Formula Optimization and Characterization of Fruit Leather based on Carica Fruit (*Carica pubescens,* L)

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ABSTRACT

Research on the production of fruit leather from carica was carried out to increase the utilization of pulp and over-ripe carica fruit, and for food diversification. The formula of this product consisting of high fructose syrup (HFS), sorbitol, sucrose, kappa carrageenan, konjac glucomannan, stevia sugar, carboxy methyl cellulose (CMC) and citric acid. This study was aimed to: 1) determine the proportion of HFS and sorbitol that can produce carica fruit leather with maximum intensity score of preferency, carica flavor, chewiness, and plasticity; minimum intensity score of hardness; and in range intensity score of softness and stickiness; 2) examine the effect of the addition of HFS and sorbitol on the sensory properties of carica fruit leather; 3) comparing carica fruit leather with optimum formula with control (products made without HFS and sorbitol). The optimization of the formula was carried out by the response surface methodology using a central composite design. There were 2 optimized factors, i.e. the proportion of HFS and sorbitol. The minimum and maximum proportions for HFS were 0 and 10%; while sorbitol were 0 and 4%. The selection of 2 blocks using design expert software (V.XIII for trial) produced 14 factor combinations. Sensory test was carried out using a scoring method with an intensity scale of 1-7. The results showed that: 1) the optimum formula for carica fruit leather with a desirability value of 0.70 was obtained with a composition of 7.13% HFS and
2.31% sorbitol; 2) Formula optimum of carica fruit leather had an actual intensity score (range 1-7) i.e. plasticity 4.29, softness 4.93, chewiness 4.25, stickiness 3.54, hardness 2.36, carica flavor 4.57, and preferency 4.74; 3) The increasing of the proportion of HFS caused an increase in the intensity of preferency, carica flavor, chewiness, stickiness, softness, and plasticity, but decreasing in the intensity of hardness; 4) The increasing of the proportion of sorbitol caused an increase in the intensity of flavor, hardness, chewiness, and stickiness, but decreasing in the intensity of preferency, softness and plasticity; 5) Carica fruit leather with the optimum formula had a higher intensity of preference, carica flavor, chewiness, softness, and stickiness than the control; while the intensity of hardness was lower; 6) With 198.65Kcal/100g energy, fruit leather with optimum formula contains carbohydrates, ash, protein, fat, and total dietary fiber i.e. 46.17%wb,
1.35%wb, 2.3%wb, 0 ,53%wb, 6.7%wb, respectively.

Keywords: *Carica pubescens,* L, fruit leather, high fructose syrup, sorbitol, response surface methodology

INTRODUCTION

Carica (Carica pubescens, Lenne & K. Koch) which is rich in dietary fiber, vitamin C and potassium is one of the main commodities of the Dieng plateau. The fruit is similar to papaya, small in size, and fragrant. Fruits that contain a lot of oxalate compounds must be processed before consumption. If eaten immediately, it will cause itching. If the sap from the fresh fruit sticks to our skin, the skin will feel itchy, slightly hot and burning. Most of the carica fruit is processed by hundreds of MSMEs in the Dieng area and its surroundings into wet candied fruit (carica cocktail). In the processing of carica cocktails, by-products are produced which until now have not been utilized, namely in the form of overripe fruit and pulp. The pulp has a strong carica flavor and is rich in fiber but quickly decomposes when stored. Pulp spoilage can be overcome by processing steps, namely boiling, mixing, filtering, and cooling with refrigeration. This process produces a filtrate (as a source of flavor). Overripe fruit that has been peeled and separated from the pulp and seeds can be boiled and crushed with the addition of pulp filtrate, and then the resulting pure carica can be used as a raw material in the manufacture of various processed fruit products.

Research on the production of fruit leather from carica was carried out to increase the utilization of pulp and over-ripe fruit, and for food diversification. The formula of this product consisting of HFS, sorbitol, sucrose, k-carrageenan, k-glucomannan, stevia, CMC, and citric acid.

This study were aimed to : 1) determine the proportion of HFS and sorbitol that can produce carica fruit leather with maximum intensity score of preferency, carica flavor, chewiness, and plasticity; minimum intensity score of hardness; and in range intensity score of softness and stickiness; 2) Examine the effect of the addition of HFS and sorbitol on the sensory properties of carica fruit leather; 3) Comparing carica fruit leather with optimum formula and control (products made without HFS and sorbitol)

MATERIALS AND METHODS

Materials

Carica fruit was obtained from Wonosobo district. Other ingrediens (HFS, sorbitol, sucrose, k-carrageenan, k-glucomannan, stevia, CMC, and citric acid) were obtained from CV.

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Method

The stages of this research were : 1) determination of basic formula and process; 2) recruitment of semi trained panelists; 3) formula optimization (skoring test); 4) physicochemical analysis of product with optimum formula

The basic formula consists of the main and supporting ingredients, The percentage of supporting ingredients was calculated based on the total of the main ingredients used (Table 1)

Table 1. The basic formula of fruit leather

Type of ingredient	Name of ingredient	Basic value (%)
Main ingredients	Puree	91
	Sucrose	9
		100
Supporting Ingredients	HFS	5
	Sorbitol	2
	Kappa carageenan	0,4
	Konjac glucomannan	0,1
	CMC	0,1
	Stevia sugar	0,5
	Citric acid	0,3
	Water	20

The stages in the product manufacturing : 1) Preparation of puree and filtrate from over ripe carica fruit; 2) Mixing and cooking ingredients; 3) Drying and Forming; 4) packaging and storage

Preparation of fruit pulp

1. After over ripe carica fruit was peeled, separated between the flesh and the pulp, and then, the flesh was cut into 8 parts.
2. Wash the flesh, boil using hot water at 80oC for 10-15 minutes, then drain
3. Pulp was mixed at low speed using water with a ratio of pulp: water = 1: 2, then cooked until boiling, cooled, filtered with a filter cloth to separate the pulp and the filtrate.
4. Puree was made by crushing the pulp obtained from stage 2 with the filtrate obtained from stage 3 in the ratio of pulp: filtrate = 2: 1

Production of fruit leather:

1. Puree, sucrose, HFS and sorbitol were mixed, then cooked over low heat, stirred, until a homogeneous dough was formed
2. Dissolve CMC, kappa carrageenan and konjac glucomannan with water to form a viscous solution that can flow, then set aside
3. Mix the hydrocolloid solution produced from stage 2 into the dough from stage 1, stir until evenly mixed
4. When the mixture boils and thickens, add the citric acid and stevia sugar which have been dissolved in water
5. Spread the dough on the baking sheet to form a thin layer with a thickness of 0.5 cm
6. Dry the dough using a cabinet dryer at a temperature of 60oC for 6-8 hours
7. Cut the fruit leather into a rectangle with a size of 3x5 cm2, then rolled and wrapped with food grade papper
8. Fruit leather was stored in a glass bottle that has been sterilized before further analysis

Formula Optimization

The optimization of the formula was carried out by the response surface methodology using a central composite design. There were 2 optimized factors, i.e. the proportion of HFS and sorbitol. The minimum and maximum proportions for HFS were 0 and 10%; while sorbitol were 0 and 4%. The selection of 2 blocks using design expert software (V.XIII for trial) produced 14 factor combinations.

The Stages of formula optimization : 1) Determination of the upper and lower limits; 2) Making products with treatments result from RSM recommendation; 3) Measurement of responses; 4) Verification and validation

RESULT AND DISCUSSION

Fruit leather is a sheet-shaped food product made from crushed and dried fruit pulp. Fruit leather has been recommended by FAO as an effective and simple way to preserve fruit. Fruit leather has a shelf life of up to 1 year if properly dried and packaged. In the last 10 years, Fruit leather has been recognized in the international market as a popular healthy snack. The expected criteria for fruit leather are that it has an attractive color, a slightly tough and compact texture, is springy, and also has good plasticity so that it can be rolled up (not easily broken). The use of hydrocolloids to form the structure, texture and consistency of dry but plastic elastic and easily rolled products such as carboxy methyl cellulose (CMC), pectin, carrageenan and agar is important in the production of fruit leather. Several studies have used CMC and agar in the production of watermelon fruit leather; CMC and carrageenan in the production of fruit leather from mixed vegetables; carrageenan in the production of fruit leather from pineapple and carrots, pectin in the production of mango fruit leather; kappa carrageenan, konjac glucomannan, and CMC on the production of salak fruit leather. The following were data from 14 formula variations recommended by DES.

Table 2. Formula variation

Run	Block	HFS (%)	Sorbitol (%)
1	Block 1	8,54	0,58
2	Block 1	5	2
3	Block 1	1,46	0,58
4	Block 1	8,54	3,4
5	Block 1	5	2
6	Block 1	5	2
7	Block 1	1,46	3,41
8	Block 2	5	2
9	Block 2	5	0
10	Block 2	10	2
11	Block 2	0	2
12	Block 2	5	2
13	Block 2	5	2
14	Block 2	5	4

The following are the results of measurements of the responses of each formula (Table 3)

Table 3. The results of measurements of the responses of each formula

Run	Plasticity ±SD*)	Softness±SD*)	Chewiness±SD*)	Stickiness±SD*)	Hardness±SD*)	*Carica Flavor* ±SD*)	Preferency ±SD*)
1	4,14±1,04	5,11± 0,63	3,78±0,95	2,89±0,85	1,71±0,66	4,54±0,99	4,14±0,84
2	4,32±0,94	4,96±0,69	4,04±1,03	2,96±0,79	1,96±0,74	4,36±0,73	4,46±0,99
3	4,18±0,98	5,07±0,72	3,89±0,92	2,86±1,01	2±0,77	4,14±0,84	4,18±1,02
4	4,14±0,80	5,14±0,71	4,28±1,01	3,42±0,88	2,42±1,03	4,61±0,74	3,92±1,01
5	4,25±0,93	5,11±0,68	3,79±0,79	3,14±0,8	1,93±0,81	4,18±0,98	4,29±1,18
6	4,29±0,94	5±0,79	3,82±0,67	3,25±0,7	2,25±0,75	4,32±0,72	4,43±0,95
7	4,36±0,68	4,79±0,68	3,96±0,88	2,93±0,89	2,96±1,1	4,39±1,06	4,36±0,91
8	4.21±0,92	4,82±0,77	4,04±0,92	3,03±0,79	2,32±0,86	4,14±0,89	4,64±1,25
9	4,43±0,96	4,86±0,65	3,71±0,89	3,14±0,85	2,21±0,73	4,21±0,68	4,32±0,82
10	4,11±0,88	5,04±0,69	4,11±0,76	3,61±0,78	2,17±0,77	4,53±0,83	4,25±0,96
11	4,04±0,74	4,82±0,66	3,75±0,84	2,82±0,86	2,39±0,95	3,78±1,16	3,86±0,80
12	4,18±0,94	4,96±0,69	4±0,72	3,18±0,9	2,11±0,78	4,25±0,93	4,39±0,95
13	4.32±0,94	4,93±1,02	3,89±0,78	3,04±0,92	2,11±0,78	4,29±1,08	4,57±1,13
14	4,39±0,69	4,89±0,68	4,32±0,98	3,43±0,69	2,68±1,05	4,32±0,86	4,29±1,01

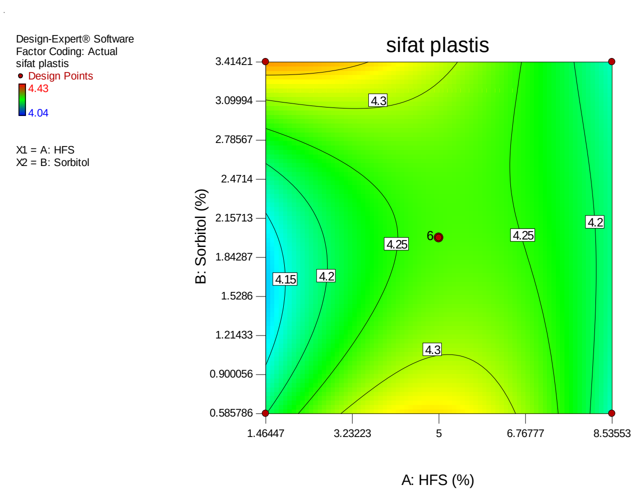
The following was Mathematic Models for All Responses (Table 4)

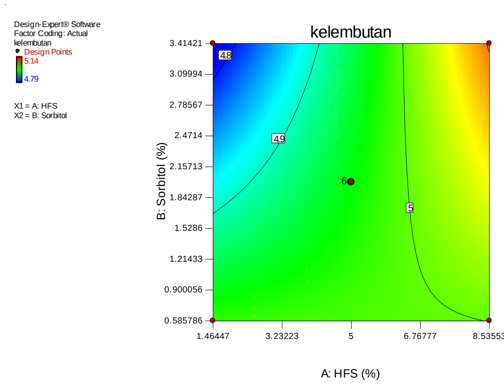
Table 4. Mathematic Models for All Responses

No	Responses	mathematic models	Mathematic equations	Significant level (p<0,05)					R^2
				Model	*Lack of fit*	A	B	AB	
1.	Plasticity	Cubic	Y= 4,26 + 0,025 (A) - 0,014 (B) - 0,045 (AB) - 0,10 (A^2) + 0,065 (B^2) + 0,059 (A^2B) - 0,090(AB^2)	0,04*	0,23	0,47	0,67	0,21	0,73
2.	Softness	2FI	Y= 4,96 + 0,088 (A) - 0,026 (B) + 0,077(AB)	0,01*	0,76	0,00**	0,28	0,04*	0,61
3.	Chewiness	Cubic	Y= 3,93 + 0,13 (A) + 0,22 (B) + 0,11 (AB) + 1,250E-003 (A^2) + 0,044 (B^2) - 0,073 (A^2B) - 0,075(AB^2)	0,04*	0,46	0,06	0,01**	0,10	0,70
4.	Stickiness	2FI	Y= 3,12 + 0,20 (A) + 0,13 (B) + 0,12 (AB)	0,00*	0,33	0,00**	0,02**	0,13	0,67
5.	Hardness	Cubic	Y= 2,11 - 0,078 (A) + 0,17 (B) - 0,062 (AB) + 0,061 (A^2) + 0,14 (B^2) + 0,25 (A^2B) -0,13(AB^2)	0,01*	0,80	0,30	0,06	0,40	0,83
6.	Carica flavor	Cubic	Y= 4,26 + 0,27 (A) + 0,039 (B) - 0,045 (AB) + 1,667E-003 (A^2) + 0,057 (B^2) + 0,041 (A^2B) - 0,11(AB^2)	0,03*	0,18	0,00**	0,46	0,40	0,75
7	Preferency	Cubic	Y= 4,46 + 0,14 (A) - 0,011 (B) - 0,100 (AB) - 0,21 (A^2) - 0,087 (B^2) - 6,066E-004 (A^2B) - 0,26 (AB^2)	0,02*	0,41	0,05*	0,85	0,12	0,76

A=proportion of HFS; B=proportion of Sorbitol

From the table it can be seen that :The mathematical model chosen for all optimized responses was able to explain well the effect of the dependent variable on the independent variable (all models are significant at 5% error level). All selected models have R2= 0.61-0.83. That is, the dependent variable of all measured responses can be explained by 61-83% of the independent variables. All selected models have an insignificant “lack of fit” value. This shows that the selection of a mathematical model was appropriate for the optimized response. The proportion of HFS has a significant effect on the intensity of softness, stickiness, carica flavor and preference. The proportion of Sorbitol has a significant effect on the intensity of chewiness and stickiness. The interaction between HFS and sorbitol has a significantly effects on the intensity of softness. The increasing of the proportion of HFS caused an increase in the intensity of preferency, carica flavor, chewiness, stickiness, softness, and plasticity, but decreasing in the intensity of hardness. The increasing of the proportion of sorbitol caused an increase in the intensity of flavor, hardness, chewiness, and stickiness, but decreasing in the intensity of preferency, softness and plasticity. Two-dimensional contour of Responses showed in Figure 1





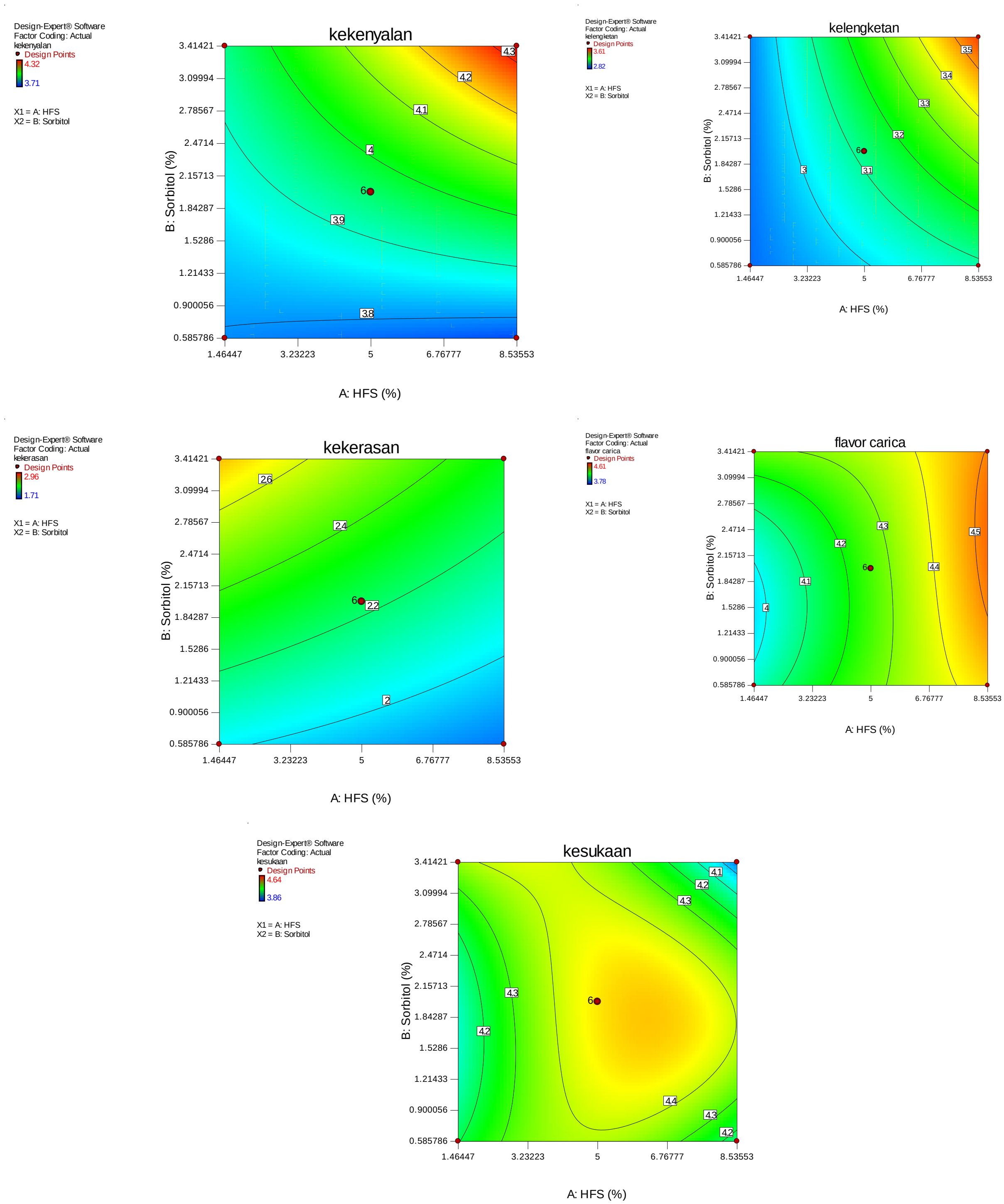


Figure 1. The two dimensional countur of all responses

The sensory profiles of fruit leather with the addition of HFS and sorbitol were due to the fact that HFS and sorbitol have many hydroxyl groups that were able to bind a lot of water and create softness and chewiness texture. HFS was also could bind flavor components that rich in hydrophilic or positively charged molecules.

The optimum formula based on criteria of responses showed in Table 5. The optimum formula recommended by the Design Expert with Desirability value = 0.7 were HFS = 7.13% and Sorbitol = 2.31% (Table 5). The actual scores of all responses were within the range predicted by DES was showed in Table 6. The spider web diagram of sensory attributes of optimum product compared to control was showed in Figure 2. The sensory and physicochemical properties of product with optimum formula and control showed in Table 7 dan Table 8

Table 5. Criteria of responses

No	Responses	Criteria	Importance
1	Plasticity	Maximum	4
2	Softness	In range	3
3	Chewiness	Maximum	4
4	Stickiness	In range	3
5	Hardness	minimum	4
6	Carica flavor	Maximum	5
7	Preferency	Maximum	5

Table 6. The actual scores of all responses

Response	Actual score ± SD* (Range=1-7)	*Prediction Interva*l (PI) 95%	
		PI low	*PI high*
Plasticity	4.29 ± 0.71	4.06	4.41
Softness	4.93 ± 0.66	4.87	5.18
Chewiness	4.25 ± 0.80	3.76	4.37
Stickiness	3.54 ± 0.92	2.95	3.62
Hardness	2.36 ± 0.73	1.75	2.53
Carica flavor	4.57 ± 0.74	4.14	4.70
Preferency	4.57 ± 0.79	4.13	4.75

Figure 2. The spider web diagram of sensory attributes

Carica fruit leather with optimum formula had a higher content of carbohydrate and total sugar than control; while water content, ash, and protein was lower. Fruit leather product with the optimum formula has a structure in the form of a thin layer of slightly brownish yellow color, the texture is slightly chewy, plastic and elastic, the consistency is cohesive, compact, stable and easy to roll without cracking/breaking, the texture in the mouth when the product is chewed (mouthfeel) is slightly tough , slightly chewy, and soft, and has high sensory scores for the typical Carica flavor and low sensory scores for stickiness and hardness. The physicochemical properties of the product are water content 21-24.5% wb, ash 2.6-3% wb, protein 4.5-5% wb, fat 1-1.2% wb, total food fiber 13-15% bk , carbohydrates 90-93% bk, total sugar 50-60% bk, and vitamin C 90-115% bk.

Table 7. The sensory properties of carica fruit leather with optimum formula

Sensory attributes	Kontrol$^{\pm}$SD*	Optimum$^{\pm}$SD*
Plasticity	4.11±1.22	4.29±0.71
Softness	3.96±0.99^{b}	4.93±0.66^{a}
Chewiness	3.79±1.20	4.25±0.80
Stickiness	3.25±1.00	3.54±0.92
Hardness	3.21±0.99^{a}	2.36±0.73^{b}
Carica flavor	4.07±0.76^{b}	4.57±0.74^{a}
Preferency	4.25±1.04	4.57±0.79

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Table 8. The psycochemical properties of carica fruit leather with optimum formula

Variables	Control ± SD*	Optimum±SD*
Water (% wb)	52.83±0.04[a]	49.68±0.12[b]
Water activity	0.86±0.01	0.83±0.01
Ash (%db)	4.67±0.22[a]	2.70±0.13[b]
Protein (%db)	6.63±0.05[a]	4.58±0.17[b]
Fat (%db)	0.57±0.16	1.07±0.13
Total dietary fibre (%db)	13.16±0.34	13.28±0.27
Carbohydrate (%db)	88.11±0.32[b]	91.65±0.11[a]
Total sugar (%db)	53.24±0.05[b]	61.44±0.15[a]
Vitamin C (mg/100g db)	29.32±3.21	32.80±2.65

CONCLUSION

The optimum formula for carica fruit leather with a desirability value of 0.70 was obtained with a composition of 7.13% HFS and 2.31% sorbitol. The increasing of the proportion of HFS caused significantly increase in the intensity of preferency, carica flavor, stickiness, and softness The increasing of the proportion of sorbitol caused significantly increase in the intensity of chewiness and stickiness. Carica fruit leather with optimum formula had a higher intensity of carica flavor and softness than control. With 198.65Kcal/100g energy, fruit leather with optimum formula contains carbohydrates, ash, protein, fat, and total dietary fiber i.e. 46.17%wb, 1.35%wb, 2.3%wb, 0 ,53%wb, 6.7%wb, respectively. Reformulation still needs to be done to increase vitamin C and reduce water content and water activity of carica fruit leather.

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BACKGROUND

1

Carica is a main commodity, indigenous fruit from Dieng plateau

2

It rich in Vit C, K, flavonoid, antioxidant, & dietary fiber

3

It can only be consumed after processing

4

One of the processed carica is cocktails which is made from unripe fruit

5

Research on the production of fruit leather from carica was carried out to increase the utilization of pulp and over-ripe fruit, and for food diversification

6

The formula of this product consisting of HFS, sorbitol, sucrose, k-carrageenan, k-glucomannan, stevia, CMC, and citric acid.

OBJECTIVES

This study were aimed to:

1. Determine the proportion of HFS and sorbitol that can produce carica fruit leather with maximum intensity score of preferency, carica flavor, chewiness, and plasticity; minimum intensity score of hardness; and in range intensity score of softness and stickiness
2. Examine the effect of the addition of HFS and sorbitol on the sensory properties of carica fruit leather
3. Comparing carica fruit leather with optimum formula and control (products made without HFS and sorbitol)

MATERIAL AND METHODS

Materials

1. Carica fruit was obtained from Wonosobo district
2. Other ingrediens (HFS, sorbitol, sucrose, k-carrageenan, k-glucomannan, stevia, CMC, and citric acid) were obtained from CV. Nuru Jaya Surabaya

The stages of research

1. Determination of basic formula and process
2. Recruitment of semi trained panelists
3. Formula optimization (skoring test)
4. Physicochemical analysis of product with optimum formula

BASIC FORMULA

Type of ingredient	Name of ingredient	Basic value (%)
Main ingredients	Puree	91
	Sucrose	9
		100
Supporting Ingredients	HFS	5
	Sorbitol	2
	Kappa carageenan	0,4
	Konjac glucomannan	0,1
	CMC	0,1
	Stevia sugar	0,5
	Citric acid	0,3
	Water	20

The basic formula consists of the main and supporting ingredients, The percentage of supporting ingredients was calculated based on the total of the main ingredients used

Stages in the product manufacturing :

1. *Preparation of puree and filtrate from over ripe carica fruit*
2. *Mixing and cooking ingredients*
3. *Drying and Forming*
4. *packaging and storage*

Preparation of fruit pulp:

1. After over ripe carica fruit was peeled, separated between the flesh and the pulp, and then, the flesh was cut into 8 parts.
2. Wash the flesh, boil using hot water at 80oC for 10-15 minutes, then drain
3. Pulp was mixed at low speed using water with a ratio of pulp: water = 1: 2, then cooked until boiling, cooled, filtered with a filter cloth to separate the pulp and the filtrate.
4. Puree was made by crushing the pulp obtained from stage 2 with the filtrate obtained from stage 3 in the ratio of pulp: filtrate = 2: 1

Production of fruit leather:

1. Puree, sucrose, HFS and sorbitol were mixed, then cooked over low heat, stirred, until a homogeneous dough was formed
2. Dissolve CMC, kappa carrageenan and konjac glucomannan with water to form a viscous solution that can flow, then set aside
3. Mix the hydrocolloid solution produced from stage 2 into the dough from stage 1, stir until evenly mixed
4. When the mixture boils and thickens, add the citric acid and stevia sugar which have been dissolved in water
5. Spread the dough on the baking sheet to form a thin layer with a thickness of 0.5 cm
6. Dry the dough using a cabinet dryer at a temperature of 60oC for 6-8 hours
7. Cut the fruit leather into a rectangle with a size of 3x5 cm2, then rolled and wrapped with food grade papper
8. Fruit leather was stored in a glass bottle that has been sterilized before further analysis

Formula Optimization

1. The optimization of the formula was carried out by the response surface methodology using a central composite design.
2. There were 2 optimized factors, i.e. the proportion of HFS and sorbitol.
3. The minimum and maximum proportions for HFS were 0 and 10%; while sorbitol were 0 and 4%.
4. The selection of 2 blocks using design expert software (V.XIII for trial) produced 14 factor combinations.

Stages :

1. Determination of the upper and lower limits
2. Making products with treatments result from RSM recommendations
3. Measurement of responses
4. Verification and validation

Result : Formula variation

The following were data from 14 formula variations recommended by DES

Run	Block	HFS (%)	Sorbitol (%)
1	Block 1	8,54	0,58
2	Block 1	5	2
3	Block 1	1,46	0,58
4	Block 1	8,54	3,4
5	Block 1	5	2
6	Block 1	5	2
7	Block 1	1,46	3,41
8	Block 2	5	2
9	Block 2	5	0
10	Block 2	10	2
11	Block 2	0	2
12	Block 2	5	2
13	Block 2	5	2
14	Block 2	5	4

Result : Determination of Responses

The following are the results of measurements of the responses of each formula

Run	Plasticity ±SD*)	Softness±SD*)	Chewiness±SD*)	Stickiness±SD*)	Hardness±SD*)	*Carica Flavor* ±SD*)	Preferency ±SD*)
1	4,14±1,04	5,11± 0,63	3,78±0,95	2,89±0,85	1,71±0,66	4,54±0,99	4,14±0,84
2	4,32±0,94	4,96±0,69	4,04±1,03	2,96±0,79	1,96±0,74	4,36±0,73	4,46±0,99
3	4,18±0,98	5,07±0,72	3,89±0,92	2,86±1,01	2±0,77	4,14±0,84	4,18±1,02
4	4,14±0,80	5,14±0,71	4,28±1,01	3,42±0,88	2,42±1,03	4,61±0,74	3,92±1,01
5	4,25±0,93	5,11±0,68	3,79±0,79	3,14±0,8	1,93±0,81	4,18±0,98	4,29±1,18
6	4,29±0,94	5±0,79	3,82±0,67	3,25±0,7	2,25±0,75	4,32±0,72	4,43±0,95
7	4,36±0,68	4,79±0,68	3,96±0,88	2,93±0,89	2,96±1,1	4,39±1,06	4,36±0,91
8	4.21±0,92	4,82±0,77	4,04±0,92	3,03±0,79	2,32±0,86	4,14±0,89	4,64±1,25
9	4,43±0,96	4,86±0,65	3,71±0,89	3,14±0,85	2,21±0,73	4,21±0,68	4,32±0,82
10	4,11±0,88	5,04±0,69	4,11±0,76	3,61±0,78	2,17±0,77	4,53±0,83	4,25±0,96
11	4,04±0,74	4,82±0,66	3,75±0,84	2,82±0,86	2,39±0,95	3,78±1,16	3,86±0,80
12	4,18±0,94	4,96±0,69	4±0,72	3,18±0,9	2,11±0,78	4,25±0,93	4,39±0,95
13	4.32±0,94	4,93±1,02	3,89±0,78	3,04±0,92	2,11±0,78	4,29±1,08	4,57±1,13
14	4,39±0,69	4,89±0,68	4,32±0,98	3,43±0,69	2,68±1,05	4,32±0,86	4,29±1,01

*=standard deviation

Result : Mathematic Models for All Responses

No	Responses	mathematic models	Mathematic equations	Significant level ($p<0,05$)					
				Model	*Lack of fit*	A	B	AB	R^2
1.	Plasticity	Cubic	$Y= 4,26 + 0,025 (A) - 0,014 (B) - 0,045 (AB) - 0,10 (A^2) + 0,065 (B^2) + 0,059 (A^2B) - 0,090(AB^2)$	0,04*	0,23	0,47	0,67	0,21	0,73
2.	Softness	2FI	$Y= 4,96 + 0,088 (A) - 0,026 (B) + 0,077(AB)$	0,01*	0,76	0,00**	0,28	0,04*	0,61
3.	Chewiness	Cubic	$Y= 3,93 + 0,13 (A) + 0,22 (B) + 0,11 (AB) + 1,250E-003 (A^2) + 0,044 (B^2) - 0,073 (A^2B) - 0,075(AB^2)$	0,04*	0,46	0,06	0,01**	0,10	0,70
4.	Stickiness	2FI	$Y= 3,12 + 0,20 (A) + 0,13 (B) + 0,12 (AB)$	0,00*	0,33	0,00**	0,02**	0,13	0,67
5.	Hardness	Cubic	$Y= 2,11 - 0,078 (A) + 0,17 (B) - 0,062 (AB) + 0,061 (A^2) + 0,14 (B^2) + 0,25 (A^2B) -0,13(AB^2)$	0,01*	0,80	0,30	0,06	0,40	0,83
6.	Carica flavor	Cubic	$Y= 4,26 + 0,27 (A) + 0,039 (B) - 0,045 (AB) + 1,667E-003 (A^2) + 0,057 (B^2) + 0,041 (A^2B) - 0,11(AB^2)$	0,03*	0,18	0,00**	0,46	0,40	0,75
7	Preferency	Cubic	$Y= 4,46 + 0,14 (A) - 0,011 (B) - 0,100 (AB) - 0,21 (A^2) - 0,087 (B^2) - 6,066E-004 (A^2B) - 0,26 (AB^2)$	0,02*	0,41	0,05*	0,85	0,12	0,76

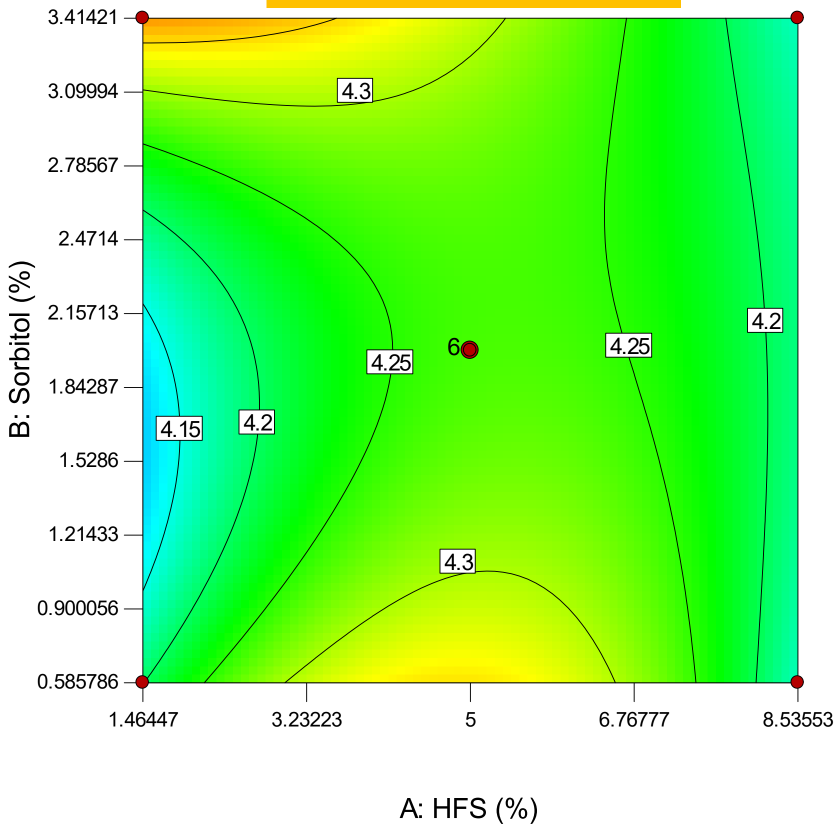
A=proportion of HFS; B=proportion of Sorbitol

From the table above it can be seen that :

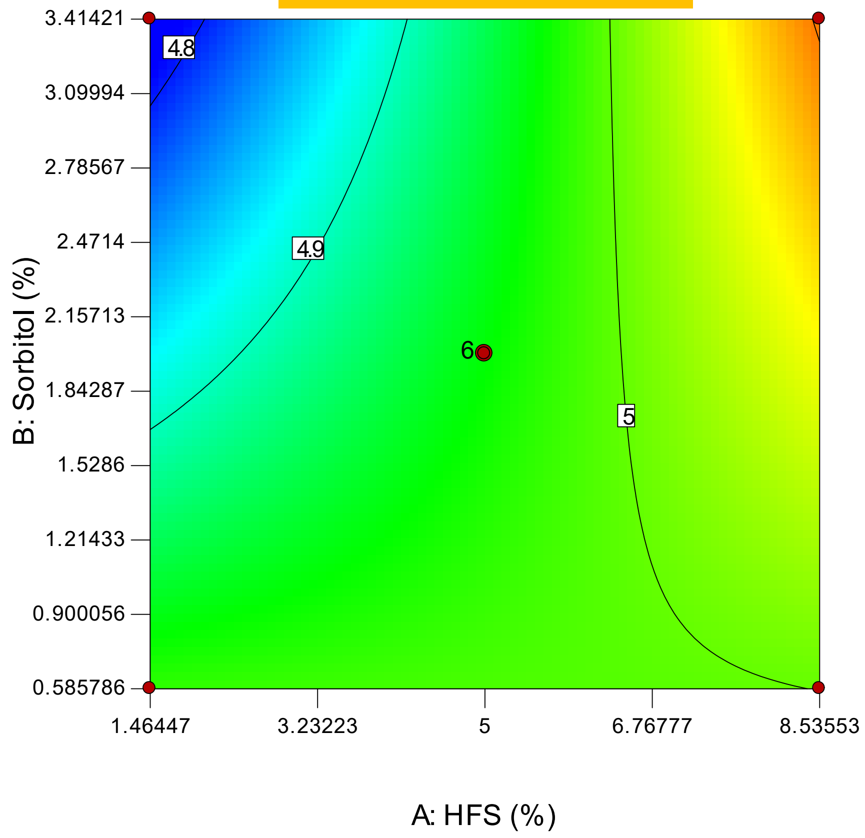
1. The mathematical model chosen for all optimized responses was able to explain well the effect of the dependent variable on the independent variable (all models are significant at 5% error level)
2. All selected models have R2= 0.61-0.83. That is, the dependent variable of all measured responses can be explained by 61-83% of the independent variables
3. All selected models have an insignificant “lack of fit” value. This shows that the selection of a mathematical model was appropriate for the optimized response
4. The proportion of HFS has a significant effect on the intensity of softness, stickiness, carica flavor and preference
5. The proportion of Sorbitol has a significant effect on the intensity of chewiness and stickiness
6. The interaction between HFS and sorbitol has a significantly effects on the intensity of softness
7. The increasing of the proportion of HFS caused an increase in the intensity of preferency, carica flavor, chewiness, stickiness, softness, and plasticity, but decreasing in the intensity of hardness
8. The increasing of the proportion of sorbitol caused an increase in the intensity of flavor, hardness, chewiness, and stickiness, but decreasing in the intensity of preferency, softness and plasticity

Two-dimensional contour of Responses

Plasticity



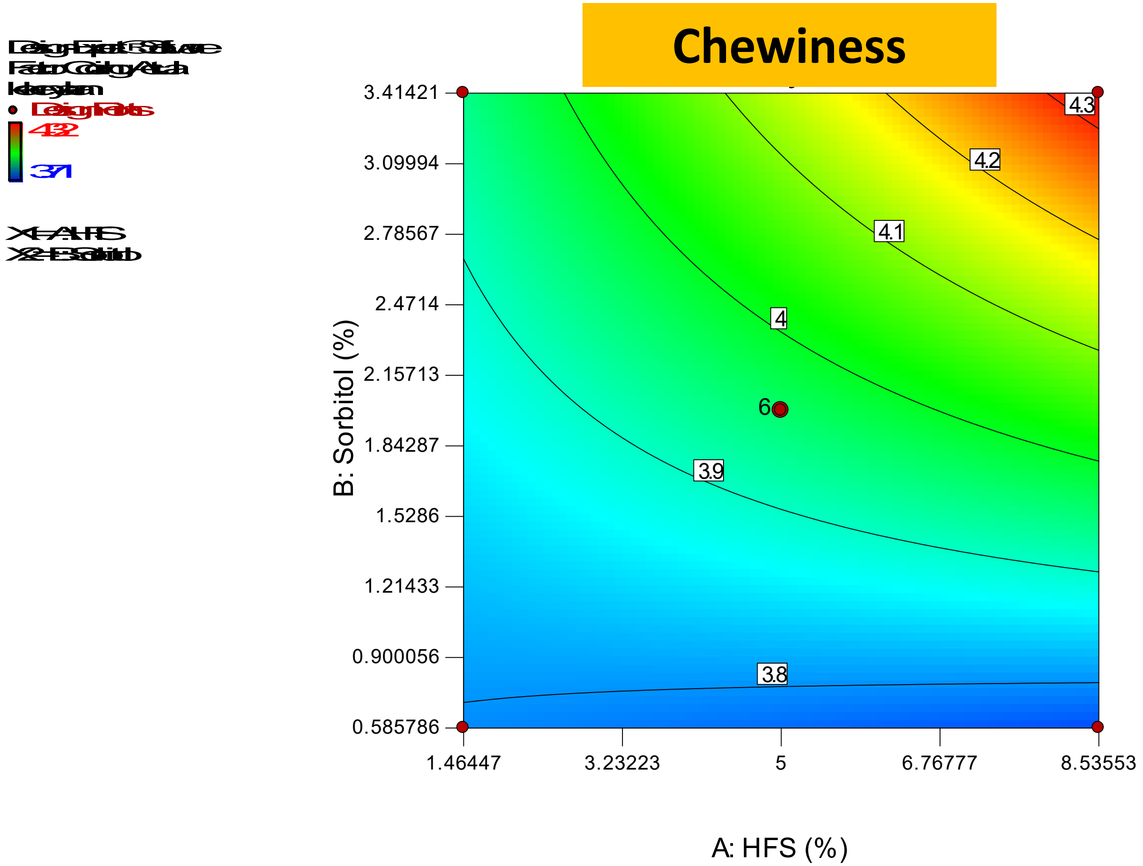
Softness



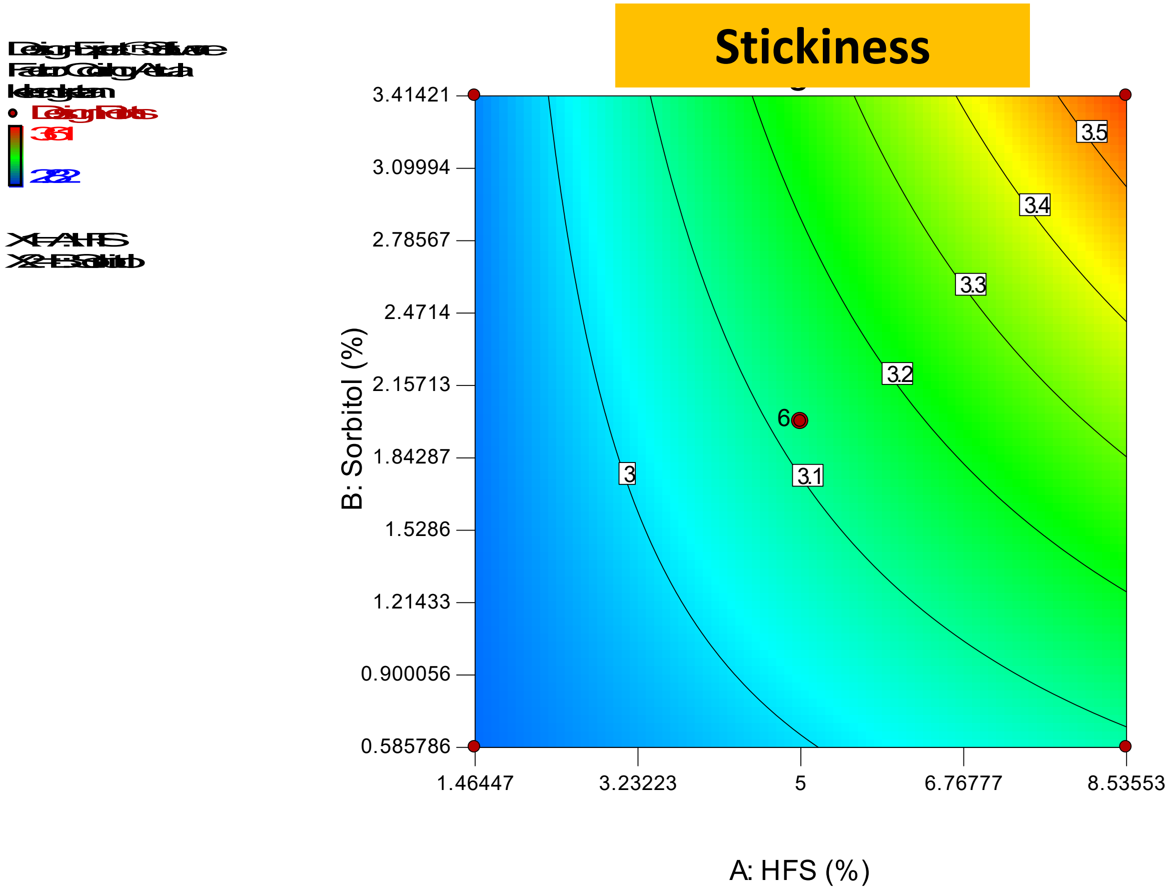
The lowest to highest values for plasticity ranged from 4.04-4.43

lowest to highest values for softness intensity ranged from 4.79-5.14

Two-dimensional contour of Responses



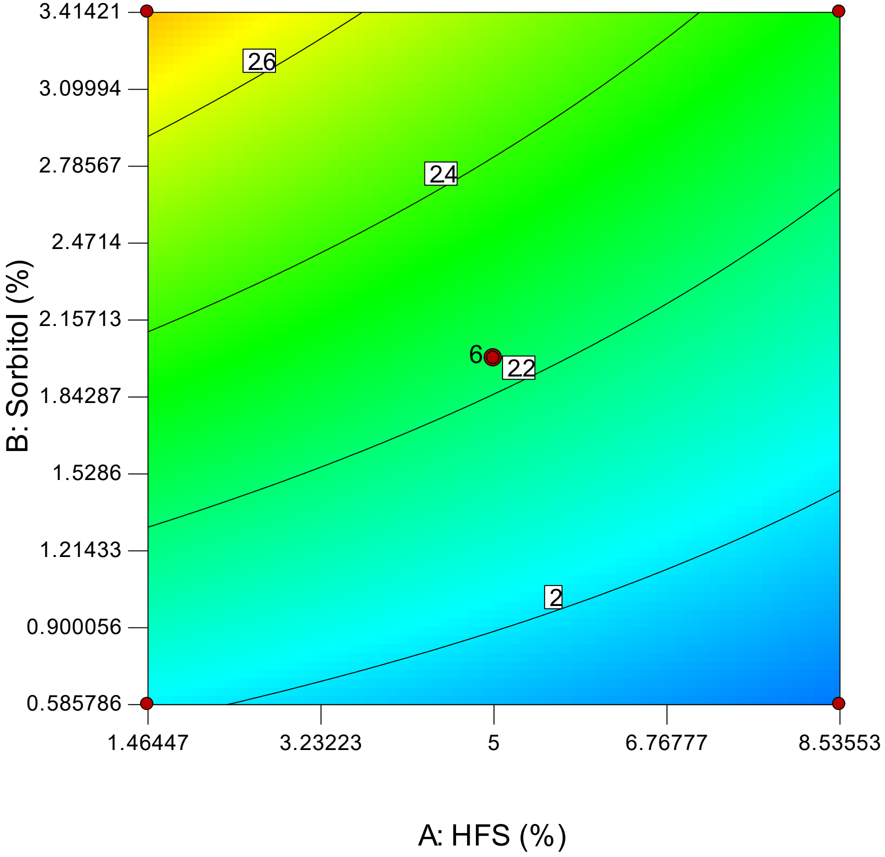
The lowest to highest values for chewiness ranged from 3.71-4.32



The lowest to highest values for stickiness ranged from 2.82-3.61

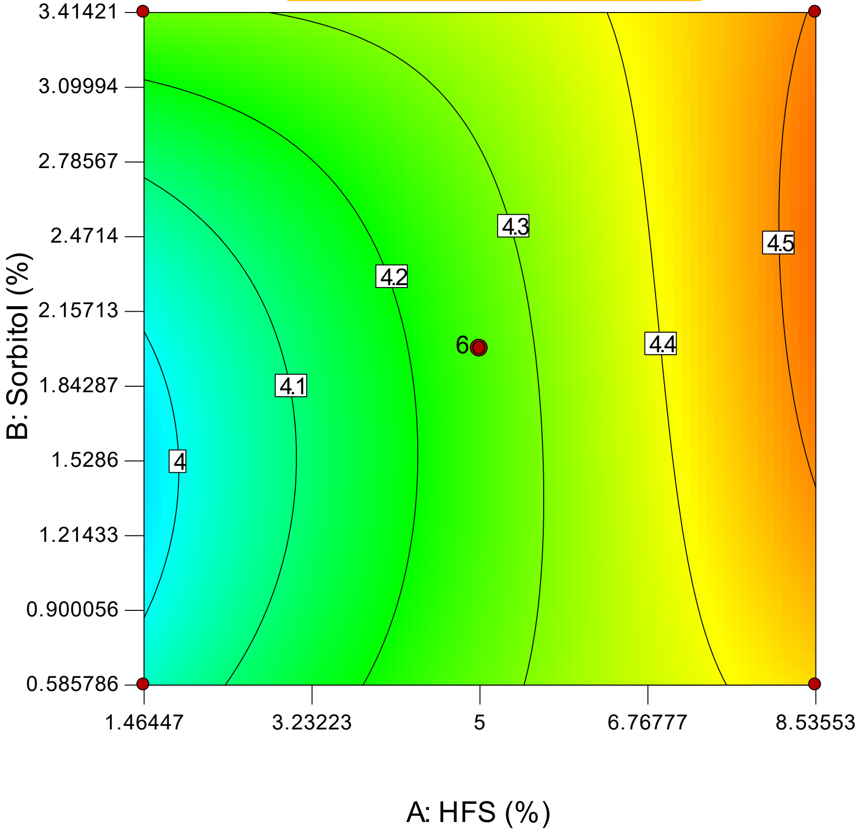
Two-dimensional contour of Responses

Hardness



The lowest to highest values for hardness ranged from 1.71-2.96

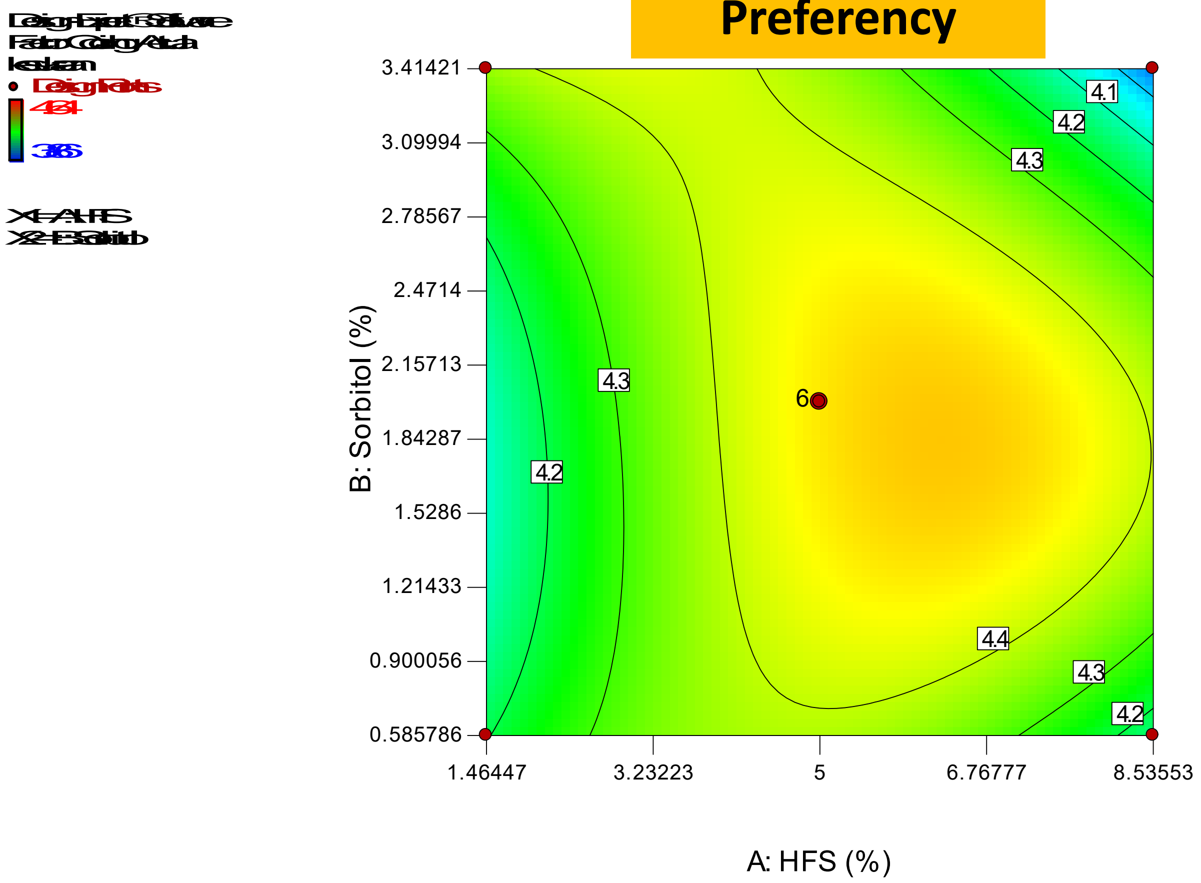
Carica Flavor



The lowest to highest values for chewiness ranged from 3.78-4.61

Two-dimensional contour of Responses

Preferency



The lowest to highest values for preferency ranged from 3.86-4.64

The sensory profiles of fruit leather with the addition of HFS and sorbitol were due to the fact that HFS and sorbitol have many hydroxyl groups that were able to bind a lot of water and create softness and chewiness texture. HFS was also could bind flavor components that rich in hydrophilic or positively charged molecules

Optimum formula

The Criteria and Importance of Responses

No.	Responses	Criteria	Importance
1	Plasticity	Maximum	4
2	Softness	In range	3
3	Chewiness	Maximum	4
4	Stickiness	In range	3
5	Hardness	minimum	4
6	Carica flavor	Maximum	5
7	Preferency	Maximum	5

The optimum formula recommended by the Design Expert :

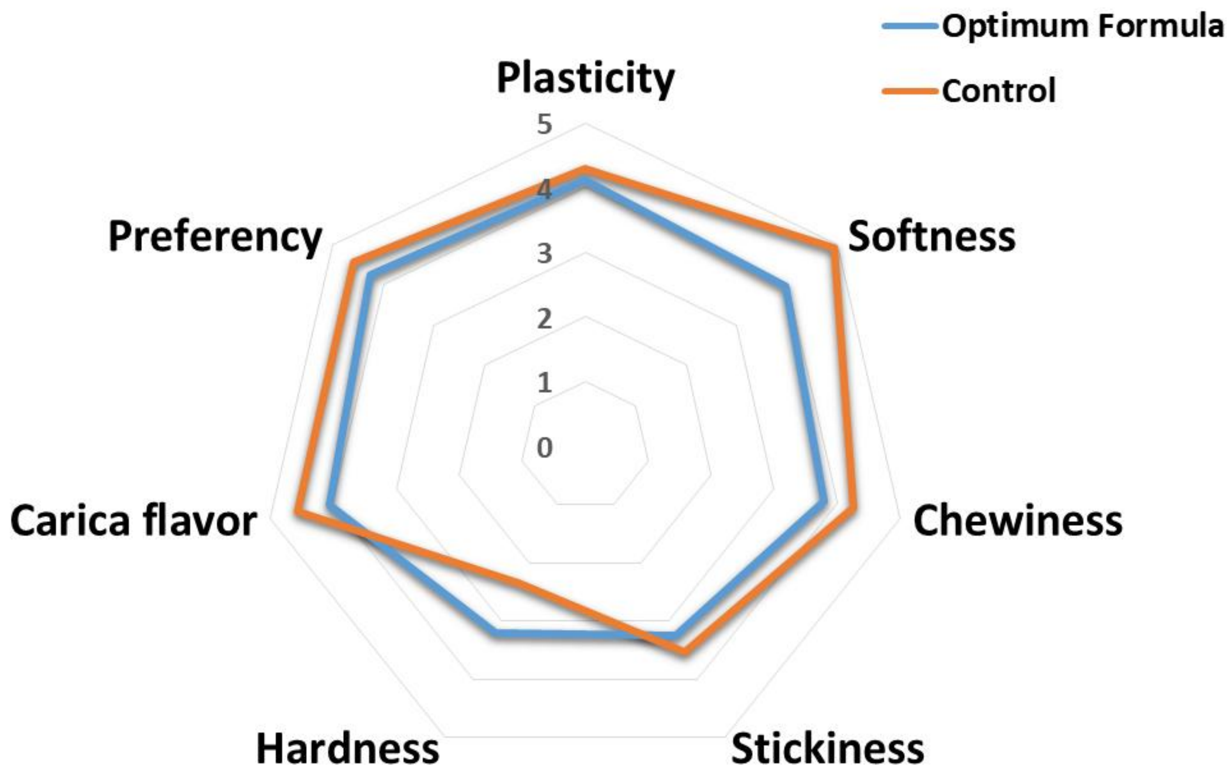
Desirability value = 0.7
HFS = 7.13%
Sorbitol = 2.31%

The sensory score of optimum formula

Response	Actual score ± SD* (Range=1-7)	Prediction Interval (PI) 95% PI low	PI high
Plasticity	4.29 ± 0.71	4.06	4.41
Softness	4.93 ± 0.66	4.87	5.18
Chewiness	4.25 ± 0.80	3.76	4.37
Stickiness	3.54 ± 0.92	2.95	3.62
Hardness	2.36 ± 0.73	1.75	2.53
Carica flavor	4.57 ± 0.74	4.14	4.70
Preferency	4.57 ± 0.79	4.13	4.75

The actual scores of all responses were within the range predicted by DES

The spider web diagram of sensory attributes of optimum product compared to control



Sensory attributes	Kontrol±SD*	Optimum±SD*
Plasticity	4.11±1.22	4.29±0.71
Softness	3.96±0.99[b]	4.93±0.66[a]
Chewiness	3.79±1.20	4.25±0.80
Stickiness	3.25±1.00	3.54±0.92
Hardness	3.21±0.99[a]	2.36±0.73[b]
Carica flavor	4.07±0.76[b]	4.57±0.74[a]
Preferency	4.25±1.04	4.57±0.79

Carica fruit leather with the optimum formula had a higher intensity of preference, carica flavor, chewiness, softness, and stickiness than the control; while the intensity of hardness was lower

The Physicochemical properties fruit leather with optimum formula compared to control

Variables	Control ± SD*	Optimum±SD*
Water (% wb)	52.83±0.04[a]	49.68±0.12[b]
Water activity	0.86±0.01	0.83±0.01
Ash (%db)	4.67±0.22[a]	2.70±0.13[b]
Protein (%db)	6.63±0.05[a]	4.58±0.17[b]
Fat (%db)	0.57±0.16	1.07±0.13
Total dietary fibre (%db)	13.16±0.34	13.28±0.27
Carbohydrate (%db)	88.11±0.32[b]	91.65±0.11[a]
Total sugar (%db)	53.24±0.05[b]	61.44±0.15[a]
Vitamin C (mg/100g db)	29.32±3.21	32.80±2.65

Carica fruit leather with optimum formula had a higher content of carbohydrate and total sugar than control; while water content, ash, and protein was lower

CONCLUSION

1. The optimum formula for carica fruit leather with a desirability value of 0.70 was obtained with a composition of 7.13% HFS and 2.31% sorbitol
2. The increasing of the proportion of HFS caused significantly increase in the intensity of preferency, carica flavor, stickiness, and softness
3. The increasing of the proportion of sorbitol caused significantly increase in the intensity of chewiness and stickiness
4. Carica fruit leather with optimum formula had a higher intensity of carica flavor and softness than control
5. With 198.65Kcal/100g energy, fruit leather with optimum formula contains carbohydrates, ash, protein, fat, and total dietary fiber i.e. 46.17%wb, 1.35%wb, 2.3%wb, 0 ,53%wb, 6.7%wb, respectively.
6. Reformulation still needs to be done to increase vitamin C and reduce water content and water activity of carica fruit leather

Thanks To...

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