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Development of Finger Millet and Sapota based Ready-to-Reconstitute *Halwa* Mix

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ABSTRACT

Background: *Eleusine coracana* (finger millet) is the fourth most important millet in the world. Finger millet is the powerhouse of health benefiting nutrients; however, it is still underutilized. Sapota contains a diverse range of phenolic compounds (as natural antioxidants) and flavonoids which has drawn the attention of many researchers. Keeping in mind the importance of traditional food products and growing popularity of convenience food market, the study was aimed to develop a ready to reconstitute (RTR) finger millet and sapota based *halwa* mix.

Methods: The rate of addition of milk, sugar and dried sapota chunks were studied and optimized using response surface methodology.

Result: The formulation with 208.8 ml of milk, 52.9 per cent sugar (percent of weight of the dried *halwa*) and 9.4 percent dried sapota chunks (percent of weight of dried *halwa*) was optimized for the development of RTR *halwa* mix. The analyses were based on sensory scores and rehydration ratio. The nutritional, bio-chemical, sensory and microbial attributes of the optimized halwa mix were evaluated.

Key words: Finger millet, *Halwa* mix, Ready to reconstitute, Rehydration, Sapota, Sensory.

INTRODUCTION

Millets are one of the early foods domesticated by humans. They are also known as nutria-cereals and are a source of food, feed and fodder (Bhat *et al*., 2018). They come from the family *Poaceae*. Modern acquired lifestyles have paved the way for micronutrient deficiencies along with diabetes, cardiovascular diseases and hypertension. Thus, millets have revived as a plausible alternative for living a healthy lifestyle (Singh *et al*., 2020). In 2019, the global millet production was 27.8 million tons. India ranks 1st in millet production, accounting for 41.0 percent of the global market share (Research and Markets, 2019). With an aim of creating domestic and global demand, the Indian Government have proposed the year 2023 as International Year of Millets which have been approved by FAO (FAO, 2022).

Eleusine coracana (finger millet) is a staple crop in Asian and African countries, particularly India and Nigeria. The principal botanical components of the finger millet kernel are the seed coat, embryo (germ) and endosperm. There are varieties that are yellow, white, tan, red, brown, or violet in color, but only the red-colored ones are widely cultivated worldwide. Finger millet is as healthy as other cereals, with high calcium content (300-350 mg/100 g) and a good amount of protein, dietary fiber and micronutrients (Tiwari *et al*., 2018). The anti-oxidant and immune-modulating properties of finger millet's rich phytochemical profile guarantees a positive health impact and make finger millet a powerhouse of health benefiting nutrients (Chandra *et al*., 2016). However, finger millet is still an underutilized crop due to lack of awareness of its nutritional quality and health benefits. Sapota is a climacteric fruit used for its sweet and delectable taste. Sapota contains a diverse range of sugars, vitamins (A, C, niacin, pantothenic acid and folate), acids, protein, minerals (Fe, K, Cu), phenolics and carotenoids. Sapota is deemed to be one of the healthiest fruits to alleviate micronutrient malnutrition (Srivastava *et al*., 2014). Sapota is also utilized as a traditional medicine in India (Divya *et al*., 2014). Many researchers and practitioners have turned their focus to sapota because of its vast range of phenolic compounds (as natural antioxidants) and flavonoids.

Halwa is a traditional dessert which is popular not only in the Indian cuisine but also in Asian and Middle Eastern cuisines. Traditionally it is prepared using semolina, ghee, seeds and nuts during festivities and occasions. It is also called as *sheera* or *kesari* in some regions.

The ready to cook (RTC) and rady to Reconstitute (RTR) food demand is increasing. The ingredients used in Indian traditional foods have tremendous health advantages (Mangalassary, 2016). There is a lack of research on development and mechanization of convenience type traditional food products. Considering the great importance

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of millets, fruits and milk in a balanced diet and the potential for RTC/RTR food products in market, a study was carried out to develop finger millet and sapota based RTR *halwa* mix.

MATERIALS AND METHODS

The study was conducted at College of Food Processing Technology and Bio Energy, Anand, Gujarat, India from November 2021 to May 2022.

Materials

Finger millet (Gujarat Nagli 8 variety) was procured from Hill Millet Research Station, Dahod, Gujarat. Sapota fruits of Kalipatti variety were purchased from a local farm in Navsari, Gujarat. Other materials required for *halwa* preparation such as milk, sugar, *ghee* and cardamom powder were purchased from local market in Anand, Gujarat.

Experimental design

Central composite design of the response surface methodology was adopted for the optimization of ingredients for the development of finger millet and sapota based RTR *halwa* mix. Level of milk (ml), sugar (percent of weight of the dried *halwa*) and dried sapota chunks (percent of weight of the dried *halwa*) were taken as independent factors. The responses taken into consideration were sensory attributes (color and appearance, body and texture, taste and aroma and overall acceptability) and rehydration ratio. The experimental plan along with the actual levels of the three ingredients is shown in Table 1.

Preparation of dried sapota chunks

Fresh ripe sapota fruits were washed, peeled and seeds and other inedible portion were removed. The edible portion was cut into 4-5 mm chunks using a stainless steel square mesh of a fruit chopper. The prepared sapota chunks were vacuum dried at 70°C and 650 mm Hg pressure. The drying process was continued until the final moisture content of sapota chunks reached 8 percent or below. The dried chunks were packed in polyethylene pouches for further use.

Preparation of *halwa* mix

For the preparation of RTR *halwa*, 100 g of finger millet flour was roasted on a low flame followed by cooking with milk. *Ghee* (at the rate of 5 percent of flour weight) was added. The prepared *halwa* was spread into a uniform layer (3 to 4 mm thick) on to stainless steel tray and vacuum dried at 60°C and at a pressure of 720 mm Hg. The dried *halwa* was ground using a mixer grinder. Depending upon the weight of powdered *halwa* obtained, powdered sugar (percent of weight of dried *halwa*) and dried sapota chunks (percent of weight of dried *halwa*) were dry blended with the mix. Total weight of halwa mix was recorded and cardamom powder was added at the rate of 0.075 percent of the total weight of dry blended *halwa* mix. The prepared RTR halwa was reconstituted by adding hot boiling water to the mix in the ratio of 1 : 1. The mix was uniformly stirred and kept covered for 3 minutes.

Analysis

The nutritional parameters such as moisture, protein, fat, crude fiber, ash and total carbohydrate were estimated according the methods described in Ranganna (2007) and AOAC (2019). Mineral estimation was carried out using ICP-OES (Model: Optima 700DV) as per the method given by Kumaravel and Alagasundaram (2014).Total phenolic content and antioxidant activity was estimated as per the procedure described by Camargo *et al*., (2016) and Upadhyay *et al*., (2015) respectively, with slight modifications. The microbial quality was analyzed as per the procedure described by Ranganna (2007).

Sensory evaluation

The sensory evaluation of rehydrated *halwa* was carried out in terms of color and appearance, body and texture, taste and aroma and overall acceptability using a 9-point hedonic scale. The sensory evaluation was conducted by 9 panelists.

Rehydration ratio

The rehydration ratio of the RTR *halwa* mix was calculated using the following equation Vaghela *et al*., (2016):

$$\text{Rehydration ratio (RR)} = \frac{\text{Weight of rehydrated sample (g)}}{\text{Weight of dehydrated sample (g)}}$$

Statistical analysis

The finger millet and sapota based RTR *halwa* developed using various runs were analyzed using Design Expert (V. 13.0.5) software. All the sensory scores were average of nine scores and the rehydration ratio was average of three readings. The responses of the product prepared using the experimental design and the actual values of the independent variables are shown in Table 1.

RESULTS AND DISCUSSION

Analysis of responses

Color and appearance

The color and appearance score of the reconstituted *halwa* ranged from 6.9 to 7.9 (Table 1). The F, R^2, adjusted $R^2$and adequate precision values were60.55, 0.9820, 0.9658 and 28.5289 respectively, indicates the model was highly significant (P<0.0001) and can be used to predict the color and appearance score within the design space.

The following quadratic model may be used for representing the variation of color and appearance score:

$$\begin{aligned}\text{Color and appearance} = {} & 7.87 - 0.1421A + 0.0196B + 0.0073C \\ & - 0.0125AB + 0.0375AC - 0.0125BC \\ & - 0.2451A^2 - 0.0330B^2 - 0.0153C^2\end{aligned}$$

It can be observed from Fig 1 that the color and appearance score increased with increase in the amount of milk upto about 210 ml after which the scores decreased. Milk fat imparted a glossy and rich visual appearance which might have affected the initial increase in color and appearance scores. Further addition lead to dilution of the dark chocolate brown color resulting in declined scores.

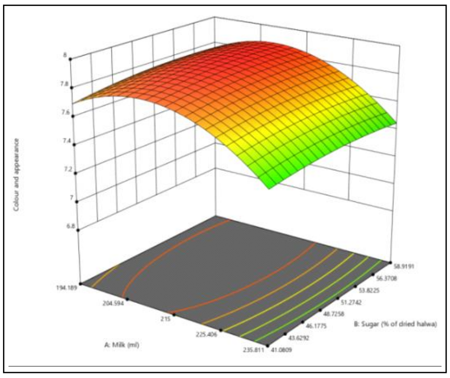

Fig 1: Response surface curve for effect of milk and sugar on color and appearance.

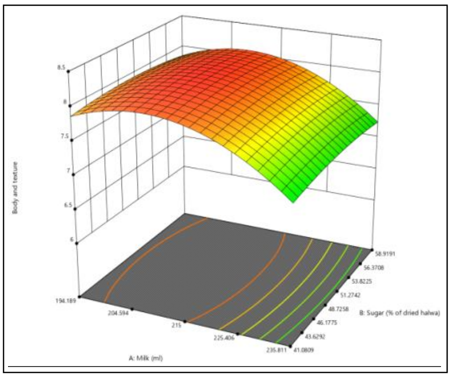

Fig 2: Response surface curve for effect of milk and sugar on body and texture.

Similar results were obtained by Vaghela *et al*., (2016) on addition of *khoa* to carrot *halwa*.

Body and texture

The body and texture of the reconstituted *halwa* ranged from 6.3 to 8.2 (Table 1). The F, R^2, adjusted R^2 and adequate precision values were 32.82, 0.9673, 0.9378 and 20.82 respectively, indicates the model was highly significant ($P<0.0001$) and can be used to predict the body and texture score within the design space.

The following quadratic model may be used to represent the variation of body and texture score:

$$\text{Body and texture} = 8.11 - 0.3185A + 0.0073B - 0.0196C + 0.0125AB + 0.0875AC - 0.0375BC - 0.4835A^2 - 0.0769B^2 - 0.1299C^2$$

The body and texture scores were significantly affected by addition of milk after a certain level (Fig 2). The use of high fat milk for development of *halwa* formed a slimy skin at powder/water interface. The hydrophobic nature of the fat prevented water penetration into the *halwa* mix during reconstitution, which resulted in poor body of the reconstituted *halwa*. Similar effect was observed by Fitzpatrick *et al*., (2016), Velpula *et al*., (2019) and Vaghela *et al*., (2016).

Taste and aroma

The taste and aroma of the reconstituted *halwa* ranged from 5.8 to 8.2 (Table 1). The F, R^2, adjusted R^2 and adequate precision values were 41.83, 0.9959, 0.9923 and 60.54 respectively, indicates the model was highly significant

Table 1: Central composite rotatable experimental design for development of finger millet and sapota based RTR *halwa* and responses of developed product.

	Variables			Responses				
Run	AMilk (ml)	B Sugar (% of dried *halwa*)	C Sapota (% of dried *halwa*)	Color and appearance	Body and texture	Taste and aroma	Overall acceptability	Rehydration ratio
1	215.0	50.0	9.5	7.9	8.0	8.1	8.0	1.90
2	235.8	58.9	6.2	7.4	7.0	7.6	7.3	1.85
3	215.0	50.0	9.5	7.9	8.2	8.0	8.0	1.95
4	250.0	50.0	9.5	6.9	6.3	8.0	7.0	1.66
5	215.0	50.0	4.0	7.8	7.9	7.7	7.7	1.80
6	215.0	50.0	9.5	7.9	8.1	8.0	8.0	1.99
7	180.0	50.0	9.5	7.4	7.4	7.8	7.6	2.40
8	215.0	50.0	9.5	7.8	8.2	8.1	8.1	1.90
9	235.8	41.1	12.8	7.5	7.1	6.9	7.2	1.88
10	215.0	50.0	9.5	7.9	8.0	8.1	8.0	2.00
11	194.2	58.9	12.8	7.7	7.5	7.7	7.6	2.37
12	235.8	41.1	6.2	7.4	6.9	6.7	7.0	1.83
13	194.2	58.9	6.2	7.8	7.8	7.6	7.8	2.20
14	194.2	41.1	6.2	7.7	7.7	6.6	7.3	2.24
15	215.0	50.0	15.0	7.8	7.8	8.2	7.9	2.00
16	235.8	58.9	12.8	7.5	7.1	7.7	7.4	1.87
17	215.0	50.0	9.5	7.8	8.1	8.1	8.1	1.95
18	194.2	41.1	12.8	7.7	7.6	6.7	7.3	2.33
19	215.0	65.0	9.5	7.8	8.0	7.0	7.6	1.97
20	215.0	35.0	9.5	7.7	8.0	5.8	7.2	1.95

(P<0.0001) and can be used to predict the taste and aroma scores within the design space.

The following quadratic model may be used to represent the variation of taste and aroma score:

$$\text{Taste and aroma} = 0.0130 - 0.0002A - 0.0023B - 0.0004C + 0.0002AB - 0.0001AC + 0.0001BC + 0.0003A^2 + 0.0031B^2 + 0.0002C^2$$

From Fig 3 it can be observed that sugar had a positive effect on the taste and aroma scores up to certain limit after which it negatively affected the taste and aroma scores. After a certain amount, the excessive sweetness imparted by high levels of sugar was not preferred by the panelists and was evident from the decreased scores of taste and aroma. With increase in addition of sapota chunks the taste and aroma scores increased from 6.7 to 7.1, which might be due to the sweet and delicate taste offered by the sapota chunks.

Overall acceptability

The overall acceptability score of the reconstituted *halwa* ranged from 7.0 to 8.1 (Table 1). The F, R^2, adjusted R^2 and adequate precision values were 41.21, 0.9737, 0.9501 and 17.97 respectively, indicates the model was highly significant (P<0.0001) and can be used to predict the overall acceptability within the design space.

The following quadratic model may be used to represent the variation of overall acceptability:

$$\text{Overall acceptability} = 8.04 - 0.1544A + 0.1444B + 0.0320C - 0.0375AB + 0.0625AC - 0.0375BC - 0.2815A^2 - 0.2461B^2 - 0.1047C^2$$

The overall acceptability of *halwa* was found to increase up to a certain range for both milk and sugar, beyond which the scores decreased. With an increase in the level of dried sapota chunks from 4 to 15 percent, the overall acceptability of reconstituted *halwa* also increased. From Fig 4 and 5, it can be inferred that overall acceptability of reconstituted *halwa* was maximum at the center point for both milk and sugar and at a high level of sapota chunks.

Rehydration ratio

The rehydration ratio ranged from 1.66 to 2.40 (Table 1). The F, R^2, adjusted R^2 and adequate precision values were 42.99, 0.8896, 0.8689 and 22.52 respectively, indicates the model was highly significant (P<0.0001) and can be used to predict the body and texture score within the design space.

The following linear model may be used for representing the variation of rehydration ratio:

$$\text{Rehydration ratio} = 0.3074 + 0.0543A - 0.0008B - 0.0125C$$

The level of milk negatively impacted the rehydration ratio (Fig 6). The rehydration ratio was found to decrease significantly with increase in the amount of milk. The high proportion of fat from milk formed a thin film around the particles of the halwa mix. This layer prevented penetration of water into the bulk and thereby resulted in lower rehydration ability of the *halwa* mix. From Fig 6, it can be observed that with increase in amount of dried sapota chunks, the rehydration ratio increased slightly. This dehydrated sapota chunks also absorbed water during

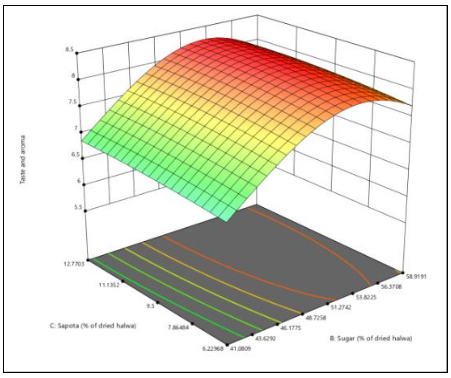

Fig 3: Response surface curve for effect of sapota and sugar on taste and aroma.

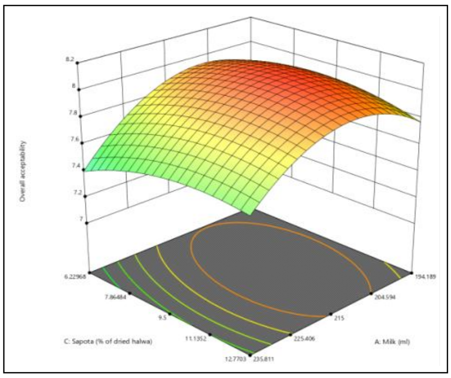

Fig 4: Response surface curve for effect of milk and sapota on overall acceptability.

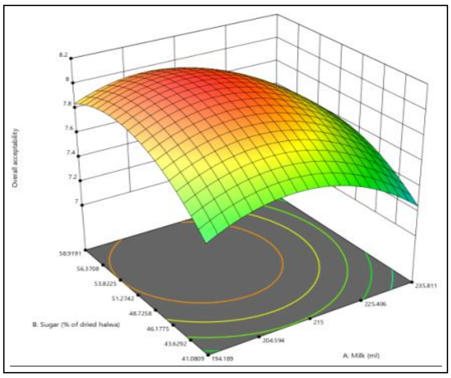

Fig 5: Response surface curve for effect of milk and sugar on overall acceptability.

Table 2: Predicted and experimental values for different parameters of optimized combination.

Parameter	Predicted values	Experimental values
Color and appearance	7.9	7.8
Body and texture	8.1	8.0
Taste and aroma	8.1	8.1
Overall acceptability	8.1	8.0
Rehydration ratio	2.0	2.1

Table 3: Nutritional, bio-chemical, sensory and microbial attributes of the optimized finger millet and sapota based RTR *halwa* mix.

Nutritional parameter	Composition (per 100 g)	Bio-chemical parameter	Composition (per 100 g)
Energy (kcal)	439.32±0.04	Total phenolic content (mg)	119.2±0.14
Moisture (percent)	4.88±0.05	Antioxidant activity (per cent)	71.33±0.12
Protein (percent)	9.71±0.12	Sensory attributes	Score (9 point hedonic scale)
Fat (percent)	6.59±0.06	Color and appearance	7.8
Crude fiber (percent)	5.02±0.04	Body and texture	7.9
Ash (percent)	2.53±0.04	Taste and aroma	8.0
Carbohydrates (percent)	71.27±0.06	Overall acceptability	8.0
Calcium (mg)	357.40±0.13	Microbiological parameter	cfu/g
Potassium (mg)	330.00±0.11	Total plate count	1.8×10^2
Phosphorous (mg)	145.50±0.04	Yeast and mold count	Absent in 1 g
Magnesium (mg)	128.00±0.03	Coliform count	Absent in 1 g
Manganese (mg)	24.20±0.05		
Iron (mg)	14.80±0.02		
Copper (mg)	0.87±0.03		
Zinc (mg)	4.74±0.04		

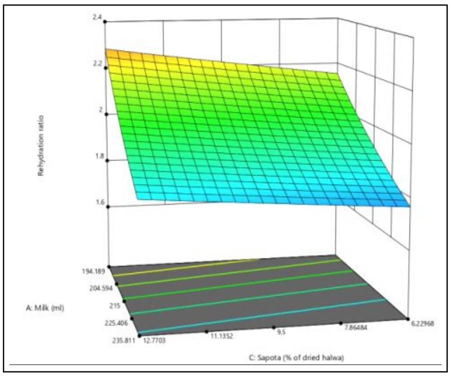

Fig 6: Response surface curve for effect of milk and sapota on rehydration ratio.

rehydration to acquire fresh fruit like characteristics. Thus, greater the amount of sapota chunks, greater amount of water was absorbed resulting in a higher rehydration ratio. Similar results were obtained for rehydration ratio by Vaghela *et al*., (2016) on addition of fatty ingredients to RTR *halwa*.

Optimization of independent variables

Numerical optimization technique of the Design Expert 13.0.5 software was used for simultaneous optimization of level of each ingredient to obtain the best product. During the optimization process, specific constraints were applied on the responses. The sensory analysis parameters such as color and appearance, body and texture, taste and aroma and overall acceptability were maximized and rehydration ratio was kept within range for desirability analysis. Out of the two solutions obtained, the solution having 208.8 ml of milk, 52.9 percent sugar (percent weight of the dried *halwa*) and 9.4 percent dried sapota chunks (percent weight of the dried *halwa*) was selected as best formulation, with a desirability of 0.991.The experimental values (average of 6) of the RTR *halwa* prepared using optimized formulation and the values predicted using the model equations are shown in Table 2. The predicted and experimental values of responses were almost similar and within the range at 95 percent level of confidence.

The nutritional, bio-chemical, sensory and microbial attributes of the optimized finger millet and sapota based RTR *halwa* mix was carried out and the average values of 3 replication (average of 9 for sensory) is reported in Table 3.

CONCLUSION

The optimized *halwa* mix contained 208.8 ml of milk, 52.9 percent sugar (percent weight of the dried *halwa*) and 9.4 per cent dried sapota chunks (percent weight of the dried *halwa*). The RTR halwa provided 439.32 kcal of energy per 100 g. The optimized *halwa* mix had a score of 7.8, 7.9, 8.0 and 8.0 for color and appearance, body and texture, taste and aroma and overall acceptability respectively and the rehydration ratio was 2.1. The RTR halwa was rich in calcium (330 mg/100 g) and magnesium (145 mg/ 100 g). It had an antioxidant activity of 71.3 percent and the total phenolic content was 119.2 mg/100 g. Considering the overall nutritional, as well as sensory attributes, the developed RTR *halwa* can fulfill the objective of providing consumers with a nutrient dense, delicious and convenient RTR healthy traditional food. The optimized millet based RTR *halwa* mix can be suitably employed for commercial production.

Conflict if interest: None.

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