not significantly different at $p < 0.05$.

gum as well as the different matrix of the fruit used and the overlapping effect of the molecules in the system [17].

Generally, in terms of all the attributes, fruit 2 without gum Arabic scored higher as shown in **Table 3**. This may due to the fact that the jam without gum Arabic had low brix (45˚) and therefore low methoxyl pectin was used as compared to the others in which high esterified pectin was used. This is likely to influence the interaction of the matrix in the system and therefore, affect the sensory quality of the final product [18].

The means of different sensory attributes for interaction between the different fruits used and different levels of sugar used in jam making are presented in **Table 4**. Fruit 2 with 35% sugar level was preferred most in all sensory attributes. This can be explained by the fact that the sharp acidity taste of the plum jam was masked by the addition of sugar and the sugar-acid balance was better achieved. This observation is in agreement with the report by [14]. Fruit 1 with 35% sugar level was scored low in all the sensory attributes. Pineapples are generally sweeter than plums and the 35% sugar felt too sweet for a sugar reduced jam. Similar findings were reported by [19]. On the contrary, [20] found that jam consumers prefer sweeter products as opposed to those with lower sweetness. As for general acceptability fruit 1 with 30% sugar, fruit 2 with 30% and 35% sugar were preferred.

Table 5 presents the means on the interaction between sugar levels and the gum Arabic levels used. Jam that had 30% sugar and 0% gum and 35% sugar and 20% gum had the best score in terms of color. This may be due to several factors

Table 3. Mean ± std error of different sensory attributes for interaction between the different fruits used and different levels of gum Arabic.

Fruit	Gum Level	Color	Spreadability	Taste	Mouth feel	Overall
1	0	$6.03^{b} \pm 0.17$	$5.80^{b} \pm 0.19$	$6.17^{ab} \pm 0.16$	$6.07^{a} \pm 0.13$	$6.05^{ab} \pm 0.17$
	15	$5.80^{b} \pm 0.16$	$5.88^{ab} \pm 0.17$	$5.77^{b} \pm 0.17$	$5.85^{ab} \pm 0.14$	$5.75^{b} \pm 0.16$
	20	$6.00^{b} \pm 0.16$	$4.88^{c} \pm 0.18$	$5.37^{c} \pm 0.19$	$5.35^{c} \pm 0.16$	$5.45^{c} \pm 0.17$
2	0	$6.27^{a} \pm 0.14$	$6.07^{a} \pm 0.16$	$6.25^{a} \pm 0.14$	$5.85^{ab} \pm 0.16$	$6.25^{a} \pm 0.12$
	15	$6.02^{b} \pm 0.14$	$6.07^{a} \pm 0.15$	$5.87^{b} \pm 0.13$	$5.52^{bc} \pm 0.18$	$5.68^{b} \pm 0.14$
	20	$6.27^{a} \pm 0.07$	$5.65^{b} \pm 0.15$	$5.98^{b} \pm 0.15$	$5.68^{b} \pm 0.16$	$5.87^{b} \pm 0.13$

Key: Means with the same letters within the column are not significantly different at $p < 0.05$.

Table 4. Mean ± std error of different sensory attributes for interaction between the different fruits used and different levels of sugar used in jam making.

Fruit	Sugar Level	Color	Spreadability	Taste	Mouth feel	Overall
1	30	$5.98^{b} \pm 0.13$	$5.74^{b} \pm 0.16$	$5.96^{a} \pm 0.14$	$5.93^{a} \pm 0.13$	$5.93^{a} \pm 0.14$
	35	$5.91^{b} \pm 0.14$	$5.30^{c} \pm 0.14$	$5.58^{b} \pm 0.12$	$5.58^{b} \pm 0.12$	$5.57^{b} \pm 0.13$
2	30	$6.22^{a} \pm 0.09$	$5.77^{b} \pm 0.14$	$5.96^{a} \pm 0.12$	$5.63^{b} \pm 0.13$	$5.92^{a} \pm 0.11$
	35	$6.14^{ab} \pm 0.10$	$6.09^{a} \pm 0.11$	$6.11^{a} \pm 0.11$	$5.73^{ab} \pm 0.14$	$5.94^{a} \pm 0.11$

Key: Means with the same letters within the column are not significantly different at $p < 0.05$.

perceived by the panelists. The jam without gum Arabic had a brighter color which could be appealing. This observation is similar to that of [21]. This phenomenon can also be explained by the fact that the brighter red color is close to that of commercial jams in which the pulp is generally bleached by preservatives used prior to jam processing and thereafter, food red color is added. The added red color is generally brighter than the original color of the plum puree. The jam with 35% sugar and 20% gum Arabic on the other hand had a deeper intensity in color for both fruits due to increased opacity as the total soluble solids increased. This therefore gave an impression of higher fruit content. This observation is in agreement with that reported by [14] [21]. Jam with 30% sugar, 0% and 15% gum level were best in terms of spreadability. Those with 30% sugar and 0% gum level scored higher in all attribute hence liked more is shown in **Table 5**.

The means of the different sensory attributes for interaction between fruits, sugar level and levels of gum Arabic used are presented in **Table 6**. The product

Table 5. Mean ± std error of different sensory attributes for interaction between different levels of sugar used and different levels of gum Arabic.

Sugar	Gum Level	Color	Spreadability	Taste	Mouth feel	Overall
30	0	$6.27^{a} \pm 0.14$	$6.23^{a} \pm 0.17$	$6.37^{a} \pm 0.14$	$6.18^{a} \pm 0.14$	$6.42^{a} \pm 0.13$
	15	$6.00^{b} \pm 0.13$	$6.02^{ab} \pm 0.16$	$6.00^{b} \pm 0.12$	$5.75^{b} \pm 0.15$	$5.80^{b} \pm 0.13$
	20	$6.03^{b} \pm 0.15$	$5.02^{d} \pm 0.18$	$5.50^{c} \pm 0.18$	$5.42^{b} \pm 0.17$	$5.57^{c} \pm 0.18$
35	0	$6.03^{b} \pm 0.17$	$5.63^{bc} \pm 0.17$	$6.05^{b} \pm 0.16$	$5.73^{b} \pm 0.15$	$5.88^{b} \pm 0.15$
	15	$5.82^{b} \pm 0.17$	$5.93^{b} \pm 0.16$	$5.63^{c} \pm 0.17$	$5.62^{b} \pm 0.18$	$5.63^{bc} \pm 0.17$
	20	$6.23^{a} \pm 0.10$	$5.52^{c} \pm 0.16$	$5.85^{b} \pm 0.16$	$5.62^{b} \pm 0.15$	$5.75^{bc} \pm 0.12$

Key: Means with the same letters within the column are not significantly different at $p < 0.05$.

Table 6. Mean ± std error of different sensory attributes for interaction between fruits, sugar level and levels of gum Arabic used.

Fruit	Sugar	Gum Arabic	Color	Spreadability	Taste	Mouth feel	Overall
1	30	0	$6.27^{a} \pm 0.19$	$6.47^{a} \pm 0.22$	$6.67^{a} \pm 0.12$	$6.57^{a} \pm 0.12$	$6.57^{a} \pm 0.16$
		15	$5.87^{b} \pm 0.19$	$6.13^{b} \pm 0.20$	$6.00^{bc} \pm 0.18$	$6.00^{b} \pm 0.18$	$5.93^{c} \pm 0.19$
		20	$5.80^{b} \pm 0.27$	$4.63^{e} \pm 0.29$	$5.20^{e} \pm 0.29$	$5.23^{d} \pm 0.26$	$5.30^{e} \pm 0.30$
	35	0	$5.80^{b} \pm 0.27$	$5.13^{d} \pm 0.24$	$5.67^{cd} \pm 0.26$	$5.57^{cd} \pm 0.20$	$5.53^{d} \pm 0.27$
		15	$5.73^{b} \pm 0.26$	$5.63^{c} \pm 0.26$	$5.53^{d} \pm 0.28$	$5.70^{cd} \pm 0.22$	$5.57^{d} \pm 0.26$
		20	$6.20^{a} \pm 0.18$	$5.13^{d} \pm 0.22$	$5.53^{d} \pm 0.23$	$5.47^{d} \pm 0.20$	$5.60^{d} \pm 0.15$
2	30	0	$6.27^{a} \pm 0.20$	$6.00^{b} \pm 0.25$	$6.07^{b} \pm 0.23$	$5.80^{bc} \pm 0.24$	$6.27^{b} \pm 0.20$
		15	$6.13^{b} \pm 0.16$	$5.90^{b} \pm 0.25$	$6.00^{bc} \pm 0.15$	$5.50^{d} \pm 0.23$	$5.67^{d} \pm 0.18$
		20	$6.27^{a} \pm 0.10$	$5.40^{c} \pm 0.20$	$5.80^{c} \pm 0.21$	$5.60^{cd} \pm 0.22$	$5.83^{cd} \pm 0.19$
	35	0	$6.27^{a} \pm 0.20$	$6.13^{b} \pm 0.19$	$6.43^{a} \pm 0.16$	$5.90^{b} \pm 0.22$	$6.23^{b} \pm 0.12$
		15	$5.90^{b} \pm 0.22$	$6.23^{ab} \pm 0.16$	$5.73^{cd} \pm 0.21$	$5.53^{d} \pm 0.28$	$5.70^{d} \pm 0.23$
		20	$6.27^{a} \pm 0.10$	$5.90^{b} \pm 0.22$	$6.17^{b} \pm 0.21$	$5.77^{c} \pm 0.23$	$5.90^{cd} \pm 0.19$

Key: Means with the same letters within the column are not significantly different at $p < 0.05$.

with fruit 1 (pineapple), 30% sugar and 0% gum Arabic scored higher for the sensory attributes including the general acceptability. Products with fruit 2 (plum), 30% sugar and 15% gum Arabic were scored less in all the attributes but fruit 1 with 30% sugar and 20% gum Arabic was most disliked.

4. Conclusion

The results obtained from this study show that gum Arabic from A*cacia senegal* var. *kerensis* can be used as an ingredient in plum and pineapple jam formulation to partially substitute sucrose. Different levels of gum and sugar affected different sensory parameters of the different fruits. From the results 15% gum is the best level to use in both fruits to improve on spreadability, mouth feel and overall acceptability. The minimum amount of sugar that produced acceptable sensory attributes is 30% for the pineapple jam and 35% for the plum jam. Therefore for sweeter fruits it is possible to reduce the amount of sugar by a bigger margin while still maintaining the sweetness. Fruits with a more tart or acidic taste require a relatively higher amount of sugar to mask the taste. The results reported in this current study present empirical data showing that it is possible to substitute 50% sucrose with 15% gum Arabic on w/w basis without adversely affecting the sensory attributes. For fruits such as pineapple, the amount of sucrose that can be substituted by gum Arabic w/w is higher than 50%.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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