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OPTIMIZING THE ACCEPTABILITY OF JAM FROM *BACCAUREA ANGULATA* FRUIT PEEL

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ABSTRACT

The purpose of this study was to utilize the fruit peel of *Baccaurea angulata* to produce a fruit jam. The *B. angulata* fruit was an underutilized fruit known as "*Belimbing Hutan*" or wild starfruit in Sabah and Sarawak. The peel of *B. angulata* fruit makes up more than 60% of the fruit and is a significant source of food waste having potential to be explored. Using conventional jam making technology, the peel of *B. angulata* was used as the principal ingredient to produce a jam besides sugar and pectin. To find the optimal formulation, the D-Optimal of Mixture Design of Design Expert Version 10 software was employed. The software generated sixteen formulations and from those sixteen formulations, sensory evaluation was conducted to determine the optimal formulation. The optimal acceptability of the *B. angulata* fruit peel jam was determined by using seven sensory responses namely sweetness, sourness, spreadability, colour, texture, aroma and overall acceptance. Of the sixteen formulations, formulation number 9 (49.5% puree, 49.5% sugar and 1.0% pectin) was selected by the sensory panellists with the highest mean score of overall acceptability (7.2). The contour plots generated using the software explained the various combinations of ingredients that affected the seven sensory responses of the fruit jam.

Keywords: D-Optimal, Mixture Design, *Baccaurea angulata*, Jam, Acceptability

INTRODUCTION

The delicacy of fruit jam dated back to the 1st century where the first ever recipe came out on a cookbook. Jam is a type of fruit preservation where fruits are either chopped, blended or turned into puree and processed by boiling with sugar, acid, pectin and other ingredients which may include colouring and flavouring to give the jam delicious aroma and consistency.

Jam is one of the most popular food products due to its low cost, all year long availability and organoleptic properties. Good jam must have a soft and even consistency without distinct pieces of fruit, a bright colour, good flavour and semi-gelled texture that is easy to spread especially on bread but has no free liquid (Ihediohanma et. al, 2014).

In the jam production, proper proportions of essential ingredients such as fruits, pectin, acid and sugar are required to provide consumer acceptance and satisfaction. Use of fruit in jam production not only provides specific flavour to the jam, it also brings out the colour of the fruit. Colour remains the first attribute that attracts consumers to buy jam product. Pectin is a natural plant substance commonly used as gelling agent in jam production. Some fruits do not contain natural pectin as gelling agent whereas fruits such as apples, blackcurrants, grapes and plums have natural pectin in it. Acid in jam is used to provide additional flavours. Fruits that have high acid

content may not require additional acid in their formulations. Lastly, sugar is used to preserve the fruits as well as to provide additional flavour.

B. angulata or locally known as '*belimbing dayak*' or '*belimbing hutan*' is an underutilized fruit found in the Borneo island of Malaysia (Nurhazni et. al, 2013). The tree grows wild and in abundant especially in the central region of Sarawak. It is a seasonal fruit and the local Iban people called it "uchong" or "ujong" meaning that this fruit will be available at the end of the season. Thus, it can be easily found at the end of the year (November to February). The fruit is sweet with a big seed and a small portion of flesh. It is red when ripe, but it can also be found in various colours ranging from red to purple and sometimes pinkish. The skin of the fruit makes up 69.28 ± 0.95% of the whole fruit (Ahmed et al., 2015).

The objective of the present study was to develop a jam from the skin of *B. angulata* fruit. To our knowledge, this was the first study reported that utilized the fruit waste of this indigenous fruit. The formulations were created by the software Design Expert using the D-Optimal Design. Sensory analysis was conducted to select the most acceptable formulation.

LITERATURE REVIEW

The oldest collection of fruits jam recipe was attributed to Marcus Gavius Apicius in the cookbook of "The Art of Cooking" by De Re Coquinaria that was compiled in the late fourth or early of fifth century (Wilson, 2013). This was related to the way of people preserved their foods by drying, smoking, salting, cooking with sugar or salt. Jam was among the great delicacies that was rich in flavour and energy. Jam can be enjoyed in all kinds of ways, from baked goodies to cheese platters and spreads for roasts.

According to the Malaysian Food Act (1983) and Food Regulations (1985), jam shall be the product prepared by boiling one or more types of sound fruits, whether raw, processed or semi-processed, with a permitted sweetening substance with or without added pectin. Jam shall contain not less than 35% fruit and 65% of soluble solids determined by refractometry at 20°C. Jam may contain permitted preservatives, permitted colouring substance, permitted flavouring substance and permitted food conditioner (Anon., 2014).

The success of fruits jam making depends on the correct combination of acidity, sugar level and pectin content. The high acidity prevents the growth of microorganisms that can cause food poisoning and food spoilage. The sugar level controls yeasts and moulds that can withstand the high acidity (Azam Ali, 2007). Other than preventing and controlling the growth of spoilage microorganisms, acidity and sweetness from sugar can enhance the flavour and texture of fruits jam. Meanwhile, pectin acts as a gelling agent giving the fruits jam proper texture (Branen et al., 2001).

The peel of *B. angulata* makes up 60% of the fruit weight. This is considered a significant fruit waste if the peel is not fully utilized. The peel of *B. angulata* was chosen to be developed into fruit jam because of its sourness. According to Mohd Naeem (2017), jam was rich in moisture, ash, fat, protein, carbohydrate, vitamin C and energy. His study also showed that fruits jams were low in fatty acids. As the price of fruit jams are affordable, it can be concluded that jam serves as a convenient source of energy and carbohydrate (Mohd Naeem, 2017).

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METHODOLOGY

Production of *Baccaurea Angulata* Jam

The fresh fruits of *B. angulata* were purchased from the central region of Sarawak, which were Sibu and Sarikei. First, the fruit were washed thoroughly with clean water. Then, it was cut and sorted into two parts which were skin and pulp or berry. The skin was then blended until it became a puree. The puree was boiled and stirred continuously. To make sure the pectin was not coagulate, sugar was added alternately followed by pectin. Then, the jam was boiled and stirred until it reached its consistency. The prepared jam was carefully poured into sterilized jam bottles following hot filling method.

Sensory Evaluation

Sensory evaluation was performed to determine acceptability of the jam produced. Thirty panellists were selected from the university community. All the samples were served on platters with small pieces of bread. There were seven sensory attributes to be evaluated namely sweetness, sourness, spreadability, colour, texture, aroma and overall acceptance. A 9-point hedonic scale was used in the questionnaire. Panellists were asked to observe and taste the given samples. They were also provided with potable water to rinse their palates after evaluating each sample to prevent taste interference.

Statistical Analysis

The formulations of fruit jam were designed and executed using D-Optimal in Mixture Design of Design Expert Version 10. Mixture Design was used in this study because the fruit jam was made from the mixing process of several ingredients (Design Expert, 2017). The result of sensory analysis was analysed by Mixture Design of Design Expert Version 10. Differences with P-values less than 0.05 was considered to be statistically significant.

RESULTS AND DISCUSSION

The first result generated by the D-Optimal in Mixture Design of Design Expert Version 10 was shown in Table 1. These formulations were produced and evaluated by sensory panellists. The results of sensory evaluation were shown in Table 2. A polynomial model was proposed by the Mixture Design for sensory analysis for each attribute in the production of jam.

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Table 1: Composition of Puree, Sugar and Pectin in Formulation of Jam

Run	Component 1 A: Puree	Component 2 B: Sugar	Component 3 C: Pectin
1	64.00	35.40	0.60
2	54.33	44.80	0.87
3	64.00	35.00	1.00
4	54.33	44.80	0.87
5	35.40	64.00	0.60
6	35.20	64.00	0.80
7	64.00	35.00	1.00
8	56.80	42.50	0.70
9	49.50	49.50	1.00
10	44.80	54.33	0.87
11	49.50	49.50	1.00
12	35.20	64.00	0.80
13	35.00	64.00	1.00
14	54.33	44.80	0.87
15	49.70	49.70	0.60
16	42.50	56.80	0.70

Table 2: Mean Sensory Score of Each Attribute

Run	A: Puree	B: Sugar	C: Pectin	Sweetness	Sourness	Spreadability	Colour	Texture	Aroma	Overall acceptance
1	64.00	35.40	0.60	7.13	6.80	6.80	7.17	6.90	6.43	7.00
2	54.30	44.80	0.87	5.57	5.93	5.20	6.30	5.77	5.73	6.00
3	64.00	35.00	1.00	6.47	6.27	6.77	6.57	6.40	6.33	6.63
4	54.30	44.80	0.87	6.77	6.43	6.40	7.20	6.67	6.77	6.83
5	35.40	64.00	0.60	5.23	4.30	2.80	6.30	3.90	4.63	3.93
6	35.20	64.00	0.80	4.30	2.93	1.07	5.97	1.60	3.07	2.37
7	64.00	35.00	1.00	8.50	6.87	6.97	6.90	6.67	6.20	6.73
8	56.80	42.50	0.70	5.57	5.57	6.20	6.87	6.37	5.77	6.43
9	49.50	49.50	1.00	7.30	7.00	6.33	7.37	6.53	6.23	7.20
10	44.80	54.30	0.87	5.80	5.570	4.77	7.17	4.77	5.63	5.40
11	49.50	49.50	1.00	6.43	6.10	6.13	7.07	6.33	6.03	6.47
12	35.20	64.00	0.80	3.73	3.60	3.03	5.37	3.53	4.10	3.43
13	35.00	64.00	1.00	6.07	5.60	2.73	6.43	4.40	4.80	4.83
14	54.30	44.80	0.87	5.83	6.20	6.67	6.77	6.33	5.53	6.50
15	49.70	49.70	0.60	6.63	6.73	7.70	7.37	6.93	6.40	7.07
16	42.50	56.80	0.70	6.27	5.97	5.07	6.43	5.73	5.73	5.90

Figure 1(a) showed the contour plot of sweetness according to the mean score of panellists. From here, it could be seen that sweetness of the jam was strongly influenced by the amount of sugar and puree used. Red colour of the contour indicated a strong degree in likeness while blue colour contour showed a less likeable scenario. In this scenario, yellow colour was perceived as more likeable in contrast with that of green colour. In term of sweetness, the percentage of sugar and puree played important roles in panellists' preference. Example of this scenario could be seen in Table 1 where Run 7 with 64% puree and 35% sugar provided a mean score of 8.50 which was the highest score out of the other sample run. However, high sugar content prevented the panellists from appreciating this formulation. This could be be seen in Table 1 where Run 12 with 35.20% puree and 64% sugar received the lowest mean score by panellists with only 3.73. This indicated that both puree and sugar percentage, together with sweetness, played important roles in the jam formulation.

In term of sourness, Figure 1(b) showed the contour with reference to the mean score of panellists. Puree played a significant role in the degree of likeness of sourness of the jam with its highest design point to be 7.00 which was close to the edge of Puree. The sourness of the jam relied primarily on fruit puree as the peel of *B. angulata* is sour. Combination of sourness and sweetness gave a delicious taste that was preferable by the palate of consumers nowadays. Not only that, the natural tartness of the fruit peel demonstrated the presence of organic acids and thus functioned in the preservation of jam.

Figure 1(c) shows the contour plot of spreadability according to the mean score given by the panellists. From the contour, it could be concluded that the degree of likeness for spreadability increased with the addition of pectin. Though the amount of pectin was small (in the range of 0.6% to 1.0%), it helped with the gelation of the jam. Spreadability is crucial in jam as consumers prefer jam that is easier to spread.

Another attribute studied was the colour of the jam (Figure 1(d)). In this study, the colour of the jam depended on the amount of puree used as there was no addition of synthetic colouring. The thicker the puree, the deeper was the colour of the jam. Colour was the first physical appearance that attracted the consumers. However, this did not signify that the increment of puree would produce a highly sought-after jam as other factors such as sourness also determined the final acceptability. The greater the percentage of puree in the formulation, the tarter the jam produced and hence may negatively affect its acceptability among the panellists. Thus, the interrelationship between colour and sourness contributed to the scores of the panellists.

Texture contour plot was shown in Figure 1(e) where the amount of pectin determined the overall texture of the jam due to its gelling and thickening properties. Texture was attributed mainly to the amount of pectin used in the formulation. However, puree and sugar also provided the consistency required in the production of jam. The right amount of these three factors would result in the smooth texture desirable in jam. It could be inferred from the contour plot that the overall colour was in orange to red, meaning that the degree of likeness on texture was dependent on the 3 correlation factors as the mean score were between 6.20 (at the edge of puree) to 7.20 (at the edge of pectin).

Figure 1(f) showed the attribute of aroma where puree has a high design points which was indicated by the orange colour of the contour. Puree did not necessarily indicate aromatic satisfaction as the result showed that the amount of sugar used may also affect the aroma of the jam. Though most of the jam's aroma was derived from puree, sugar also contributed a sweet

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aroma to the jam. This was evident from the mean sensory score where puree content of 54.33% and 44.80% gave the highest mean score for the specific attribute. The combination of the puree's sourness as well as the sweet aroma of sugar produced the unique taste in the jam.

In terms of overall acceptability, Figure 1(g) showed the contour plot of the specific attribute. From here, all three factors namely puree, sugar and pectin provided equal amount of likeness if these they were considered in the jam production. Both edges of puree and pectin showed a reddish colour, suggesting that panellists liked both the formulations. However, the middle area contour suggested that equal amount of the three factors should be avoided as they do not produce the best rating. The contour suggested that high amount of puree and sugar with a low amount of pectin should be used in the jam production. On the other hand, high amount of pectin with equal amount of puree and sugar could also be used. From here, it indirectly suggested that formulation 9 and formulation 15 were to be used in the jam production.

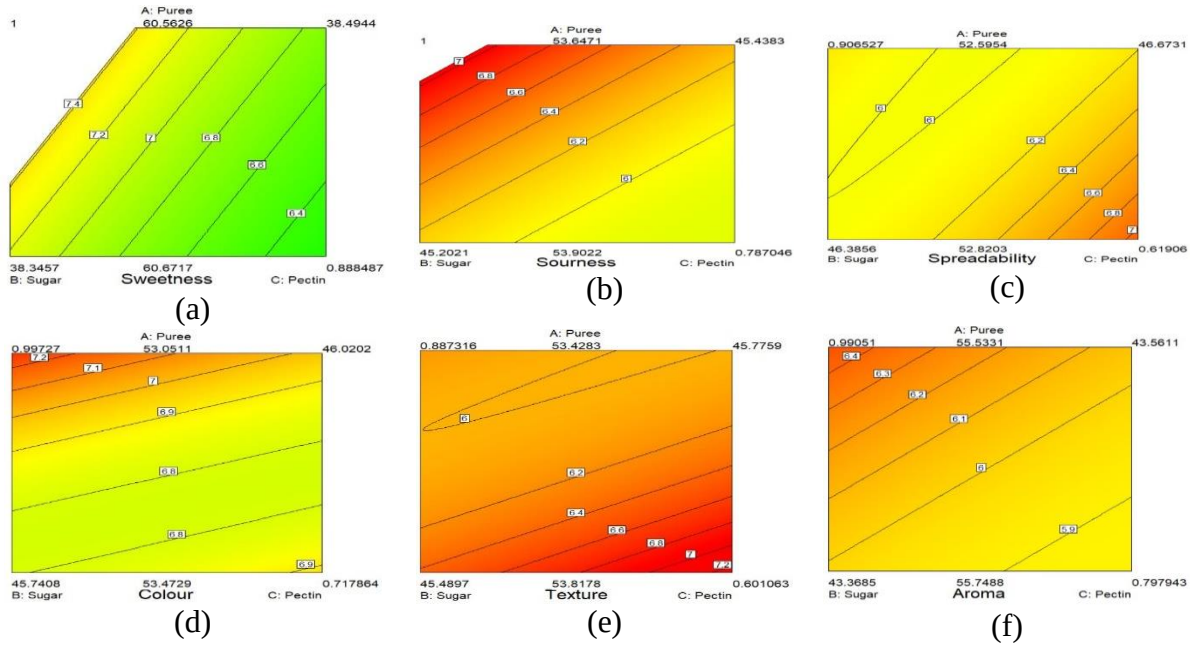
Contour profile plots in Figure 1(h) showed the optimum values in producing *B. angulata's* jam. Based on the contour, the optimum value for the jam production was 55.18% puree, 43.74% sugar and 0.64% pectin. Equation 1 whereby,

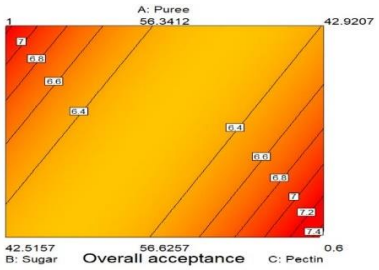
Y= 0.124329A + -0.0299338B + 2659.98C + 0.00742642AB - 27.0678AC - 26.988BC
where,

A = Puree
B = Sugar
C = Pectin

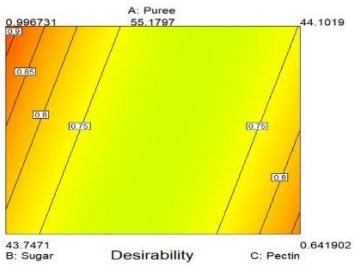
showcased the final equation in terms of actual components that were optimised by Design Experts to satisfy all attributes whilst giving the best formulation in the production of *B. angulata's* jam.

Figure 1: The contour plot of responses according to the mean score of panellists.





(g)



(h)

CONCLUSION

The present study was to develop a jam using the peel of *B. angulata* fruit. D-Optimal in Mixture Design of Design Expert Version 10 was used to optimize the formulation of the three-component mix of puree, sugar and pectin. Out of the sixteen formulations, the best formulation was formulation 9 with 49.5% puree, 49.5% sugar and 1.0% pectin. This formulation has the highest mean for sourness (7.00), colour (7.37) and overall acceptability (7.20). The final formulation generated by the D-Optimal in Mixture Design was

Y= 0.124329A + -0.0299338B + 2659.98C + 0.00742642AB - 27.0678AC - 26.988BC
where,

A = Puree
B = Sugar
C = Pectin

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