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Quality Evaluation of Syrup Food Models Derived from *Prosopis cineraria* (L.) Druce Ripened Pods

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Abstract: Khejri (*Prosopis cineraria* (L.) Druce) is among the most endemic hardy plant species of semi-arid tropical regions of Thar Desert. Its ripened pods has considerable amount of natural sugars, minerals and importantly high amounts of proteins. The aim of the present work was to evaluate different food models by quality of syrups obtained from khejri pods (*Prosopis cineraria* (L.) Druce). The syrups were obtained through concentrated pod extract. Physicochemical parameters (protein content, moisture and specific gravity) were evaluated considering the quality parameters for syrups. The *in-vitro* digestibility tests for proteins and starch were conducted and estimated glycemic index were calculated through first order kinetics. *Prosopis* pod syrup food models presented quality parameters statistically different from the control (honey) used in this study for comparison. The values observed for honey match with range reported by other authors for food standards from several parts of the world. The syrups presented superior nutritional quality regarding their protein and mineral contents. The *Prosopis* syrup might be considered a good protein and mineral source for human nutrition.

Key words: *Prosopis cineraria,* Syrups, physicochemical properties, *in vitro* digestibility.

Khejri (*Prosopis cineraria* (L.) Druce) is among the most adaptable and nitrogen fixing trees in arid regions and traditionally became natural to semi-arid tropical regions of Thar Desert (Khandelwal *et al*., 2015). This tree has been regarded as valuable source of food and fodder. Sweet, fresh pods are commonly used as vegetables in indigenous cuisines (Khatri *et al*., 2010) and immature pods were consumed raw by children and adults in rural areas (Mann and Saxena, 1980). However, with changing times more exotic and tropical fruits replaced this tradition and the ripened pods of this wonder tree are now almost forgotten. The pods generally get ripened in peak summers and get rotten after falling on ground.

The unripened green pods are used for making curry and pickle. These are consumed as vegetables and is considered as one of the best delicacies in western India. The flour of mature pods is used for cookies preparation and other local dishes. The leaves and dry pods are annually harvested for cattle and sheep feed (Sobhy Amin Afifi and Abu Al-rub, 2019). A resin occurring naturally on the tree, known as *Prosopis* gum, is also occasionally eaten by people and known for its medicinal use in traditional remedies (Siddiqui *et al*., 2017).

These pods has considerable amounts of natural sugars, minerals and importantly high amounts of proteins (Sobhy Amin Afifi and Abu Al-rub, 2019). The similar pods from different species of same genus are used to make enriched syrups called ‘algorrobina’ made from *Prosopis pallida* in rural areas of northern Peru (Quispe *et al*., 2014). The process of making this syrup is carried out on a household level in rural Peru using very simple kitchen equipment and the “algarrobina” produced is sold in reusable glass bottles (Guilherme *et al*., 2009).

A good way for preserving fruit juices and plant extract is by concentration. It is a method of preserving foodstuff without the need of additives or the use of refrigerated systems. In this work, concentrated khejri pod extracts was processed to obtain syrups with medium sugar content. The quality properties of the final products were evaluated. Syrups rich in proteins and minerals and sugars obtained from plant extracts are suitable for food industry applications. In confectionary industries, plant syrups can be used to replace glucose syrups (caramels, toffees, gums and fudges), which are the most common syrups used in the

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industry. Syrups can also be directly consumed like honey and maple syrup. However, little information on these honey-like products has been published. The syrups studied herein were also shown to be a good source of nutrients for human diet.

Honey is a natural sweet substance produced by bees (*Apis mellifera*) from the nectar of plants. This food consists mainly of sugars, predominantly glucose and fructose besides other substances such as minerals (Singh and Bath, 1997). Because of its sweetness, honey has been a highly valued food item since primitive times.

In the present work, the use of khejri pods (*Prosopis cineraria* (L.) Druce) syrups with different food models as low-cost honey-like products were evaluated. The food models were designed as such to replace added sugar by jaggery and solidifying agent by natural *Prosopis* gum and study their improvement in nutrient content. Quality parameters (°Brix, total proteins and specific gravity) and *in vitro* digestibility were compared to natural honey. Product acceptance was evaluated through sensory analysis.

Materials and Methods

Chemicals and raw materials

All reagents used were of analytical grade. Enzymes were purchased from Qualigens (India). Other chemicals used in the study were purchased from Merck (Germany). Brown ripened pods of *Prosopis cineraria*, *Prosopis* gum, Pectin (Brand: Urban Platter, gelled texture, food grade) and jaggery powder (Brand: Dhampur green) and sugar were purchased locally from Rajasthan, India.

Food model preparation

Prosopis pod syrup was obtained according to the protocol described for mesquite syrup preparation by Bravo *et al*., 1998 with modifications. The *Prosopis* pods were milled after deseeding in a laboratory high speed grinder. The soluble solids from the pods were extracted by adding water to the milled pods (1 L per 100 g) under intermittent stirring for 60 mins. The insoluble solids were removed by filtration in a cotton cloth filter and allowed to rest at room temperature for 3 hrs. Fine solids were removed by filtering the extract through a cotton filter. The extract was concentrated at 55-60°C until the total soluble content reached 70–80°Brix (the minimum content required for honey is 65°Brix; Nanda *et al*., 2009).

Five different syrup models (A, B, C, D and E) were prepared using ingredients as given below:

Ingredients	Food models				
	A	B	C	D	E
Prosopis fruit pulp	150 ml	150 ml	150 ml	150 ml	150 ml
Lemon juice	10 ml	10 ml	10 ml	10 ml	10 ml
Pectin powder	15 g	7.5 g	15 g	-	-
Prosopis gum	-	7.5 g	-	15 g	15 g
Jaggery powder	-	25 g	50 g	50 g	-
Sugar crystals	50 g	25 g	-	-	50 g

Nutritional evaluation

Proximate analysis: Protein, fat, ash contents were estimated using standard methods of analysis (AOAC, 1990). Total reducing sugars were estimated by following the method of Gonçalves *et al.,* 2010.

Determination of the syrup quality parameters

The total soluble solid contents of the samples were determined using an Atago refractometer (30-80°Brix, heat resistant, Model: Master 80H, Tokyo, Japan) at room temperature (28°C). Results were expressed as °Brix. The specific gravity was determined by dividing the weight of a bottle (50 ml) filled with syrup by the weight of the same bottle filled with water (Nanda *et al*., 2009).

Color was estimated by recording transmittance spectra with standard 10 mm quartz cuvettes with an empty cuvette as a reference with no additional sample preparation apart from filtration at room temperature with Whatmann filter paper (Grade 1) (Tuberoso *et al.,* 2014). The measurements were calculated by color calculation software by OSRAM Sylvania, Inc. and values were presented in C.I.E. $L^*a^*b^*$ format. The ΔE^*_{ab} values were calculated by formula:

$\Delta E * ab = \sqrt{(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - b_1^*)^2}$

where, 1 = reference values and 2 = sample values.

Protein digestibility

In vitro protein digestibility was determined by following the method described by Akeson and Stahmann (1964). The digest were subjected to protein quantification spectrophotometrically (Lowry *et al.*, 1951) against a standard of known concentration of bovine serum albumin (BSA).

Determination of total starch

The amount of total starch was determined by Goñi *et al.*, 1997 with a change in enzyme dose. In the present study, pancreatic amylase of 23 IU mg^{-1} and amyloglucosidase of 21 IU mg^{-1} were used.

Determination of in vitro starch digestibility and glycemic index (GI)

The protocol of Goñi *et al.*, 1997 was followed to determine the digestibility. The samples were digested and digestible starch was calculated between 0 to 180 mins at an interval of every 30 mins. The rate constant was determined by following the equation

$C_t = C_\infty(1 - e^{-kt})$

C_t= Percentage of hydrolysis done at time t

C_∞= Equilibrium percentage of hydrolysis at 120 mins

k = Kinetic (rate) constant.

The area under curve (AUC) was calculated for the samples using following equation

$$AUC = C_\infty(t_f - t_0) - \left(\frac{C_\infty}{k}\right)[(1 - e^{-k(t_f - t_0)})]$$

and hydrolysis index (HI) was determined as ratio of AUC of sample to AUC of white bread (Taye *et al.*, 2016).

GI was calculated by following equation *eGI=8.198+0.862(HI)* as described by Granfeldt *et al.*, 1992.

Sensory analysis

The different models of syrup were evaluated by sensory analyses. The acceptance tests were carried out with 40 untrained panelists. The tests were performed using the hedonic rating option, asking the panelists to rate color, flavor and overall acceptance using a structured 5-point hedonic scale, where 5 meant "Excellent" and 1 meant "Satisfactory" (Peryam and Pilgrim, 1957). The panelists were also asked about the similarities between the syrup and honey regarding their appearance and viscosity. Sensory tests were performed in individual booths in the morning shift (9:30-11:30 a.m.) under white light. The syrups were served with cheese crackers (2 x 2 cm). Samples were randomly coded as per model numbers. A glass of water was served between the samples.

Statistical analysis

The results are presented as mean values and standard deviations in duplicates. Analysis of variance and significant differences among means were tested by one way ANOVA using SPSS 16.0.

Results and Discussion

Proximate analysis

The compositional attributes of food models such as reducing carbohydrate, protein, fat, ash, moisture and crude fibre were statistically different ($P<0.05$) according to the results presented in Table 1, *Prosopis* pods syrup food models presented total protein content varying from 2.07% to 5.33%, The highest was recorded in Food model C, which contained jaggery with high phosphorous and iron minerals combined with pectin that might be responsible for enhancing the bioavailaibility of proteins in intestine (Abhirami and Karpagapandi, 2018). The reducing carbohydrates ranged from 38.76% to 49.95% with estimated medium glycemic index range (Foster-Powell *et al.*, 2002) On the other hand, the control presented the quality parameters within the standard range mentioned (Nanda *et al.*, 2009). Comparing the results obtained from food models of *Prosopis* pods syrup, the values were significantly different with higher percentage of protein content (3.16 and 5.33) and high minerals in terms of total ash per cent (1.28 and 2.65) in model food A and C which contained pectin combinations with sugar and jaggery, respectively. This increases the bioavailaibility of minerals (Varzakas *el al.*, 2016). The quality parameters of the °Brix and specific gravity of these two models also corroborated with control.

*Table 1. Proximate analysis and syrup quality parameters (values are given in mean ± S.E.) in g 100 g^{-1} wet matter as per food models**

Food models	Initial carbohydrate (%)	Protein (%)	Fibre (%)	Ash (%)	Moisture (%)	Soluble solids (°Brix)	Specific gravity	Estimated glycemic index (eGI)
A	41.80±0.4	3.16±0.01	0.14±0.01[a]	1.28±0.24	24.34±0.43	75±0.52	1.38±0.52[a]	44.19±1.3
B	38.76±0.4	2.78±0.01	0.42±0.03	0.83±0.03	29.87±0.21	70±0.87[a]	1.34±0.87[a]	65.84±1.76
C	39.96±0.2	5.33±0.05	0.79±0.06	2.65±0.09	23.04±0.65	65±0.46	1.31±0.46[a]	65.72±0.96
D	44.52±0.3	4.77±0.02	0.15±0.02[a]	0.46±0.02	36.43±0.46	70±0.32[a]	1.34±0.32[a]	65.38±0.98
E	49.95±0.1	2.07±0.00	0.19±0.01	0.67±0.01	37.65±0.43	79±0.43	1.40±0.43[a]	49.53±0.68
Honey	99.80±0.0	0.23±0.01	0.00±0.01	0.01±0.00	18.45±0.34	62±0.34	1.30±0.34[a]	47.20±0.7

*Values with same letters within a column are not significantly different (P<0.05).

For the color measurements, resulting L* value refers to the lightness of the sample (0=black; 100=white), a* value refers to the redness of the sample (+100 in direction red, -100 in direction green) and the b* value gives the yellowness of the sample (+100 in direction yellow, -100 in direction blue). The calculated ΔE*ab value is necessary to be used for evaluating the difference in color of samples from the consumer's point of view compared with honey as a reference based on the values measured in the L*a*b* color system, The color measurement is elaborated in Table 2. The two models A and C recorded similar values to the control (honey). The color was towards the lighter hues when compared to the other models in terms of L* while ΔE^*_{ab} values recorded for A and C were 23.04, 21.20 respectively when compared with control (Tuberoso *et al*., 2014). No published data for *Prosopis* pod syrup were found in the literature but comparison with commercially available mesquite syrup (Guilherme *et al*., 2009), these food models showed higher protein levels and low moisture content.

*Table 2. Color measurements according to CIE L*a*b*, ΔE^*_{ab} and %T (560 nm) for the food models*

Food models	L*	a*	b*	%T at 560 nm	ΔE^*_{ab}
A	84.82	9.28	60.40	71.3	23.04
B	79.14	16.72	61.80	60.3	16.36
C	83.96	13.76	60.03	58.8	21.20
D	67.20	16.96	83.42	41.7	08.90
E	45.87	41.60	76.70	13.69	33.25
Honey*	70.38	19.16	75.40	51.0	00.00

*All the food models were compared to Honey as reference for color difference.

Protein digestibility

As per the observation of initial protein content (Table 3) the values are higher of all the food models designed for syrup compared to the negligible amount of protein present in honey (Singh and Bath, 1997). Also, the values are significantly higher in terms of initial proteins that reflected higher digestibility especially in food model C. This might be due to presence of jaggery with pectin. Pectin, being a polysaccharide, when combined with jaggery can be capable of keeping the hydrolysed peptides of *Prosopis* pods intact until the digestion with pancreatin enzyme converts it to essential amino acids (Xu *et al*., 2014). Also,

*Table 3. Initial protein, final protein and protein digestibility (%) (values are given in mean ± S.E.) in g 100 g^{-1} wet matter as per treatment**

Samples	Treatment	Initial proteins	Final proteins	Protein digestibility (%)
A	Pectin + sugar	3.16±0.01	0.35±0.01	88.95±0.01
B	Gum + pectin** + jaggery + sugar**	2.78±0.01	0.44±0.00	84.19±0.01
C	Pectin + jaggery	5.33±0.05	0.24±0.02	95.57±0.03
D	Gum + jaggery	4.77±0.02	0.33±0.04	93.16±0.03
E	Gum + sugar	2.07±0.00	0.15±0.01	92.66±0.01
Honey		0.23±0.01	0.11±0.01	53.63±0.01

*Values with same letters within a column are not significantly different (P<0.05).
** Ratio = 1:1

Table 4. Initial carbohydrates, total starch, digestible starch and resistant starch (Values are given in means ± S.E.) in g 100 g^{-1} wet matter as per treatment of food models*

Samples	Treatment	Total starch (TS)	Resistant starch (RS)	Digestible starch (DS)	Total starch hydrolysis (%)	Kinetic constant (k)	Initial reducing sugar	Estimated glycemic index (eGI)
A	Pectin + sugar	5.24±1.9	1.32±0.6[a]	3.92±1.2[a]	74.80±1.5	0.068±0.0015[a]	41.8±0.4	44.19±1.3
B	Gum + pectin** jaggery + sugar**	8.81±2.6	5.71±0.6	3.10±1.6[a]	35.18±2.1	0.021±0.002	38.76±0.4	65.84±1.76
C	Pectin + jaggery	4.67±1.1[a]	1.25±0.8[a]	3.43±0.9[a]	73.44±1.0	0.066±0.001[a]	39.96±0.2	65.72±0.96
D	Gum + jaggery	4.35±0.8[a]	1.64±0.57	2.71±0.6[a]	62.22±0.7	0.048±0.006	44.52±0.3	65.38±0.98
E	Gum + sugar	2.95±0.1	1.30±1.8[a]	1.65±0.4[a]	55.93±0.2	0.040±0.002	49.95±0.1	49.53±0.68
Honey						0.020±0.001	99.8±0.0	47.20±0.7

*Values with same letters within a column are not significantly different (P<0.05). ** Ratio = 1:1

jaggery contains its own proteins (Nath *et al.*, 2015).

Carbohydrate digestibility and estimated GI

Food models showed presence of starch and polysaccharides which is due to content of pods, pectin or gum used in the recipes (Table 4). However, no such presence was observed in honey because major carbohydrate portion that it contains is of fructose (Singh, 2015). All the food models show significant values for higher starch hydrolysis except Food model B (Table 4). The reason may be presence of two type of plant polysaccharide (pectin and natural gum) in presence of jaggery were not readily cleaved by enzyme action in food model B. While, the starch-pectin/gum mixtures in other food models might be contributing in increasing the starch hydrolysis (Zhang *et al.*, 2018).

The initial reducing sugars were present in considerable amount with no significant difference in the amount except in the control, which is the actual source of simple natural sugars (Singh and Bath, 1997). The effect can be seen in terms of estimated glycemic index. All food models including honey were medium glycemic index foods. The honey sourced from *Acacia*, generally recorded low glycemic index ranging from 35-50 due to presence of high fructose levels (Singh, 2015).

Sensory analysis

There were significant differences (P<0.05) in sensory features in terms of flavor, taste, texture, color, sweetness and overall acceptability among food models formulated from pod extracts (Table 5). The food model A and C had higher score. This could be due to jaggery and sugar palatability with pectin (Nath *et al.*, 2015).

Conclusion

The quality parameters of the studied syrups are in agreement with the quality regulation of syrups, except for higher moisture content (%) ranging from 24.04-37.65. The evaluated products can be considered as low-cost and locally available honey substitutes and have presented superior nutritional values (higher

*Table 5. Sensory scores of the food models**

Syrup model	A	B	C	D	E
Taste	3.87±0.23[a]	3.00±0.19	3.87±0.22[a]	2.78±0.23	1.91±0.13
Color	3.34±0.21	3.00±0.22	3.78±0.24	2.52±0.18	1.95±0.14
Aroma	3.60±0.20	3.00±0.16	3.30±0.24	2.87±0.15	1.78±0.13
Sweetness	4.08±0.18	3.39±0.17	3.82±0.23	2.60±0.15	1.73±0.12
Flavor	3.91±0.14	3.17±0.17	3.78±0.21	2.21±0.13	2.00±0.12
Texture	3.91±0.17[a]	3.26±0.18	3.87±0.19[a]	3.26±0.15	2.52±0.14
Overall accepatability	3.74±0.22	2.83±0.17	3.74±0.24	2.18±0.14	2.35±0.20

Hedonic scores: 1 = Satisfactory; 2 = Fair; 3 = Average; 4 = Good; 5 = Excellent.
*Values with same letters within a column are not significantly different (P<0.05).

per cent proteins with high digestibilities and minerals in terms per cent of ash when compared to natural honey as control. These attributes are important for human and animal consumption. Among the *Prosopis* pods food models B, D and E did not present good acceptability for direct consumption. But good acceptance was observed for food model A and C where jaggery was totally used to substitute sugar giving high nutritional enrichment in terms of proteins (%) i.e. 3.16 and 5.33, respectively and higher minerals (in terms of ash (%) ranging 1.28-2.65 in that order). The entire food models' reducing carbohydrates ranged between 38.76-49.95% indicating the presence of simple sugars, polysaccharides and starch of medium glycemic index after *in vitro* digestibility.

This suggests that the addition of locally available foods and subsequent conversion to traditional recipes is more palatable and are capable to solve local nutritional issues. Further, the study also paves a path through which novel food intervention in traditional recipes can also be explored at regional and national level to meet the nutritional and health requirements.

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