International Journal of Food Science and Nutrition
ISSN: 2455-4898
Impact Factor: RJIF 5.14
www.foodsciencejournal.com
Volume 3; Issue 4; July 2018; Page No. 194-199

Formulation and evaluation of dehydrated red Hawaiian hibiscus (*Hibiscus rosa-sinensis)* incorporated valued added products

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Abstract
The objective of the present study was to assess the nutritional composition and antioxidant activity of dehydrated red *Hibiscus rosa-sinensis* flowers and to develop value added products by incorporating the dehydrated flower powder to increase the consumption of edible flowers in the daily diet. Three different variations of the chocolates, cake and shrikhand were prepared by incorporating dehydrated hibiscus powder and were subjected to acceptability studies. The macronutrient composition was computed and shelf life study was carried out. Chocolates with 5 per cent variation and cake and shrikhand with 10 per cent variation were found to be most acceptable. Chocolate was found to be suitable for consumption after 60 days of storage, while cake could be store up to 7 days under refrigerated conditions.

Keywords: Edible flowers, *Hibiscus rosa-sinensis*, dehydration, value addition, nutrient and antioxidant properties, storage studies

Introduction

"The edible flower is defined as non-toxic, innocuous flowers with health benefits consumed in human diet" (Lu *et al*., 2010) [1]. Edible flowers impart unique and powerful color, flavor and aroma to the food, and therefore have gained popularity in the culinary world as an innovative ingredient.

Hibiscus rosa-sinensis, commonly known as Hawaiian hibiscus or Chinese hibiscus, is an evergreen, glabrous shrub, belonging to the *Malvaceae* family. All the parts of *Hibiscus rosa-sinensis* and their respective chemical constituents are used for their antiovultory, anti-tumor, spasmolytic, antifertility, antipyretic, hypoglycaemic, anti-inflammatory, analgesic, antimicrobial, CNS depressant, and hypertensive activity (Jadhav *et al*., 2009) [2].

Flowers are highly perishable owing to their high moisture content. Dehydration is one of the most convenient methods of food preservation practiced worldwide. Dehydration aids in the removal of moisture, which prevents the growth and proliferation of microorganisms responsible for decay and also diminishes many moisture driven deterioration reactions. It provides substantial reduction in volume and weight thus diminishing the cost of transportation and packaging (Palomeres *et al*., 2009) [3]. Value addition to food products has assumed vital importance in recent days. Thus, the present investigation is an attempt to analyze the nutritional composition of dehydrated red Hawaiian hibiscus flowers, formulate value added products from the dehydrated flower powder and study their shelf life.

Materials and methods

The raw material required for the study was procured from home gardens of farmers of Doddaballapura taluk of Bengaluru. The sepals were manually separated, the petals and stalk were washed in tap water to remove extraneous matter and finely chopped using stainless steel knife. The chopped flowers were spread on a tray drier and allowed to dry at 60±4°C. Drying was continued till the flowers became completely dry and crisp and constant weight was attained. The dehydrated flowers were ground into powder using grinder and sieved through a 60 mesh sieve. The powder was packed in aluminum foil pouches and stored in an airtight container at 8°C in a refrigerated condition until used for further study. The dehydrated flower powder was subjected to nutrient analysis. Moisture, protein, fat, crude fiber, ash, potassium, iron and zinc were estimated following AOAC standard methods (1980) [4]. Calcium content was determined by titrating it against 0.01 N EDTA as described by Heau *et al.* (1965) [5]. The vitamin C concentration was determined using redox titration with potassium iodate in the presence of potassium iodide (Tauber and Kleiner, 1935) [6]. The concentration of β-carotene was measured in spectrophotometer at 450 nm (Ranganna, 2002) [7]. Antioxidant capacity was estimated by DPPH (2, 2-diphenyl-1-picrylhydrazyl) radical scavenging activity method (Kang and Saltveit, 2002) [8]. Different variations of chocolates, cake and shrikhand were prepared by incorporating dehydrated hibiscus

Table 1: Development of value added products

Name of the product	Ingredients used	% Level of incorporation of dehydrated hibiscus powder
Chocolates	Chocolate compound	5, 7.5 and 10
Cake	Refined flour, eggs, sugar, butter, milk powder, baking powder	5, 10 and 20
Shrikhand	Hung curd, sugar, dry fruits, milk, cardamom essence	5, 7.5 and 10

flower powder (Table 1) Nutrient composition of the best accepted developed products was computed based on the nutritional composition of the ingredients (Gopalan *et al*., 2014) [9]. Shelf life study was done for the products based on sensory scores and microbial analysis. Data was analyzed using one-way analysis of variance (ANOVA) and in randomized complete block design to determine the level of significance.

Results and discussion

Nutritional analysis of dehydrated flowers

The results of the nutritional analysis of dehydrated red Hawaiian hibiscus flowers are shown in Table 2. The analysis indicated that dehydrated *Hibiscus rosa-sinensis* flowers had 13.0 per cent moisture, 6.23 g protein and 1.8 g fat. Total ash was 16.00 g / 100 g, crude fibre was 5.88 g and carbohydrate content was 62.97g per 100 g. Among vitamins the dehydrated flowers had 2359.33 µg of β-carotene and 17.84 mg of vitamin C per 100 g. The analysis of the mineral content showed that the dehydrated powder consisted of calcium (1224 mg), potassium (1112.60 mg), sodium (14.95 mg), phosphorous (156.30 mg), zinc (3.16 mg) and iron (12.28 mg). These findings can be compared to Adebayo and Samuel [10], 2009 who reported that the dehydrated flowers of *Hibiscus sabdariffa* contains 14.85 per cent moisture, 5.92 per cent ash, 8.34 per cent crude protein, 7.82 per cent crude fiber and 9.26 per cent fat content. The variation in the proximate composition of fresh and dehydrated *Hibiscus rosa-sinensis* flowers may be attributed to the difference in genetic, environmental, ecological and harvest conditions of the plant.

Table 2: Nutrient analysis of dehydrated red *Hibiscus rosa-sinensis* flowers

Nutrient	Dehydrated *Hibiscus rosa-sinensis* flowers (per 100g dry weight)
Moisture (%)	13.00
Protein (g)	6.23
Fat (g)	1.80
Total ash (g)	16.00
Crude fibre (g)	5.88
Carbohydrate (g)	62.97
Energy (Kcal)	293.00
Vitamins	
β-carotene (µg)	2359.33
Vitamin C (mg)	17.84
Minerals	
Calcium (mg)	1224
Potassium (mg)	1112.60
Iron (mg)	12.28
Zinc (mg)	3.16
Total antioxidant capacity (mg ascorbic acid equivalents/100g)	36.70

The total antioxidant activity of dehydrated flower powder was found to be 36.70 mg ascorbic acid equivalents/100g of powder. There was a decline in the total amount of antioxidants which may be due to the heat applied for drying which leads to degradation of certain heat sensitive antioxidants like vitamin C. However, some antioxidant activity was still preserved which may be due to the presence of certain heat resistant antioxidants in the flower which became concentrated in the powder form or heat processing may have led to improvement of antioxidant properties of some naturally occurring compounds or formation of novel compounds which exhibit antioxidant properties. The results are in line with the results of a study conducted by Tuyen *et al.* (2010) [11] to assess the effects of spray drying on total antioxidant activity of gac fruit aril powder which suggested that increasing the drying temperature from 120°C to 200°C causes significant loss of total antioxidant activity (TAA), from 0.14 to 0.08 mmol TE/g of powder.

Development of the products and organoleptic evaluation

Value added products *viz.*, chocolates, cake and shrikhand were prepared by incorporating dehydrated hibiscus flowers. Sensory evaluation was carried out for acceptance of the products using nine point hedonic scale by 21 semi-trained panel members.

Chocolates are popular products among all age groups. Cocoa, the main ingredient of chocolate, is rich in polyphenols, particularly in flavan-3-ols such as epicatechins, catechins, and procyanidins. The score for appearance ranged from 7.66 to 8.42, for texture ranged from 7.61 to 8.04, aroma ranged from 7.76 to 8.28, for color ranged from 7.95 to 8.38, for taste ranged from 7.28 to 8.33 and for overall acceptability ranged from 7.57 to 8.38. The control had highest score for aroma, taste and overall acceptability and score for texture was same for control, HCH1 and HCH 2. Among three variations of hibiscus chocolates, HCH1 (5 per cent) scored better in all sensory attributes and HCH3 (10 per cent) scored least. Similar results with slightly higher sensory scores for overall acceptability (8.4), texture and flavour (8.00) and colour (8.70) for chocolates with full fat soya flour were reported by Pandey and Singh (2011) [12].

Among hibiscus cakes, HCK2 was found to be most accepted with scores 7.52, 7.61, 8.19, 8.19, 8.09 and 8.19 for appearance, colour, aroma, texture, taste and overall acceptability respectively. Least scores were observed for cake prepared by incorporating 20 per cent hibiscus powder with scores *viz.* 7.33, 7.71, 7.71, and 7.66 for appearance, aroma, taste and overall acceptability. Control scored highest on all the parameters except the score for taste was higher in HCK2. The scores for appearance and color are highest in control and least in 20 per cent variation. This may be attributed to the fact that the colour of the cake turns greener with increase in the amount of hibiscus powder due to the baking at high temperatures which deteriorates the anthocyanin pigments and green chlorophyll is left behind, which was previously masked by the plant's anthocyanins. Similar findings were reported by Kim *et al.* (2012) [13] who reported that the colour became darker and more greenish, as measured by the colourimeter in fibre-enriched sponge cakes made with *Opuntia humifusa*.

Cultured dairy products are the vital component of the human diet in India. Apart from imparting nutrition and novelty, these products help to preserve the precious nutrients in milk which tend to quick deterioration. Shrikhand is a traditional Indian sweet dish prepared from yogurt. The scores for appearance ranged from 7.38 to 8.33, for colour 7.47 to 8.33, for aroma 7.38 to 8.28, for texture 7.52 to 8.28, for taste 7.04 to 8.14 and for overall acceptability 7.23 to 8.33. The control had the

highest score for all the characteristics compared to the other variations. Among hibiscus powder incorporated shrikhand, HSR2 (7.5 per cent flower powder) was found to be best accepted with highest scores for aroma (7.85), texture (7.66), taste (7.19) and overall acceptability (7.61). The scores for appearance and colour were higher for HSR1 (5 per cent flower powder) being 7.85 and 7.76 respectively. HSR3 (10 per cent flower powder) scored the least on all the parameters. These results coincide with the results suggested by Nigam *et al*. (2009) [14] in a study where papaya pulp was incorporated in shrikhand at 20, 40 and 60 per cent respectively. Control scored higher compared to all other variations with 7.18, 7.28, 7.20, 7.28 and 7.23 scores for flavour, texture, appearance, sweetness, and overall acceptability respectively.

Computation of the nutritional composition of the developed products

The nutrient composition of the best accepted and control products were computed and the results are displayed in Table 3. Among chocolates, HCH1 had slightly more protein and less fat compared to the control probably due to the replacement of 5 per cent milk compound with hibiscus powder. HCH1 had lesser caloric value compared to control. Hibiscus chocolates (HCH1) recorded lesser nutritive value (4.01 g protein, 67.24 g of carbohydrate and 22.49 g of fat) when compared to cocoa beans chocolates (6.40 g protein, 60 g of carbohydrate and 30 g of fat) as reported by Torres-Moreno *et al.* (2015) [15].

Table 3: Nutritional composition of developed products (per 100g)

Products		Moisture (%)	Protein (g)	Fat (g)	Total ash (g)	Crude fibre (g)	Vitamin C (mg)	β -carotene (µg)	Calcium (mg)	Iron (mg)
Chocolates	Control	2.65	3.90	24.0	0.90	0.00	0.00	0.00	23.28	0.50
	HCH1	3.16	4.01	22.49	1.65	0.89	117.95	117.95	83.32	1.08
Cake	Control	22.20	7.00	24.24	0.18	0.20	344.10	344.10	57.60	1.24
	HCK2	21.40	6.45	23.95	1.75	1.98	565.65	565.65	176.59	2.22
Shrikhand	Control	62.35	3.25	5.76	0.31	0.90	26.10	26.10	112.76	0.42
	HSR2	57.13	3.49	5.61	1.50	2.16	203.00	203.00	194.13	1.33

The moisture, protein and fat content reduced in HCK2 compared to the control which may be attributed to substitution of eggs and refined flour with hibiscus powder. However, the crude fibre and the carbohydrate content increased while providing the same caloric value. The results are comparable with the findings of Lu *et al.* (2010) [1] who reported the nutritive value of green tea incorporated cakes. Protein, total dietary fibre and ash contents were found in the descending order whereas moisture, fat and carbohydrate contents showed no significant variation.

There was a decrease in moisture, fat and crude fiber in HSR2 compared to control shrikhand probably due to reduction in the quantity of curd used in preparation which was substituted by hibiscus powder having a very low amount of moisture and fat. Similar results were reported by Nadaf *et al*. (2013) [16] where the fat per cent decreased and the carbohydrate and ash content increased with increase in the level of gulkand and rose petal powder in shrikhand.

There was a major increase in the β-carotene content of the chocolates upon addition of hibiscus powder due to the high content of β-carotene in the flower powder. The calcium content also improved significantly. Tarar (2007) [17] reported higher values for protein (12.52-12.63) in chocolate with dates and vetch flour. Bharadwaj *et al.* (2016) [18] reported higher amount of vitamin C (122 mg / 100 g) content in guava milk chocolates.

There was a major improvement in the calcium content of the hibiscus incorporated cakes due to high calcium content of the hibiscus powder. However, the phosphorus content reduced in the variation as compared to the control.

There was an increase in all the micronutrients in shrikhand incorporated with 7.5 per cent hibiscus powder compared to the control. The β-carotene increased from 26.10 to 203 µg. The calcium content was higher in shrikhand than all other products developed due to the utilization of curd in the preparation which has high calcium content. There was an increase in the micronutrient composition of hibiscus incorporated gulkand. However, the difference was minor.

Total antioxidant activity of developed products

The total antioxidant activity of the control and best accepted variations of the developed products were analyzed and expressed as mmol ascorbic acid equivalents (AAE) per 100 g. The results are displayed in Figure 1.

Shelf life study of the developed products

Chocolates, shrikhand and cake were packed laminate pouches made of metalized polyester polyethylene pouches and stored at refrigerated temperature. Sensory attributes and microbial population were observed at an interval of 30 days i.e. initial, 30th and 60th day for chocolates and initial, 5th and 7th day for shrikhand and cake.

Shelf life study of the products by sensory evaluation

The results in the form of mean sensory score after evaluation of chocolates from initial day to 60 days of storage are presented in the Table 4. Decrease in the sensory score of chocolates was observed during storage period. The control sample showed scores of 7.85, 7.76, 7.71, 7.80, 7.47 and 7.80 for appearance, colour, texture, aroma, taste and overall acceptability respectively, whereas the HCH1 (5 per cent) variation had mean sensory scores of 7.80 (appearance), 7.71 (texture), 7.76 (colour), 7.80 (aroma), 7.71 (taste) and 7.90 (overall acceptability) after 60 days of storage studies.

Table 4: Mean sensory score for shelf life of hibiscus chocolates

Products	Duration	Appearance	Color	Texture	Aroma	Taste	Overall acceptability
Control	Initial	8.28	8.33	8.04	8.28	8.33	8.38
	30th day	8.14	8.23	7.85	8.00	8.04	8.09
	60th day	7.85	7.76	7.71	7.80	7.47	7.80
	F value	NS	*	NS	*	*	*
	SEm±	0.12	0.13	0.14	0.11	0.16	0.15
	CD at 5%	-	0.37	-	0.31	0.47	0.45
HCH 1 (5%)	Initial	8.42	8.28	8.04	8.19	8.00	8.19
	30th day	8.19	8.19	7.90	7.95	7.95	8.00
	60th day	7.80	7.76	7.71	7.80	7.71	7.90
	F value	*	*	NS	NS	NS	NS
	SEm±	0.14	0.14	0.14	0.16	0.14	0.15
	CD at 5%	0.42	0.40	-	-	-	-

HCH1- Hibiscus chocolate 1 (5%), HCK2- Hibiscus cake 2 (10%), HSR2- Hibiscus shrikhand 2 (7.5%) *Significant at 5% level, NS- Non significant, HCH1- Hibiscus chocolate 1

The results in the form of mean sensory score after evaluation of cake from initial day to 7 days of storage are presented in the Table 5. Decrease in the sensory score of cake was observed during storage period. The control sample showed scores of 8.09, 8.28, 8.04, 7.80, 7.80 and 7.95 for appearance, colour, texture, aroma, taste and overall acceptability respectively, whereas the HCK2 (10 per cent) variation had mean sensory scores of 7.28 (appearance), 7.90 (texture), 7.09 (colour), 7.95 (aroma), 7.95 (taste) and 7.80 (overall acceptability) after 7 days of storage studies.

Table 5: Mean sensory score for shelf life of hibiscus cake

Products	Duration	Appearance	Color	Texture	Aroma	Taste	Overall acceptability
Control	Initial	8.47	8.52	8.33	8.52	8.04	8.42
	05th day	8.19	8.33	8.14	7.90	7.90	8.23
	07th day	8.09	8.28	8.04	7.80	7.80	7.95
	F value	NS	NS	NS	*	NS	NS
	SEm±	0.15	0.15	0.15	0.12	0.14	0.13
	CD at 5%	-	-	-	0.34	-	-
HCK 2 (10%)	Initial	7.52	7.61	8.19	8.19	8.09	8.19
	05th day	7.38	7.14	8.04	8.00	8.00	7.90
	07th day	7.28	7.09	7.90	7.95	7.95	7.80
	F value	NS	NS	NS	NS	NS	NS
	SEm±	0.16	0.18	0.15	0.18	0.18	0.14
	CD at 5%	-	-	-	-	-	-

*Significant at 5% level, NS- Non significant, HCK2- Hibiscus cake 2

The results of the mean sensory score evaluation of shrikhand from first day to 7 days of storage study period are presented in the Table 6. Decrease in the sensory score of shrikhand was observed during storage period. The control sample showed scores of 7.80, 8.00, 7.90, 7.80, 7.71 and 7.85 for appearance, colour, texture, aroma, taste and overall acceptability respectively, whereas the HSR2 (7.5 per cent) variation had mean sensory scores of 7.42 (appearance), 7.33 (texture), 7.28 (colour), 7.23 (aroma), 6.80 (taste) and 7.28 (overall acceptability) after 7 days of storage studies. Control was more acceptable after the storage than variation HSR2 with 7.5 per cent of hibiscus powder sample.

Table 6: Mean sensory score for shelf life of hibiscus shrikhand

Products	Duration	Appearance	Color	Texture	Aroma	Taste	Overall acceptability
Control	Initial	8.33	8.33	8.28	8.28	8.14	8.33
	3rd day	8.33	8.38	8.23	8.28	8.09	8.33
	05th day	8.14	8.19	8.09	8.04	7.95	8.09
	07th day	7.80	8.00	7.90	7.80	7.71	7.85
	F value	*	NS	*	*	NS	*
	SEm±	0.14	0.14	0.10	0.13	0.12	0.12
	CD at 5%	0.39	-	0.29	0.36	-	0.35
HSR 2 (7.5%)	Initial	7.80	7.66	7.66	7.85	7.19	7.61
	3rd day	7.76	7.66	7.57	7.66	7.14	7.57
	05th day	7.66	7.47	7.52	7.57	6.95	7.47
	07th day	7.42	7.28	7.33	7.23	6.80	7.28
	F value	NS	NS	NS	NS	NS	NS
	SEm±	0.16	0.17	0.16	0.16	0.14	0.12
	CD at 5%	-	-	-	-	-	-

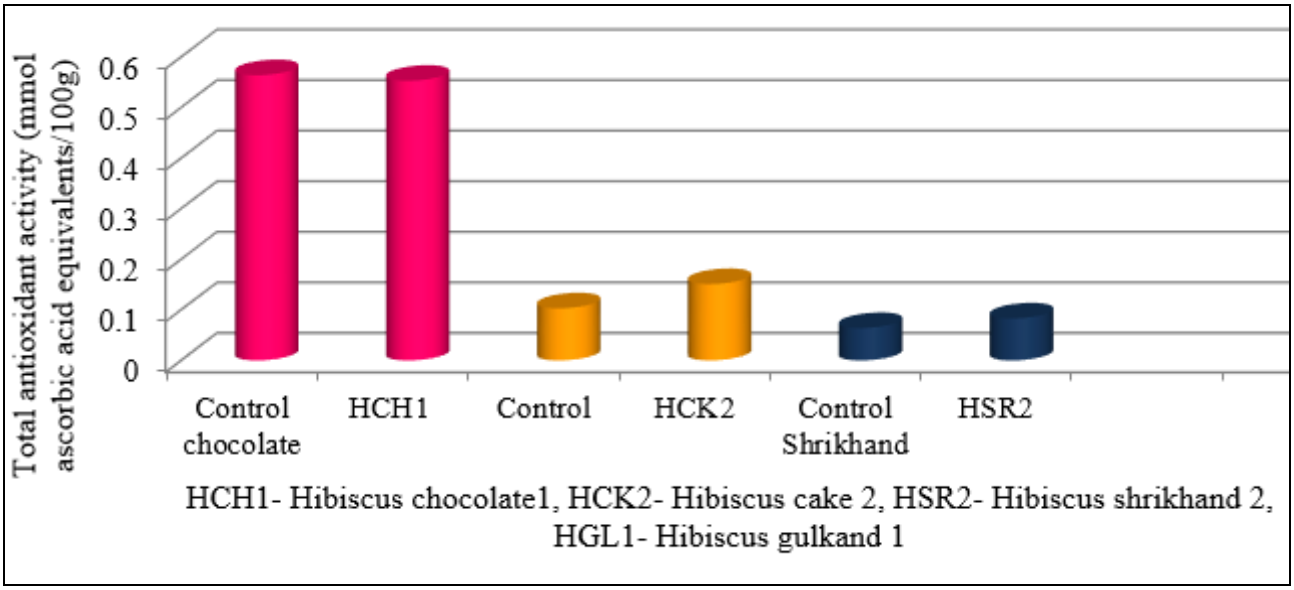
Shelf life study of the products by microbial population

Microbial population (bacteria, moulds and coliforms) of control and best accepted variations of developed products was estimated using standard plate count method on initial, 30th and 60th days for chocolates and 3rd, 5th and 7th days of storage for cake and shrikhand.

Microbial population was estimated for total bacteria, moulds and *Escherichia coli* by standard plate count method and results are presented in Fig.2 for chocolates. The increase in total bacterial population of chocolates from initial day to 60th day was from nil to 1.03×10^2 cfu/g for control chocolates and 0.83×10^2 cfu/g for HCH1. The mould population increased from nil to 0.36×10^2 cfu/g and 0.56×10^2 cfu/g for control and HCH1 respectively on 60th day of storage. *Escherichia coli* was absent in both the samples on initial day and increased to 0.40×10^2 cfu/g for control and 0.53×10^2 cfu/g of chocolates for HCH1 during the storage period of 60 days.

Microbial population was estimated for total bacteria and moulds by standard plate count method and results are depicted in Fig.3 for hibiscus cake. The increase in total bacterial population from initial day to 7th day was from nil to 2.13×10^2 cfu/g of cake for control and 1.96×10^2 cfu/g of cake for HCK2. The mould population increased from nil to 1.26×10^2 cfu/g and 1.10×10^2 cfu/g of cake for control and HCK2 respectively on 7 days of storage.

Microbial population was estimated for total bacteria, moulds and *Escherichia coli* by standard plate count method and results are depicted in Fig.4 for hibiscus shrikhand. The total bacterial population on initial day was 0.60×10^2 cfu/g and increased to 4.73×10^2 cfu/g of shrikhand on 7th day for control, while for HSR2 it increased from 0.56×10^2 cfu/g on initial day to 4.46×10^2 cfu/g of shrikhand on day 7. The mould population increased from 0.20×10^2 cfu/g to 1.40×10^2 cfu/g and from 0.20×10^2 cfu/g to 1.66×10^2 cfu/g in shrikhand during the 7 days of storage period for control and HSR2 respectively. *Escherichia coli* population increased from 0.13×10^2 cfu/g to 0.86×10^2 cfu/g in shrikhand for HSR2 after 7 days.



*Significant at 5% level, NS- Non significant, HSR2- Hibiscus shrikhand 2

Fig 1: Total antioxidant activity of the developed products

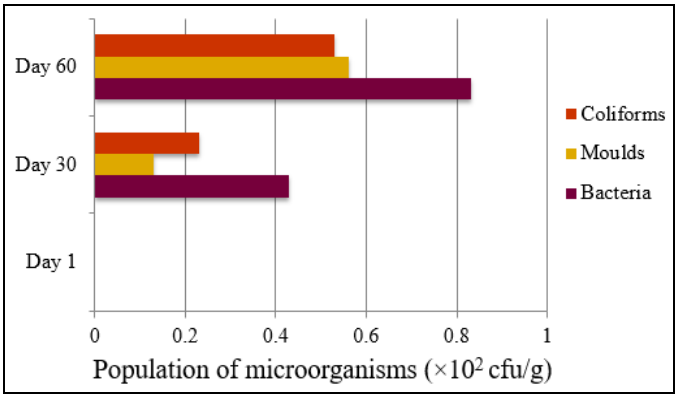


Fig 2: Microbial population of hibiscus chocolate (HCH1 5%) on storage (per g)

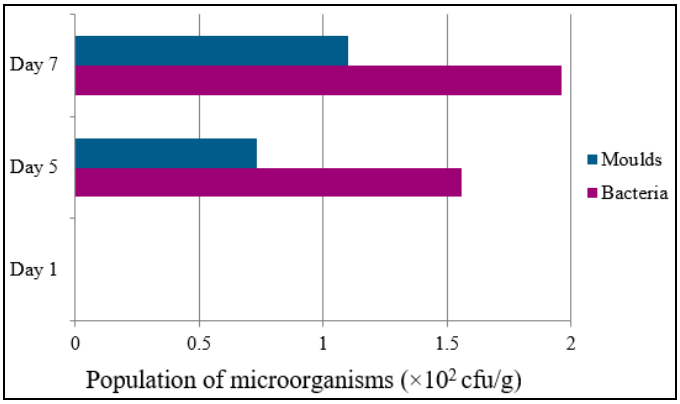


Fig 3: Microbial population of hibiscus cake (HCK2 10%) on storage (per g)

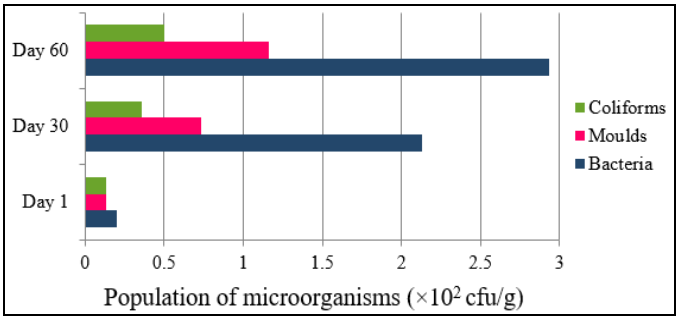


Fig 4: Microbial population of hibiscus shrikhand (HSR2 7.5%) on storage (per g)

Conclusion

The study showed that hibiscus flowers are rich in protein, fibre, β-carotene, vitamin C, calcium and iron. Hibiscus flowers can be dehydrated into a powder form and acceptable value added products can be developed by incorporating the dehydrated flower powder to enhance nutritional value and enrich therapeutic benefits. Thus, with further modification, hibiscus flowers can very well be exploited for value addition and consumption.

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