

Utilization of *Foeniculum vulgare* in herbal candy preparation and analysing its effect on the physico-chemical and sensory properties

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***Foeniculum vulgare*, also known as fennel, is a medicinal herb belonging to the Apiaceae (Umbelliferae) family. The present study examined the effect of different processing techniques (sun- and tray-drying, and roasting) on fennel seeds and aimed to find the best method for incorporation of powder in the formulation of hard candy to deliver phytochemicals and bio-active compounds that it possesses, thus rendering health benefits. The proximate and physico-chemical evaluation of fennel-seed powder showed that sun-drying is the most effective technique. It retains most of the nutrients of fennel seeds. It also requires less technical know-how, no sophisticated equipment and is economical. Thus, sun-dried fennel-seed powder was used in the formulation of hard candy and DF11 (5% fennel-seed powder) was the best formulation deemed to be optimized with physico-chemical and sensory characteristics that were found acceptable.**

Keywords: Fennel seeds, herbal candy, processing techniques, physico-chemical and sensory properties.

FOENICULUM VULGARE (fennel) is a medicinal herb belonging to the Apiaceae (Umbelliferae) family. In ancient times fennel was known as ‘maddhurika’, in early Sanskrit writings^{1,2}. It is cultivated in India since 2000 BC (ref. 3). Plant parts and roots are used as edible herb and seeds as spice⁴. About 100 g edible fennel seeds contain on average 8.8 g water, 15.8 g protein, 14.9 g fat, 36.6 g carbohydrates, 15.7 g fibre and 8.2 g ash (1.2 g Ca, 19 mg Fe, 1.7 g K, 385 mg Mg, 88 mg Na, 487 mg P and 28 mg Zn), vitamin A (135 IU), niacin (6 mg), thiamine (0.41 mg) and riboflavin (0.35 mg), with energy value about 1440 kJ (ref. 3).

Fennel has been a part of the traditional medicine since ancient times; it has been used in diseases and disorders of digestive, endocrine, reproductive and respiratory systems. It is widely used by lactating mothers as it is a

common galactagogue (chemical agents that help in increased production of milk). It is also used in pharmaceuticals because of its antimicrobial, antiviral, anti-inflammatory, antimutagenic, antispasmodic, antithrombotic, antitumour, cardiovascular, chemomodulatory, hepatoprotective, diuretic, analgesic, hypoglycaemic and memory-boosting properties⁵⁻⁷.

It is found that from pre-school children to the elderly, all are fond of confectionery products. Confectionery includes sugar-based products like sweets, candies, toffees, chocolates, etc. Therefore, in the present study we analyse the effect of processing conditions on the physico-chemical properties of fennel, to chose an appropriate process for preparing a fennel-based herbal candy.

Materials and methods

The raw material, viz. fennel (*Foeniculum vulgare*, variety Hisar Swarup) was procured from the experimental farms of Lovely Professional University (LPU), Phagwara, Punjab, while table sugar was procured from the local market in Jalandhar, and liquid glucose from Glushan Polyols Ltd, Gujarat.

Drying techniques

For sun-drying, fennel seeds were kept under sunlight (30–35°C) for 2 days (12 h of sunlight) and ground to make a powder. For tray-drying, fennel seeds were kept in a tray drier (Narang Scientific and Electronic Equipment, Pvt Ltd, New Delhi) at 55°C for 3 h until the final three consecutive readings were taken. For roasting, fennel seeds were roasted at 75–80°C for 30 min.

Proximate analysis

Moisture content: Sample (5 g) was weighed accurately into a cooled and tare glass petri placed. The sample was

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heated in hot-air oven maintained at $105 \pm 2^\circ\text{C}$ for 3 h. Next, the dish was transferred to desiccators, cooled and weighed⁸. Moisture content was calculated as

$$\text{Moisture content} = \frac{(W_1 - W_2 \times 100)}{W_1 - W}$$

where W is the weight of the empty dish (g), W_1 the weight of the dish with the sample (g) and W_2 is the final weight of the dish (g).

Fat content: This was calculated using Soxhlet extraction method⁸. Sample (5 g) was taken in a thimble and extracted with petroleum ether in Soxhlet extraction apparatus for 6–8 h in a pre-weighed round-bottom flask. The poured content was heated at 70°C for 1 h and then the temperature was raised to 140°C for the next 1 h. After heating, the remaining content was evaporated at 102°C till final weight was analysed. The content was calculated using the formula

$$\text{Fat (\%)} = \frac{W_2 - W_1}{S} \times 100,$$

where W_1 is the weight of the empty silica crucible (g), W_2 the weight of the silica crucible with ash (g) and S is the weight of the sample (g).

Protein content: This was determined using Kjeldhal method. Weighed sample (0.3 g) was digested along with concentrated sulphuric acid (10 ml) and digestion mixture (4 g potassium sulphate and 1 g copper sulphate) in a Kjeldhal digestion flask. The contents were cooled, diluted with 400 ml of distilled water and transferred into a distillation flask. Next, 25 ml of 4% boric acid with methylene red indicator was taken in a conical flask. Approximately 90 ml of 40% NaOH was added to the distillation flask. The conical flask was placed below the condenser until 300 ml distillate was collected⁹. The evolved $\text{N}_2\%$ was determined by titrating the condensate with 0.1 N HCl. Percentage protein was calculated by the formula

$$\text{Nitrogen (\%)} = \frac{\left(\frac{(\text{Sample titre} - \text{blank titre}) \times (\text{normality of HCl} \times 14.01 \times 100)}{\text{Weight of sample} \times (\text{aliquot taken for distillation} \times 1000)} \right)}{\left(\right)}$$

$$\text{Protein \%} = \text{nitrogen \%} \times 6.25.$$

Ash content: Approximately 5 g sample was weighed into a crucible and kept for charring on a hot plate for 2 h. After charring, the sample was kept for ashing in a muffle furnace at $550 \pm 2^\circ\text{C}$ for 6 h (ref. 8). Ash content was calculated as

$$\text{Ash content} = \frac{W_2 - W_1}{S} \times 100,$$

where W_1 is the weight of the empty silica crucible (g), W_2 the weight of the silica crucible and ash (g) and S is the weight of the sample (g).

Physico-chemical analysis

Flavonoids: Sample (0.1 g) was extracted with 5 ml of 80% aqueous ethanol by centrifuging at 6000 rpm for 30 min. Then 0.25 ml of the extract was taken in test tube, to which 1.25 ml distilled water and 0.75 ml of 5% sodium nitrate were added. After allowing to stand for 5 min, 0.15 ml of 10% aluminum chloride was added and then the mixture was further allowed to stand for 6 min. Next, 0.5 ml of 1 N NaOH and 0.275 ml distilled water were added to the test tube and absorbance was measured at 510 nm using a spectrophotometer. Blank was prepared by taking 80% ethanol instead of extract and the same procedure was followed as mentioned above. The total flavonoid content was expressed in milligrams of catechin equivalents (CE) per gram of the extract. All the determinations were carried out in triplicate¹⁰.

Total phenolics content: Sample (0.1 g) was extracted with 5 ml of 80% aqueous ethanol by centrifuging at 6000 rpm for 30 min. Supernatant was taken in another test tube and boiled until evaporation. Distilled water (5 ml) was added to the residue and 0.2 ml of the solution was transferred to another test tube and made up to 3 ml, with distilled water. Folin Ciocalteu reagent (5 ml) was added and the solution was kept for 3 min before adding 2 ml of 20% sodium carbonate to the test tube. The solution was boiled for 1 min and absorbance was measured at 650 nm using a spectrophotometer. Blank was prepared using 80% ethanol. The total phenol content was expressed in milligrams of gallic acid equivalents (GAE) per gram of extract. All the determinations were carried out in triplicate¹¹.

Ascorbic acid content: This was determined using 2,6-dichlorophenolindophenol dye. Sample (10 g) was extracted in 3% m-phosphoric acid and titrated with dye to pink colour end-point. Results were expressed as milligrams per 100 g of sample¹² and calculated using the formula

$$\begin{aligned} &\text{Ascorbic acid} \\ &= \frac{\text{Titre} \times \text{dye factor} \times \text{volume made up} \times 100}{\text{Aliquot of extract} \times \text{weight of volume of sample}} \end{aligned}$$

Free-radical scavenging activity

The DPPH free-radical scavenging method was used to evaluate antioxidant property. Sample (0.5) was taken in

a test tube and 5 ml of 80% methanol was added to it. After allowing to stand for 5 min, 0.1 ml of the solution was pipetted out into another test tube and 3.9 ml of 1 mM DPPH solution was added to it. The test tube was kept for 30 min in dark and absorbance was measured at 517 nm using a spectrophotometer. Blank was prepared using 80% ethanol¹³. Inhibition of DPPH free radical (%) was calculated as

$$\text{Inhibition (\%)} = \frac{\text{A-control} - \text{A-test}}{\text{A-control}} \times 100,$$

where A-control is the absorbance of the control and A-test is the absorbance of the reaction mixture samples.

All the tests were done in triplicate ($n = 3$) and average values calculated.

Formulation and preparation of hard candy

The hard candy formulation consisted of water (22.2%), sugar (66.6%), corn syrup (11.1%) and citric acid (0.1%) as standard ingredients. Fennel powder was added to the above mixture at an incremental level of 0.5 g, ranging from 0.5 to 8 g, thus making 16 formulations, excluding control (with no fennel powder). Sucrose was dissolved in water and then glucose syrup was added. The mixture was stirred continuously to 143.3°C, removed from the flame and citric acid and fennel-seed powder were added. The contents were poured into silicon moulds and allowed to cool until they hardened.

Sensory evaluation

For this, all the concentrations of hard candy made using different percentages of fennel-seed powder were analysed to find the best option. Five parameters, viz. colour and appearance, flavour, body and texture, mouthfeel and overall acceptability were used for sensory evaluation¹⁴. A nine-point hedonic scale was also used for the evaluation. The sensory panel consisted of 50 (25 males and 25 females; aged 25–40 years) semi-trained healthy individuals from the premises of LPU, Phagwara.

In addition, consumer analysis was carried out separately for the optimized hard candy. The untrained consumer panel consisted of 150 random persons. The same parameters mentioned above were used for the analysis. Hard candy was analysed to determine its commercial acceptability.

Statistical analysis

The data obtained in this study were subjected to statistical analysis. One-way analysis of variance (ANOVA) was applied and Duncan's multiple range test was

employed to analyse the test of significance using SPSS 22.0 software (SPSS Italia, Bologna, Italy).

Results and discussion

Proximate and physico-chemical properties of fennel-seed powder

The fennel seeds were powdered and processed (sun- and tray-drying and roasting) before being analysed for their proximate and physico-chemical composition (Table 1). There was a significant difference ($P < 0.05$) in moisture, fat, protein, ash and dietary fibre for sun-dried powder, roasted powder and tray-dried powder of fennel seeds.

The physico-chemical properties such as total phenolics, flavonoids, ascorbic acid and antioxidant activity were found to be retained to the highest level in sun-dried samples compared to tray-dried and roasted samples and the values differed significantly ($P < 0.05$). Similar results were found by other authors showing that the thermolabile nature of phenolic compounds degraded upon roasting and tray-drying¹⁵. They get easily degraded upon heat treatment, and since the temperature in tray-drying and roasting is concentrated and relatively higher than that during sun-drying (which is fluctuating), the polyphenolic content is lower in the former. There is a high correlation between phenolic content and antioxidant activity, suggesting that higher the phenolic content, higher will be the antioxidant activity. This accounts for the higher antioxidant activity of sun-dried fennel-seed powder compared to roasted and tray-dried samples¹⁶. Significant losses of ascorbic acid and total phenolics are due to increase in the drying temperatures¹⁷ (sun-drying at 30–35°C, tray-drying at 55°C and roasting at 75–80°C). Mild heat treatments have less effect on the volatile components despite their long treatment time, whereas intense treatments have significant effect¹⁸. From the mean values of proximate analysis for all the three samples, sun-dried powder was found to be the most appropriate for incorporation.

Sensory evaluation of hard candy

Hard candy samples prepared using sun-dried fennel powder was optimized using sensory evaluation. Sensory properties such as colour and appearance (Figure 1), flavour, body and texture, and overall acceptability of the hard candy were evaluated; Table 2 shows the results. DF1 (hard candy control) scored less, i.e. colour and appearance (7.5 ± 0.07), flavour (7.5 ± 0.07), body and texture (7.5 ± 0.05), mouthfeel (7.3 ± 0.08) and overall acceptance (7.6 ± 0.05). There was a significant difference ($P < 0.05$) between DF1 and DF11 in terms of sensory parameters. The acceptability increased as

Table 1. Proximate and physico-chemical analysis of fennel-seed powder

Components	Sun-dried powder	Roasted powder	Tray-dried powder
Moisture (g/100 g)	6.86 ± 0.35 ^a	4.92 ± 0.06 ^b	5.30 ± 0.52 ^b
Ash (g/100 g)	7.5 ± 0.45 ^a	4.1 ± 0.12 ^b	4.0 ± 0.31 ^b
Carbohydrates (g/100 g)	60.01 ± 0.25 ^c	69.75 ± 0.35 ^b	71.49 ± 0.45 ^a
Fat (g/100 g)	12.90 ± 0.60 ^a	9.63 ± 0.71 ^b	8.52 ± 0.49 ^{cb}
Protein (g/100 g)	12.73 ± 0.85 ^a	11.60 ± 0.42 ^b	10.69 ± 0.34 ^c
Dietary Fibre (g/100 g)	6.51 ± 0.34 ^a	4.35 ± 0.21 ^b	4.03 ± 0.46 ^b
Total phenolics (mg/GAE 100 g)	522 ± 0.04 ^a	497 ± 0.06 ^b	300 ± 0.07 ^c
Flavonoids (mg/CE 100 g)	606 ± 0.04 ^a	564 ± 0.07 ^b	492 ± 0.03 ^c
Vitamin C (µg/100 g)	325 ± 0.07 ^a	217 ± 0.04 ^b	209 ± 0.05 ^b
Antioxidant activity (%)	22.70 ± 0.06 ^a	19.43 ± 0.05 ^c	20.29 ± 0.04 ^b

All values are calculated in triplicate ($n = 3$). Values are represented as mean ± standard deviation. Values represented with different superscripts differ significantly in a column ($P < 0.05$).

the concentration of fennel powder increased till DF11. As the concentration increased further, the sensory parameters were affected. This may be due to the strong aroma and bitter taste of fennel at higher concentration, which was not preferred by the panelists. The texture was also affected at higher concentrations. It has been reported that with increase in the concentration of fennel powder, its sensory parameters are affected owing to its strong aroma and the taste was affected due to bitterness¹⁹. Colour of a food product is an essential component that determines the quality and its acceptance by the consumers. Visual appearance is the primary factor to evaluate the quality of food. DF11 scored higher in colour and appearance than the other combinations. Taste or flavour is one of the main determinants of food quality²⁰. Highest value against hard candy flavour was observed for DF11 with the addition of 5% fennel powder, while the lowest was obtained for DF16 and DF17 with the addition of 7.5% and 8% fennel powder respectively. This is because at concentrations of 7.5% and 8%, the candy becomes bitter. Texture is a quality parameter that affects the overall acceptability of the product²¹. Highest value against hard candy texture was obtained for DF11 (5% fennel powder) and lowest for DF17 (8% fennel powder). The results were similar where higher concentration produced viscous texture²⁰. The fennel powder started to give grassy flavour and texture, which affected its mouthfeel. For general acceptability, this indicated that DF11 was accepted by the panelists followed by DF1, while the least accepted was DF17 with an overall acceptability of 5.9 ± 0.09 . The higher the concentration of fennel powder (DF17), lower is the preference level of consumers. This is because at 8% fennel powder concentration, the hard candy has a dark colour, bitter taste and viscous texture. DF11 was the most accepted formulation (hard candy with 5% fennel powder) ranking highest according to the colour and appearance (8.1 ± 0.07), flavour (8.1 ± 0.06), body and texture (8.1 ± 0.05), mouthfeel (8.0 ± 0.06), and overall acceptance (8.2 ± 0.05).

Table 3 represents data obtained by a consumer study of the best chosen sample of hard candy on the basis of

sensory evaluation. Overall acceptability is the clear indication of consumer behaviour towards the samples. DF1 (control) that scored as colour and appearance (7.6 ± 0.08), flavour (7.2 ± 0.08), body and texture (7.3 ± 0.07), mouthfeel (7.1 ± 0.07), and overall acceptability (7.4 ± 0.06) was compared with sample DF11 (5% fennel powder) that scored as colour and appearance (7.7 ± 0.05), flavour (7.6 ± 0.06), body and texture (7.6 ± 0.04), mouthfeel (7.5 ± 0.07), and overall acceptability (7.7 ± 0.06). There was significant difference ($P < 0.05$) in flavour, body and texture, mouthfeel and overall acceptability, but there was no significant difference in colour and appearance as it is totally dependent on the like/dislike of the panelists.

Proximate and physico-chemical analysis of hard candy

Figure 2 shows the optimized process for hard candy formation. Table 4 shows the results of proximate composition of hard candy – control and sun-dried powder – on the basis of sensory evaluation. The moisture content of the samples ranged between 12.23 and 14.33 g 100⁻¹ g, and was not found to be significantly different. The slight difference in moisture may be due to the incorporation of insoluble dietary fibre with fennel powder that absorbs moisture²¹. Control candy had the highest moisture content (14.33 g 100⁻¹ g). The moisture content of food is significantly important for its general acceptability, shelf-life and packaging²². High moisture content promotes bacterial growth and thus leads to shorter shelf-life²³. Hard candy (sun-dried powder) was found to have high ash content (3.2 ± 0.05 g 100⁻¹ g), which was significantly different from the control sample. This is due to the fibre content of fennel powder. Furthermore, ash content increases with incorporation of spices due to its mineral content²⁰, which can also be observed in the case of fennel. The fat content (0.6 ± 0.03 g 100⁻¹ g) of hard candy (sun-dried powder) was high compared to that of control. There was significant difference ($P < 0.05$) in fat

Table 2. Sensory evaluation of hard candy (sun-dried powder)

Sample	Concentration of fennel powder (%)	Colour and appearance	Flavour	Body and texture	Mouthfeel	Overall acceptance
DF1	0	7.5 ± 0.07 ^{dc}	7.5 ± 0.07 ^c	7.5 ± 0.05 ^d	7.3 ± 0.08 ^d	7.6 ± 0.05 ^d
DF2	0.5	7.1 ± 0.08 ^e	7.1 ± 0.08 ^c	7.0 ± 0.06 ^f	7.0 ± 0.07 ^e	7.1 ± 0.06 ^f
DF3	1	7.3 ± 0.09 ^e	7.1 ± 0.01 ^f	7.3 ± 0.06 ^e	7.1 ± 0.09 ^e	7.3 ± 0.07 ^e
DF4	1.5	7.3 ± 0.06 ^e	7.3 ± 0.07 ^d	7.4 ± 0.06 ^e	7.4 ± 0.07 ^{cd}	7.4 ± 0.05 ^e
DF5	2	7.3 ± 0.07 ^e	7.1 ± 0.07 ^{ef}	7.4 ± 0.08 ^e	7.0 ± 0.07 ^e	7.3 ± 0.05 ^e
DF6	2.5	7.2 ± 0.07 ^{fe}	7.2 ± 0.08 ^{df}	7.3 ± 0.08 ^e	7.1 ± 0.08 ^e	7.3 ± 0.08 ^e
DF7	3	7.1 ± 0.08 ^e	7.1 ± 0.07 ^e	7.3 ± 0.07 ^e	7.2 ± 0.06 ^{de}	7.4 ± 0.07 ^e
DF8	3.5	7.5 ± 0.07 ^{dc}	7.2 ± 0.06 ^{df}	7.7 ± 0.06 ^{cbd}	7.5 ± 0.07 ^e	7.5 ± 0.05 ^{de}
DF9	4	7.6 ± 0.06 ^c	7.4 ± 0.07 ^c	7.6 ± 0.05 ^{dc}	7.7 ± 0.06 ^b	7.8 ± 0.04 ^c
DF10	4.5	7.9 ± 0.06 ^b	7.8 ± 0.06 ^b	7.8 ± 0.06 ^{bc}	7.8 ± 0.06 ^b	7.9 ± 0.05 ^{bc}
DF11	5	8.1 ± 0.07 ^a	8.1 ± 0.06 ^a	8.1 ± 0.05 ^a	8.0 ± 0.06 ^a	8.2 ± 0.05 ^a
DF12	5.5	7.3 ± 0.08 ^e	7.2 ± 0.09 ^{df}	7.3 ± 0.06 ^e	7.4 ± 0.07 ^{cd}	7.5 ± 0.07 ^{de}
DF13	6	7.2 ± 0.09 ^{fe}	7.1 ± 0.08 ^e	7.3 ± 0.09 ^e	7.2 ± 0.08 ^{de}	7.3 ± 0.06 ^e
DF14	6.5	7.1 ± 0.09 ^{ef}	7.2 ± 0.06 ^{df}	7.1 ± 0.04 ^f	7.1 ± 0.07 ^e	7.5 ± 0.07 ^{de}
DF15	7	7.1 ± 0.08 ^e	7.1 ± 0.08 ^e	7.0 ± 0.06 ^f	7.0 ± 0.07 ^e	7.1 ± 0.06 ^f
DF16	7.5	6.1 ± 0.07 ^h	6.3 ± 0.06 ^h	6.4 ± 0.08 ^e	6.5 ± 0.06 ^f	6.5 ± 0.06 ^e
DF17	8	5.8 ± 0.01 ⁱ	6.3 ± 0.07 ^h	4.2 ± 0.07 ^h	5.0 ± 0.09 ^e	5.7 ± 0.09 ^h

DF1–0% FP; DF2–0.5% FP; DF3–1% FP; DF4–1.5% FP; DF5–2% FP; DF6–2.5% FP; DF7–3% FP; DF8–3.5% FP; DF9–4% FP; DF10–4.5% FP; DF11–5% FP; DF12–5.5% FP; DF13–6% FP; DF14–6.5% FP; DF15–7% FP; DF16–7.5% FP; DF17–8% FP.

Means of ratings by 50 panelists using a descriptive sensory scale ($n = 50$). Values are represented as mean ± standard deviation. Values represented with different superscripts differ significantly in a column ($P < 0.05$).

Table 3. Analysis of consumer behaviour regarding hard candy of fennel

Sample	Concentration (%)	Colour and appearance	Flavour	Body and texture	Mouthfeel	Overall acceptance
DF1	0	7.6 ± 0.08 ^a	7.2 ± 0.08 ^b	7.3 ± 0.07 ^b	7.1 ± 0.07 ^b	7.4 ± 0.06 ^b
DF11	5	7.7 ± 0.05 ^a	7.6 ± 0.06 ^a	7.6 ± 0.04 ^a	7.5 ± 0.07 ^a	7.7 ± 0.06 ^a

DF1–0% FP; DF11–5% FP. Means of ratings by 150 panelists using a descriptive sensory scale ($n = 150$). Values are represented as mean ± standard deviation. Values represented with different superscripts differ significantly in a column ($P < 0.05$).



Figure 1. Visual appearance of hard candy with increment in fennel powder (FP) concentration. (a) DF1 (control), (b) DF2 (0.5% fennel powder), (c) DF3 (1% FP), (d) DF4 (1.5% FP), (e) DF5 (2% FP), (f) DF6 (2.5% FP), (g) DF7 (3% FP), (h) DF8 (3.5% FP), (i) DF9 (4% FP), (j) DF10 (4.5% FP), (k) DF11 (5% FP), (l) DF12 (5.5% FP), (m) DF13 (6% FP), (n) DF14 (6.5% FP), (o) DF15 (7% FP), (p) DF16 (7.5% FP) and (q) DF17 (8% FP).

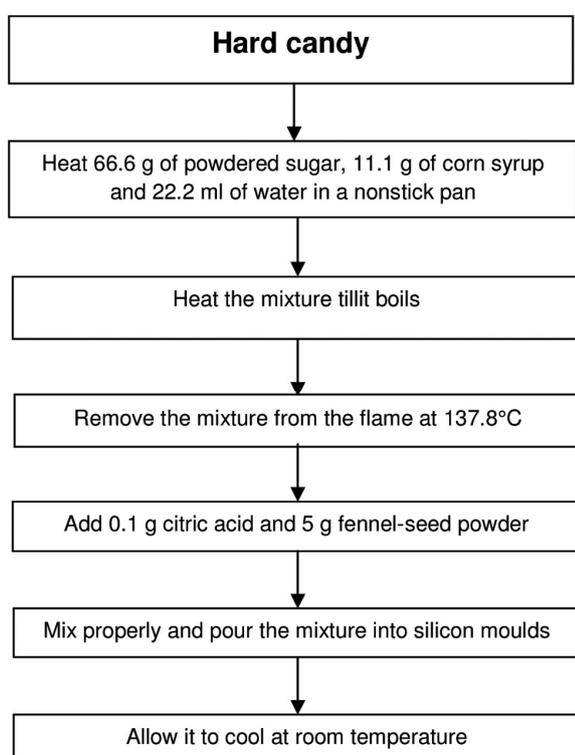
content of the samples. The protein content (1.2 ± 0.01 g 100^{-1} g) of hard candy (sun-dried powder) was significantly ($P < 0.05$) higher than that of control. Protein content was found to be lower in the final product as

compared to that in the sun-dried powder due to the less amount of fennel powder incorporated in the final hard-copy. Results were in accordance with tomato candy prepared by Hasanuzzaman *et al.*²⁴. The carbohydrates

Table 4. Proximate and physico-chemical analysis of hard candy

Components	Control	Hard candy (sun-dried powder)
Moisture (g/100 g)	14.33 ± 1.52 ^A	12.23 ± 1.23 ^A
Ash (g/100 g)	2.2 ± 0.02 ^B	3.2 ± 0.05 ^A
Carbohydrates (g/100 g)	83.47 ± 0.45 ^A	82.77 ± 0.45 ^A
Fat (g/100 g)	0.00	0.6 ± 0.03 ^A
Protein (g/100 g)	0.00	1.2 ± 0.01 ^A
Dietary Fibre (g/100 g)	0.00	2.09 ± 0.09 ^A
Total phenolics (mg/GAE 100 g)	0.00	373 ± 0.60 ^A
Flavonoids (mg/CE 100 g)	0.00	243 ± 1.3 ^A
Vitamin C (µg/100 g)	0.00	229 ± 0.5 ^A
Antioxidant activity (%)	0.00	16.6 ± 0.23 ^A

All values are calculated in triplicate ($n = 3$). Values are represented as mean ± standard deviation. Values represented with different superscripts differ significantly in a row ($P < 0.05$). GAE, Gallic acid equivalents; CE, Catechin equivalents.

**Figure 2.** Optimized process for hard candy formation.

content of the final product (82.77 ± 0.45) was lower than that of control (83.47 ± 0.45), but the difference was not significant. Dietary fibre (2.09 ± 0.09 g 100^{-1} g) of hard candy was significantly different ($P < 0.05$) from the control. Fibre content was found to be higher as the powder incorporated was of $300 \mu\text{m}$ size. The total phenolics content (373 ± 0.60 g 100^{-1} g) was found to be higher than that of the control, but the results obtained were less than those obtained for powder. The decrease was due to the increase in temperature, as phenols are thermo-labile. Significant difference ($P < 0.05$) was seen for both total phenolics and flavonoids. Vitamin C content ($229 \pm 0.5 \mu\text{g}$

100^{-1} g) of hard candy (sun-dried powder) was significantly higher than that in the control. Vitamin C content of sun-dried fennel powder was higher than that of the final product⁵. It was found that vitamin C content in the candy was good enough to serve as food material to humans²⁵. Antioxidants were found to be higher in the powder-incorporated candy; this is because of concentration of fennel powder in it. Similar data have been presented in another study²⁶. A significant difference ($P < 0.05$) was seen in hard candy (sun-dried powder) and control.

Conclusion

Fennel has been a part of the traditional diet of many people, but neglected as a nutritional source. In this study, the best method for the drying of fennel seeds is explored, which will be useful for the production of other value-added products. Sun-drying is the most effective method for the drying of fennel seeds as it conserves most of its nutrients, needs no technical equipment and is economical. The heat treatment in sun-drying is less compared to tray-drying and roasting, though the treatment time period is more. The powder from the sun-drying method was used in the formulation of hard candy and the most acceptable formulation was identified (DF11; 5% fennel powder). The proximate and physico-chemical analysis of DF1 (control) and DF11 showed that there was significant difference in the functional and nutritional properties. Therefore, mere incorporation of 5% fennel could increase the associated benefits to human health.

Conflict of interest: The authors declare no conflict of interest.

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