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Some variables of gelling blend and bulk sweetener on textural and sensorial properties of Wax Apple Fruit (*Syzygium Samarangense*) Jam

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Wax apple fruit (*SyzygiumSamarangense*) grew and ripen within a very short period of the year leading to an overabundance during harvesting season. It's highly perishable due to high moisture content and enzymatic reaction. It could be converted into high value added product for long-term consumption via jam making. Consumer tended to jam containing low-calorie, high protein and dietary fibre for better health benefit. Gelling agents were inevitable to create a thick gel consistency for jam. Guar gum was used in the food industry for its ability to bond and immobilize large amounts of water. Carrageenan had ability to modify the rheology of food systems. Hydrogenated starch hydrolysate would be as ideal replacement for sucrose in jam preparation. In this research, two independent variables, including various levels of gelling blend (guar gum:carrageenan, 30:70, 40:60, 50:50, 60:40, 70:30 w/w) and bulk sweetner (hydrogenated starch hydrolysate:sucrose, 15:85, 30:70, 45:55, 60:40, 75:25 w/w) were verified. Jam was taken to evaluate overall acceptance and textural properties such as hardness, adhesiveness and springiness. Results showed that carrageenan increased consistency index of wax apple jam while guar gum decreased functional characteristic. Guar gum: carrageenan should be at 40:60 to obtain good gel consistency and organoleptic attribute. Hydrogenated starch hydrolysate could replace 45% sucrose in wax apple jam making.

Keywords: Adhesiveness, carrageenan, guar gum, hardness, hydrogenated starch hydrolysate, overall acceptance, springiness, wax apple jam

INTRODUCTION

Wax apple (*Syzygiumsamarangense*) waspopularlydistributedin the South of Vietnam. It's non-climacteric tropical fruit also known as wax jambu, java apple and rose apple(Nuruljannah et al. 2018). It had pearshape with pink, light red, greenish-white and creamcolors. Generallyit had crisp, juicy, refreshing, acid-sweet taste and aromatic flavour (Rosnah et al. 2012). The epicarpwas thin, smooth and red dish; the mesocarp and the endocarp were whitish and succulent (Costa et al. 2006).Itspulp was a rich in protein, carbohydrates, vitamins, fibres,phenolics, flavonoids andantioxidants (Moneruzzamanet al. 2011; Mohammad, 2014; Madhavi and Ram, 2015; Lirin et al. 2017). There were many therapeutic advantages from using this fruit (Mohammad et al. 2012).

The most availabe components in jam making included fresh fruit, sucrose, gelling agent at low acidity boiled to a thick gel consistency and firm enough to hold the fruit tissues in position (Ho et al. 2020). Hydrocolloids could effectively enhance and preserve rheological properties such as texture, viscosity, and structure of low caloric jam (Pereira et al. 2017). Guar gum was a glycosidic polysaccharide constituted with units of β-

1,4glycosidic mannose and includes a α-1,6 galactose unit in every two units of mannose, causing ramifications (Mudgil et al. 2014). Guar gum produced viscous solution useful in different applications in thickening, stabilization, rheological and viscosity control, suspension and formation of the body, modification of the texture, and retention of water (Dziezak, 1991; Sanderson, 1996). Carrageenan was polysaccharide originated from marine red algae of the Rhodophyceae class. It provided unique functional characteristics as gelling agent, thickener and stabilizer. In solution, in the presence of some cations (K^+, Rb^+, Ca^{++}), the double helices of carrageenan could aggregate and form gel. The functional properties of carrageenan gels, such as rigidity, turbidity, and tendency to syneresis generally decreased with the increasing degree of sulphation in these polymers. Carrageenan provided only fiber with no nutritional value for the human body but making unique functional characteristics of food (Jancikova et al. 2019).

Sucrose was commonly supplemented into jam for sweet taste and a natural preservative in retardation of microbial growth under low moisture content (Alsuhaibani and Al-kuraieef, 2018). Unfortunately sucrose abuse was ussually correlated to high energy consumption inducing to higher risks for health such as obesity, metabolic syndrome, and diabetes (Krystyjan et al. 2015; Ho et al. 2020). People requested jam containing low sucrose contnet, high protein and dietary fibre (Abdullah and Cheng, 2001; Mamede et al. 2013; Amin et al. 2016; Anna et al. 2018). Hydrogenated starch hydrolysate could be effectively used in food industry and other sectors as bulk sweetener, texture, preservation, filling, moisture capture, and cooling effect in the mouth (Fitch and Keim, 2012; Małgorzata, 2015; Awuchi, 2017). Although the sweetness of hydrogenated starch hydrolysate was lower than saccharose (0.4 to 0.9), it contributed to neither tooth decay, caramelization nor high calorie intake while having the same bulk volume (Bradshaw and Marsh, 1994; Soma and Sudha, 2012). Owing to slow and incomplete absorption, it had a reduced glycaemic potential relative to glucose for individuals with and without diabetes (Wheeler et al. 1990; Geoffrey, 2003). Hydrogenated starch hydrolysate could be applied to partly replace saccharose or corn syrup in bakery such as cakes, cookies and granola bars due to its excellent humectancy (Adrienne and William, 2017). Objective of our study investigated some variables of gelling blend (guar gum: carrageenan) and bulk sweetner (hydrogenated starch hydrolysate:sucrose) to the textural sensorial properties of wax apple fruit (*SyzygiumSamarangense*) jam..

MATERIALS AND METHODS

Material

Wax apple fruits were harvested in Can Tho city, Vietnam. They must be cultivated following VietGAP to ensure food safety. After collecting, they must be washed thoroughly under turbulent washing water to remove foreign matters. Apar from was apple fruits, other materials such as guar gum, carrageenan, hydrogenated starch hydrolysate, sucrose were purchased from local market in SocTrang province, Vietnam.

Researching method

A recommended gelling blend of guar gum and carrageenan solution (15 g/1000 mL water) in different ratio (30:70, 40:60, 50:50, 60:40, 70:30 w/w) was thoroughly mixed. Wax apple pulp after removing seeds was added and heated for 20 minutes. Bulk sweetner of hydrogenated starch hydrolysate and sucrose (250 g/1000 g material) in different ratio (15:85, 30:70, 45:55, 60:40, 75:25 w/w) was added and heated for 5 minutes. Jam was poured into sterilized jar and preserved at 10±2^{o}C before evaluation.

Textural and sensorial evaluation

Hardness (g), adhesiveness (g.s) and springiness (mm) were measured by using texture analyzer. Overall acceptance was evaluated by a group of panellist using 9-point Hedonic scale.

Statistical analysis

The experiments were run in triplicate with different groups of samples. The data were presented as mean±standard deviation. Statistical analysis was performed by the Statgraphics Centurion version XVI.

RESULTS AND DISCUSSION

Hardness

Hardness (g) was defined as peak force required for first compression. Springiness, showed the same tendency as hardness, but adhesiveness had a negative correlation with hardness. A blend of guar gum with a smaller amount of carrageenan may be used to improve a high-quality ice cream (Nussinovitch, 1997). The influence of gelling blend (guar gum:carrageenan,

30:70, 40:60, 50:50, 60:40, 70:30 w/w) and bulk sweetner ratio (hydrogenated starch hydrolysate:sucrose, 15:85, 30:70, 45:55, 60:40, 75:25 w/w) to hardness (g) of wax apple jam was presented in table 1. It's clearly noticed that the higher ratio of guar gum: carrageenan, the hardness of wax apple jam decreased slightly. Meanwhile, higher ratio of hydrogenated starch hydrolysate:sucrose resulted to a higher hardness. Pietrasik (2003) found that carrageenan had a substantial increase in hardness of processed meats. Jancikova et al. (2019) evaluated the effect of carrageenan and pectin on preparation of cherry and apricot jam. These jams should be prepared with 1 % pectin and 0.5 % carrageenan. Carrageenan possessed better binding properties than pectin.

Springiness

Springiness (mm) was the distance that sample recovered after first compression. In our research, the springiness of wax apple jam by incorporation of guar gum: carrageenan and hydrogenated starch hydrolysate: sucrose was presented in table 2. It's obviously noticed that the higher ratio of guar gum: carrageenan, the springiness of wax apple jam decreased slightly. Meanwhile, higher ratio of hydrogenated starch hydrolysate: sucrose resulted to a better springiness. During heating in jam production, carrageenan existed as random (disordered) ball structures because of the electrostatic repulsions between the polymer chains. Once cooled, the polymeric chains changed conformation to a helix structure (ordered). The presence of cations (K^+, Ca^{+2}, and Na^+), especially Ca^{+2} in wax apple pulp leaded to the aggregation of helixes and formation of a stable gel forming by intermolecular interactions between carrageenan chains (Rhein-Knudsen et al. 2015; Tavassoli-Kafrani et al. 2016). The gelation of carrageenan went from the transition of disordered random coil to the ordered helical state (Budak, 2017). The texture significantly influenced the final product assessment (Valente et al. 2011). Improper texture might cause unacceptable feeling to consumer (Aprea et al. 2006; Lokke et al. 2012). Jam consistency depended on the amount and type of sweeteners, gelling agents, and fruit pulp (Basu et al. 2013, Basu and Shivhare, 2010).

Adhesiveness

Adhesiveness (g.s) was defined as the negative force area for the first bite representing the work necessary to pull the compressing plunger away from the sample. In our research, the adhesiveness of wax apple jam by incorporation of guar gum: carrageenan and hydrogenated starch hydrolysate:sucrose was presented in table 3. It's obviously noticed that the higher ratio of guar gum:carrageenan, the adhesiveness of wax apple jam increased dramatically. Meanwhile, higher ratio of hydrogenated starch hydrolysate: sucrose resulted to a decrease of adhesiveness. Sugar had an important role injam production to bind water inducing pectin gelatinization, reducing the water activity, inhibiting microbial growth and subsequent deterioration contributing to the acceptable physicochemical and sensory attributes (Basu and Shivhare, 2010). Texture of jam had to provide a balance between desired mechanical stability and desired instability (Basu et al. 2011).

Overall acceptance

The acceptability of wax apple jam by incorporation of guar gum: carrageenan and hydrogenated starch hydrolysate: sucrose was presented in table 4. It's obviously noticed that the higher ratio of guar gum: carrageenan, the overall acceptance of wax apple jam decreased slightly. Meanwhile, higher ratio of hydrogenated starch hydrolysate: sucrose resulted to better overall acceptance. 45% hydrogenated starch hydrolysate in replacement to sucrose had the highest organoleptic property. Amanda and Carole (1991) examined the possibility of hydrogenated starch hydrolysate to partially replace sucrose to the texture of yellow layer cakes. Bayarri et al. (2004) and Bayarri et al. (2006) concluded that gelling agents modifies the mechanical properties (diffusion) of gels, influencing the perception of flavor. Kostyra and Baryłko-Pikielna (2007) reported that the addition of guar gum decreased the perception of flavor in mayonnaise. Formation of a high viscosity system was associated with the structure of guar gum. The low acceptability related to guar gum occurred because of not forming gel property (Nikaedo et al. 2004). Pietrasik (2003) confirmed that the supplementation of carrageenan resulted in darker products compared with those without any addition. Pereira et al. (2017) found that an increase in the addition of carrageenan resulted in lower scores for the flavor attribute of sugar-free guava preserves. Michelle et al. (2019) evaluated the effect of low methoxyl pectin, guar gum, and carrageenan on the properties of low caloric orange jellies.

Table 1: Hardness (g) of wax apple jam affected by gelling blend ratio and bulk sweetner ratio

Guar gum:carrageenan (w/w)	Hydrogenated starch hydrolysate:sucrose (w/w)				
	15:85	30:70	45:55	60:40	75:25
30:70	6.14±0.09^{cd}	6.81±0.17^{c}	7.45±0.09^{bc}	8.19±0.14^{ab}	8.97±0.11^{a}
40:60	5.63±0.16^{d}	6.09±0.11^{cd}	6.90±0.12^{c}	7.58±0.06^{bc}	8.03±0.12^{b}
50:50	5.17±0.13^{de}	5.73±0.24^{d}	6.18±0.17^{cd}	6.97±0.13^{c}	7.56±0.09^{bc}
60:40	4.81±0.10^{e}	5.16±0.16^{de}	5.79±0.11^{d}	6.15±0.11^{cd}	6.94±0.14^{c}
70:30	4.75±0.11^{e}	4.79±0.12^{e}	5.20±0.15^{de}	5.81±0.17^{d}	6.13±0.16^{cd}

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 2: Springiness (mm) of wax apple jam affected by gelling blend ratio and bulk sweetner ratio

Guar gum:carrageenan (w/w)	Hydrogenated starch hydrolysate:sucrose (w/w)				
	15:85	30:70	45:55	60:40	75:25
30:70	4.75±0.13^{c}	5.01±0.12^{bc}	5.26±0.11^{b}	5.48±0.16^{ab}	5.72±0.18^{a}
40:60	4.39±0.07^{cd}	4.74±0.08^{c}	5.02±0.19^{bc}	5.20±0.12^{b}	5.45±0.10^{ab}
50:50	4.02±0.12^{de}	4.48±0.13^{cd}	4.74±0.06^{c}	4.96±0.11^{bc}	5.19±0.14^{b}
60:40	3.69±0.16^{e}	4.21±0.15^{d}	4.49±0.18^{cd}	4.70±0.19^{c}	4.93±0.11^{bc}
70:30	3.65±0.13^{e}	3.97±0.17^{de}	4.23±0.23^{d}	4.44±0.23^{cd}	4.68±0.16^{c}

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 3: Adhesiveness (g.s) of wax apple jam affected by gelling blend ratio and bulk sweetner ratio

Guar gum:carrageenan (w/w)	Hydrogenated starch hydrolysate:sucrose (w/w)				
	15:85	**30:70**	**45:55**	**60:40**	**75:25**
30:70	0.72±0.03^{c}	0.59±0.01^{cd}	0.46±0.02^{d}	0.29±0.00^{ef}	0.17±0.02^{f}
40:60	0.83±0.01^{bc}	0.70±0.00^{c}	0.54±0.03^{d}	0.41±0.02^{de}	0.26±0.01^{ef}
50:50	0.92±0.00^{b}	0.81±0.02^{bc}	0.66±0.01^{cd}	0.50±0.03^{d}	0.35±0.02^{e}
60:40	1.01±0.02^{ab}	0.93±0.03^{b}	0.75±0.00^{c}	0.61±0.01^{cd}	0.47±0.00^{d}
70:30	1.13±0.03^{a}	1.02±0.01^{ab}	0.87±0.02^{b}	0.73±0.00^{c}	0.58±0.01^{cd}

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 4: Acceptability (sensory score) of wax apple jam affected by gelling blend ratio and bulk sweetner ratio

Guar gum:carrageenan (w/w)	Hydrogenated starch hydrolysate:sucrose (w/w)				
	15:85	**30:70**	**45:55**	**60:40**	**75:25**
30:70	8.79±0.02^{b}	8.86±0.00^{ab}	8.98±0.01^{a}	8.43±0.03^{bc}	8.02±0.00^{d}
40:60	8.71±0.00^{b}	8.83±0.03^{ab}	8.91±0.02^{a}	8.37±0.01^{c}	7.89±0.01^{de}
50:50	8.20±0.03^{cd}	8.36±0.01^{c}	8.49±0.00^{bc}	8.06±0.00^{d}	7.55±0.03^{e}
60:40	7.65±0.01^{e}	7.98±0.02^{d}	8.13±0.03^{cd}	7.84±0.02^{de}	7.13±0.02^{f}
70:30	7.10±0.02^{f}	7.57±0.00^{e}	7.89±0.01^{de}	7.32±0.01^{ef}	6.72±0.00^{g}

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant (α = 5%).

They concluded to use low methoxyl pectin concentration between 0.75% and 1% and carrageenan concentration of 0%–0.25% as well

as to exclude guar gum. The formulations containing high guar gum concentration obtained less acceptance.

CONCLUSION

The demand for low-sugar jam increased on the market. Guar gum and carrageenan belonged to hydrocolloids having a wide range of application in the food industry. Hydrogenated starch hydrolysate was successfully utilized as sugar-free sweetener to partly replace sucrose in wax apple jam. It had multiple potential health benefits. Its non-cariogenic, low glycemic, low-energy, low insulin emic, low-digestible, osmotic carbohydrate. Making jam from this indigenous fruit was an efficient approach to utilize the excess fruit to improve its palatability. The possibility of low calorie jam production from wax apple would create employment, improve income for local farmers. Consumer had more chance to use this healthy product..

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Nguyen Phuoc Minh arranged the experiments and also wrote the manuscript.

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