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Effect of Spice Incorporation on Sensory and Physico-chemical Properties of Matcha-Based Hard Candy

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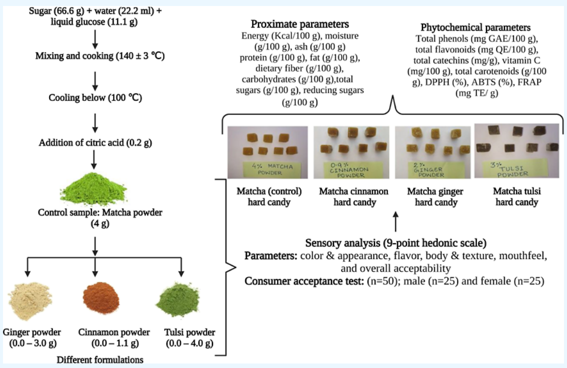
ABSTRACT: The present study was carried out to formulate and determine the sensory, proximate, phytochemical, and antioxidant properties of matcha hard candies incorporated with spices such as ginger (*Zingiber officinale* Rosc.), cinnamon (*Cinnamomum zeylanicum* and *Cinnamon cassia*), and holy basil (tulsi) (*Ocimum sanctum* L.). Standardized matcha (*Camellia sinensis*) hard candy was taken as a control, and spices/herbs were incorporated in different concentrations. The best formulation was GC5 (2% ginger powder) for matcha ginger hard candy, CZ10 (0.9% cinnamon powder) for matcha cinnamon hard candy, and TC7 (3% tulsi powder) for matcha tulsi hard candy. These formulations were selected based on the organoleptic evaluation. Furthermore, these selected hard candies were evaluated for the determination of proximate, phytochemical, and antioxidant profiles which exhibited significant results. This study demonstrates the excellent nutritional and phytochemical potential that spiced matcha hard candy has for use as a nutraceutical food product.



■ INTRODUCTION

Spices and herbs have been used since Egyptian times for medicinal purposes and mummification 5000 years ago as they are rich sources of phytochemicals that are antimicrobial.[1] Apart from adding flavor and aroma, herbs and spices are used for their preservative properties and medicinal value in various food products.[2] Spices and herbs are known to be rich in major bioactive compounds (such as alkaloids, tannins, vitamins, and diterpenes as well as phenolic and sulfur-containing compounds), which aid in reducing oxidative stress in the body.[3]

Ginger (*Zingiber officinale* Rosc.) has long been used due to their potential antimicrobial activity properties against different microbial pathogens. It is widely used in the treatment of the common cold, cough, and flu. It is also used as a remedy for throat pain. It has been traditionally used from time immemorial for the treatment of human ailments such as upset stomach, diarrhea, and nausea.[4] Cinnamon improves blood circulation and stimulates appetite and digestion. It is useful for the treatment of anorexia, heart disease, piles, and helminthic infections. It is effective against cold and associated fever and headache, muscular pain, arthritic pain, and amenorrhea which are the failure of menstruation. It is also useful in bronchitis and pneumonia.[5] Tulsi has been used in the treatment of fever and bronchitis. It also checks vomiting and antihelmintic. It is also used for treating malaria, diarrhea, dysentery, skin diseases, arthritis, and chronic fever.[6]

Matcha is a Japanese traditional powdered green tea characterized by a mildly astringent taste and strong umami taste. It has recently become popular as a food ingredient.[7] Matcha possesses various health benefits, viz., antiviral, antibacterial, anti-inflammatory, anticancer, antitumor, antioxidative, neuroprotective, cholesterol-lowering, and cardioprotective effects.[8] Most often due to disliking their taste, the benefits of matcha fail to reach the masses. Therefore, confectionary products, such as hard candy, are the ideal food matrix for the delivery of these catechins and other antioxidant compounds as they dissolve slowly in the mouth, have an adequate shelf life, and can be formulated with high sensory acceptability.[9] Such formulated hard candies which provide basic nutrition along with the benefits of disease-preventing and health-promoting properties are known as functional foods.[10] Moreover, adding herbs and spices to the product improves the acceptability, adds value to the products, and helps deliver the antioxidant and antimicrobial potential of matcha, herbs, and spices to the consumer. Thus, the current

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Table 1. Sensory Evaluation of Matcha and Ginger Hard Candies[a]

		hard candies (ginger powder)				
sample name	concentration of ginger powder (g)	color and appearance	flavor	body and texture	mouthfeel	overall acceptance
GC1	0	7.18 ± 0.27[b]	7.26 ± 0.26[a]	7.29 ± 0.36[b]	7.36 ± 0.27[a]	7.59 ± 0.35[a]
GC2	0.5	7.25 ± 0.37[b]	7.29 ± 0.38[a]	7.35 ± 0.28[b]	7.41 ± 0.28[a]	7.64 ± 0.38[a]
GC3	1	7.45 ± 0.28[b]	7.57 ± 0.37[a]	7.39 ± 0.57[b]	7.59 ± 0.26[a]	7.69 ± 0.37[a]
GC4	1.5	7.51 ± 0.47[b]	7.69 ± 0.47[a]	7.48 ± 0.38[b]	7.64 ± 0.47[a]	7.75 ± 0.25[a]
GC5	2	7.89 ± 0.37[a]	7.88 ± 0.26[a]	7.91 ± 0.35[a]	7.87 ± 0.26[a]	8.19 ± 0.45[a]
GC6	2.5	6.05 ± 0.27[c]	6.26 ± 0.36[b]	6.33 ± 0.58[c]	6.46 ± 0.26[b]	6.23 ± 0.66[b]
GC7	3	5.15 ± 0.21[d]	5.37 ± 0.37[c]	4.02 ± 0.27[d]	5.43 ± 0.49[c]	5.56 ± 0.29[c]

[a]Means of ratings by 50 panelists using a descriptive sensory scale ($n = 50$). The values of the result represented in the form mean ± standard deviation. Values represented with different small superscripts differ significantly in a row ($p < 0.05$).

research focuses on producing a functional matcha hard candy incorporated with different concentrations of spices/herbs, including holy basil (tulsi), cinnamon, and ginger.

■ MATERIALS AND METHODS

Collection of Raw Materials. The raw material, viz., sugar was taken from the local market of Jalandhar, Punjab. The finely powdered matcha (*Camellia sinensis*) was procured from Cloudtail, India, and liquid glucose was procured from Saby Food, New Delhi, India. Other chemicals and reagents for the analysis of proximate, phytochemical, and antioxidant profiles were purchased from LOBA Pvt Ltd., Mumbai, India and HiMedia Pvt Ltd, Mumbai, India.

Preparation of Hard Candy. The hard candy was prepared using liquid glucose, powdered sugar, water, citric acid, matcha, and different concentrations of ginger, cinnamon, and tulsi powder. The powdered sugar (66.6 g) was mixed with 22.2 mL of water and 11.1 g of liquid glucose. The mixture was heated at temperature range 140 ± 3 °C and constantly stirred using a wooden spatula in a non-stick heating pan. The mixture was heated till it reaches a temperature of 137.8 °C, which was recorded using a digital candy thermometer. At below 100 °C, 0.2 g of citric acid was added, and then, 4 g of matcha and different concentrations of ginger (0.0−3.0 g), cinnamon (0.0−1.1 g), and tulsi (0.0−4.0 g) powder were added to the prepared mixture and mixed until a homogeneous mixture was obtained. The final mixture different formulation of candy was poured into silicone molds and cooled at room temperature for 25−30 min. After 30 min, the candy was removed from the molds, coated with powdered sugar, and wrapped in butter paper. The candies were stored in airtight containers to protect them from moisture and air. The control candy was prepared with the addition of 4 g of matcha only, and other candies have ginger, cinnamon, and tulsi powder in addition to matcha powder.

Proximate Analysis. The methods described by AOAC[11] were used for carrying out the proximate analysis, that is, ash content, moisture, protein, and fat content of candy samples. Total sugars and reducing sugars were estimated using methods described by Ranganna.[12]

Carbohydrate Content. The carbohydrate content of the hard candy was calculated using the differential method; however, the energy value was calculated by the unit calorific value of the basic nutrients.[13]

$$\text{Total carbohydrate content (\%)} = 100 - [\text{moisture (\%)} + \text{ash (\%)} + \text{protein (\%)} + \text{fat (\%)}]$$

$$\text{energy (kcal)} = (3.36 \times \%\ \text{protein}) + (3.60 \times \%\ \text{carbohydrate content}) + (8.37 \times \%\ \text{fat content})$$

Phytochemical Analysis. The sample was prepared by extracting 0.1 g of hard candies with 5 mL of 80% ethanol (80:20 ethanol/water). The mixture was then filtered and used for the analysis of different phytochemical components. Total flavonoid and total phenolic contents were determined using methods described by Kamtekar et al.[14] The ascorbic acid content was determined by the 2,6-dichlorophenolindophenol method Ranganna.[12] The total carotenoid and total catechin content of the candy samples was estimated using methods stated by Sadasivam and Manickam[15] and Ghabru.[16]

Antioxidant Activity. 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay, 2,2′-casino-bis(3-ethyl-benzothiazoline-6-sulfonic acid) (ABTS) radical scavenging assay, and ferric reducing antioxidant power (FRAP) assay were estimated by methods described by Kumar et al.[4]

Sensory Analysis. Sensory analysis of hard candy was performed at a nine-point hedonic scale considering color and appearance, flavor, body and texture, mouthfeel, and overall acceptability (OA) as sensory attributes. 50 healthy semi-trained randomly selected panelists constituting the age group of 25−40 years consisting of 25 males and 25 females from the Lovely Professional University, Phagwara, Punjab were employed.[4]

The sensory evaluation study was conducted as per ethical approval from the ethical committee of Lovely Professional University for the use of animal and human interventions in research. The sensory panel members were recruited with informed consent and were provided basic sensory training for the attributes to be evaluated during the sensory analysis. The evaluators were presented with candy samples (not more than five samples including control in a single session, session interval 4 h) in clean gray-colored, odor-free plastic cups (cup size 30 gm), served in a clean pastel cream-colored tray. To eliminate the sensory carry over, panel members followed a pallet cleansing process with a cracker (unsalted) and rinsing water (at room temperature), prior to subsequent sample testing. The general protocol for tasting candy included sucking on each candy sample for at least 10 s to reach a judgment.

Statistical Analysis. Statistical analysis was performed for the data obtained during this research investigation. The test of significance (at the level of $p < 0.05$) was analyzed by applying a one-way analysis of variance and Duncan's multiple range

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Table 2. Sensory Evaluation of Matcha and Cinnamon Hard Candies[a]

		hard candies (cinnamon powder)				
sample name	concentration of cinnamon powder (g)	color and appearance	flavor	body and texture	mouthfeel	overall acceptance
CZ1	0	7.21 ± 0.53[a]	7.23 ± 0.39[a]	7.29 ± 0.38[a]	7.38 ± 0.39[a]	7.45 ± 0.28[b]
CZ2	0.1	7.25 ± 0.37[a]	7.29 ± 0.34[a]	7.31 ± 0.38[a]	7.45 ± 0.34[a]	7.49 ± 0.45[b]
CZ3	0.2	7.34 ± 0.38[a]	7.31 ± 0.31[a]	7.45 ± 0.46[a]	7.56 ± 0.38[a]	7.52 ± 0.44[b]
CZ4	0.3	7.41 ± 0.44[a]	7.39 ± 0.38[a]	7.49 ± 0.27[a]	7.64 ± 0.39[a]	7.59 ± 0.48[b]
CZ5	0.4	7.49 ± 0.47[a]	7.45 ± 0.46[a]	7.54 ± 0.58[a]	7.66 ± 0.81[a]	7.61 ± 0.47[b]
CZ6	0.5	7.56 ± 0.56[a]	7.50 ± 0.71[a]	7.62 ± 0.59[a]	7.69 ± 0.46[a]	7.68 ± 0.41[b]
CZ7	0.6	7.64 ± 0.31[a]	7.56 ± 0.37[a]	7.65 ± 0.57[a]	7.72 ± 0.56[a]	7.79 ± 0.57[b]
CZ8	0.7	7.69 ± 0.54[a]	7.63 ± 0.59[a]	7.69 ± 0.56[a]	7.75 ± 0.64[a]	7.81 ± 0.77[b]
CZ9	0.8	7.71 ± 0.31[a]	7.69 ± 0.48[a]	7.74 ± 0.68[a]	7.79 ± 0.36[a]	7.86 ± 0.37[b]
CZ10	0.9	7.95 ± 0.58[a]	7.89 ± 0.54[a]	7.88 ± 0.49[a]	7.86 ± 0.75[a]	8.59 ± 0.47[a]
CZ11	1.0	6.85 ± 0.41[a]	6.36 ± 0.47[b]	5.27 ± 0.47[b]	6.04 ± 0.49[b]	6.78 ± 0.69[c]
CZ12	1.1	5.79 ± 0.43[b]	5.57 ± 0.34[c]	4.19 ± 0.54[c]	4.03 ± 0.45[c]	5.57 ± 0.44[d]

[a]All the values are calculated in triplicates ($n = 3$). The values of the result represented in the form mean ± standard deviation. Values represented with different capital superscripts differ significantly in a row ($p < 0.05$).

Table 3. Sensory Evaluation of Matcha and Tulsi Hard Candies[a]

		hard candies (tulsi powder)				
sample name	concentration of tulsi powder (g)	color and appearance	flavor	body and texture	mouthfeel	overall acceptance
TC1	0	7.25 ± 0.48[a]	7.29 ± 0.49[b]	7.24 ± 0.53[a]	7.16 ± 0.35[b]	7.65 ± 0.42[b]
TC2	0.5	7.34 ± 0.46[a]	7.35 ± 0.41[b]	7.29 ± 0.59[a]	7.27 ± 0.36[b]	7.75 ± 0.31[b]
TC3	1	7.46 ± 0.47[a]	7.48 ± 0.44[b]	7.31 ± 0.68[a]	7.46 ± 0.44[b]	7.79 ± 0.35[b]
TC4	1.5	7.54 ± 0.34[a]	7.54 ± 0.39[b]	7.47 ± 0.56[a]	7.59 ± 0.24[b]	7.81 ± 0.37[b]
TC5	2	7.66 ± 0.51[a]	7.62 ± 0.58[b]	7.52 ± 0.48[a]	7.64 ± 0.26[b]	7.86 ± 0.37[b]
TC6	2.5	7.78 ± 0.87[a]	7.76 ± 0.39[b]	7.66 ± 0.48[a]	7.75 ± 0.29[b]	7.89 ± 0.48[b]
TC7	3	7.96 ± 0.38[a]	8.65 ± 0.54[a]	8.28 ± 0.69[a]	8.19 ± 0.25[a]	8.98 ± 0.57[a]
TC8	3.5	6.98 ± 0.31[a]	6.54 ± 0.57[c]	6.56 ± 0.57[b]	6.54 ± 0.46[c]	5.54 ± 0.37[c]
TC9	4	6.36 ± 0.54[b]	6.31 ± 0.46[c]	6.11 ± 0.56[b]	5.72 ± 0.39[d]	5.33 ± 0.44[c]

[a]Means of ratings by 50 panelists using a descriptive sensory scale ($n = 50$). The values of the result represented in the form mean ± standard deviation. Values represented with different small superscripts differ significantly in a row ($p < 0.05$).

test using SPSS 22.0 software (SPSS Italia, Bologna, Italy). The obtained data are presented as mean ± standard deviation.

■ RESULTS AND DISCUSSION

Sensory Evaluation of Hard Candies. The matcha hard candies were prepared using different concentrations of ginger, cinnamon, and tulsi powder with the maximum level incorporated and optimized using sensory evaluation parameters basis. The properties such as color, appearance, flavor, body, texture, mouthfeel, and OA were evaluated in sensory analysis. The results for ginger, cinnamon, and tulsi-incorporated matcha hard candies are shown in Tables 1−3, respectively.

The candies have 4 g of matcha powder (control) and different concentrations of ginger, cinnamon, and tulsi powder. In the case of matcha ginger hard candy, GC5 (4 g of matcha powder and 2 g of ginger powder) scored maximum in color and appearance (7.89 ± 0.37), flavor (7.88 ± 0.26), body and texture (7.91 ± 0.35), mouthfeel (7.87 ± 0.26), and OA as compared to GC1 (4 g of matcha powder and 0 g of ginger powder). While the GC5 hard candies did not show any significant difference in flavor, mouthfeel, and OA as compared to control GC1, they were significantly different ($p < 0.05$) in color and appearance and body and texture. The maximum acceptable concentration for ginger was 2 g and after that, the sensory parameters were negatively affected by increasing the ginger concentration further. The lowest value was obtained in sensory analysis for sample GC6 and GC7 with 2.5 and 3 g of ginger powder. It was also observed that the acceptability of the product decreases at higher concentrations of ginger due to the amplified pungency.[4] The matcha cinnamon hard candy, CZ10 (4 g of matcha powder and 0.9 g of cinnamon powder) scored maximum in color and appearance (7.95 ± 0.58), flavor (7.89 ± 0.54), body and texture (7.88 ± 0.49), mouthfeel (7.86 ± 0.75), and OA (8.59 ± 0.47) as compared to control CZ1 (4 g of matcha powder and 0 g of cinnamon powder). CZ10 and CZ1 were significantly different ($p < 0.05$) in OA. The maximum acceptable concentration of cinnamon was 0.9 g, and when increasing the concentration further, the sensory parameters were affected. The lowest value of sensory data was obtained for CZ11 and CZ12 samples. This decrease is due to the bitter taste and strong aroma of cinnamon at high concentrations. A similar attempt was made for the formulation of hard candy incorporated with fennel seed powder which revealed that the most acceptable candy sample was the one containing 5% sun-dried fennel seed powder. It was observed that a further increase in the concentration of fennel seed powder was linked to an overall bitter taste.[17] Similar results have been found in the literature where the rating scores of sweets decreased due to the increased pungency from the spice.[18]

The OA for CZ11 and CZ12 samples was lower which indicates that panelists choose hard candy with a slight taste of cinnamon, but higher concentrations significantly reduced the acceptability. This is mainly due to the strong taste and aroma of cinnamon. The color is determined by the matcha powder

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Table 4. Proximate Analysis of Hard Candies[a]

component	matcha ginger hard candy	matcha cinnamon hard candy	matcha tulsi hard candy
energy (kcal/100 g)	327.84 ± 0.96c	332.96 ± 1.04^{b}	335.64 ± 0.54^{a}
moisture (g/100 g)	8.98 ± 0.85^{a}	7.54 ± 0.98^{b}	6.64 ± 1.08^{b}
ash (g/100 g)	0.19 ± 0.007^{b}	0.15 ± 0.008^{c}	0.25 ± 0.002^{a}
protein (g/100 g)	1.2 ± 0.02^{b}	0.89 ± 0.07^{c}	1.53 ± 0.15^{a}
sat (g/100 g)	0.23 ± 0.005^{a}	0.18 ± 0.002^{b}	0.17 ± 0.005^{c}
dietary fiber (g/100 g)	1.4 ± 0.05^{b}	0.50 ± 0.09^{c}	1.62 ± 0.08^{a}
carbohydrates (g/100 g)	89.41 ± 1.15^{b}	91.24 ± 0.98^{a}	91.41 ± 1.04^{a}
total sugars (g/100 g)	84.10 ± 0.47^{b}	87.84 ± 0.35^{a}	87.45 ± 0.21^{a}
reducing sugars (g/100 g)	2.51 ± 0.54^{a}	2.65 ± 0.20^{a}	2.93 ± 0.36^{a}

[a]All the values are calculated in triplicates ($n = 3$). The values of the result represented in the form mean ± standard deviation. Values represented with different capital superscripts differ significantly in a column ($p < 0.05$).

Table 5. Phytochemical Analysis of Hard Candies[a]

component	matcha ginger hard candy	matcha cinnamon hard candy	matcha tulsi hard candy
total phenols (mg GAE/100 g)	348.65 ± 1.97^{b}	313.89 ± 1.27^{c}	383.26 ± 1.39^{a}
total flavonoids (mg QE/100 g)	312.75 ± 1.64^{b}	294.91 ± 0.81^{c}	367.04 ± 0.24^{a}
total catechins (mg/g)	255.21 ± 1.38^{b}	248.20 ± 1.54^{c}	287.09 ± 1.78^{a}
vitamin C (mg/100 g)	5.88 ± 0.24^{a}	5.59 ± 0.24^{b}	5.52 ± 0.36^{b}
total carotenoids (g/100 g)	27.29 ± 0.59^{c}	33.34 ± 0.67^{a}	29.98 ± 0.35^{b}
DPPH (%)	56.68 ± 1.63^{c}	62.93 ± 2.26^{b}	80.54 ± 2.21^{a}
ABTS (%)	96.85 ± 0.41^{b}	94.29 ± 0.14^{c}	97.85 ± 0.19^{a}
FRAP (mg TE/g)	75.71 ± 0.54^{b}	69.11 ± 0.75^{c}	82.08 ± 0.29^{a}

[a]All the values are calculated in triplicates ($n = 3$). The values of the result represented in the form mean ± standard deviation. Values represented with different small superscripts differ significantly in a column ($p < 0.05$).

as it is present in high amounts compared to cinnamon. It was also reported in the literature that color and appearance were not influenced by the addition of cinnamon.[19] The cinnamon bark has a spicy taste.[5] This is also responsible for the decreased acceptability of hard candies at concentrations higher than 0.9 g of cinnamon. As per the observation, the addition of cinnamon powder greatly influenced the overall taste of the product.[20] The body and texture are affected by the addition of matcha and cinnamon. This is due to the coarseness contributed by the cinnamon and matcha powder. The higher concentration produced a more viscous texture which contributes to acceptability. For matcha tulsi hard candy, TC7 scored maximum in color and appearance (7.96 ± 0.38), flavor (8.65 ± 0.54), body and texture (8.28 ± 0.69), mouthfeel (8.19 ± 0.25), and OA (8.98 ± 0.57) as compared to control TC1 (4 g of matcha powder and 0 g of tulsi powder). TC1 and TC7 were significantly different ($p < 0.05$) in flavor, mouthfeel, and OA. The maximum acceptable concentration of tulsi was 3 g, and the sensory scores declined upon further increasing the concentration. The lowest scores were obtained for TC8 and TC9. The acceptability decreased owing to the bitter taste of tulsi that became more prominent in higher concentrations. Also, the texture of the candies became grassy and chewy which was not acceptable to the panelists.

Proximate Analysis of Hard Candies. The hard candies were evaluated for proximate composition, and the results are shown in Table 4. Energy values were found to be 327.84 ± 0.96, 332.96 ± 1.04, and 335.64 ± 0.54 kcal/100 g for matcha ginger, matcha cinnamon, and matcha tulsi hard candy, respectively. The energy content is due to the protein and fat content of the spices in addition to the matcha powder. The energy content for matcha tulsi hard candy was maximum as it contains 4 g of matcha and 3 g of tulsi powder. It was significantly different ($p < 0.05$) from the energy values of other candies. The moisture content was 8.98 ± 0.85, 7.54 ± 0.98, and 6.64 ± 1.08 g/100 g for matcha ginger, matcha cinnamon, and matcha tulsi hard candy, respectively. The moisture content is an important aspect of maintaining product quality as the product with the lowest water content has a more durable shelf life.[10] With increasing the concentration of powder, the water content decreases. The decrease in the moisture content is due to the increased fiber content of candies with the incorporation of matcha and spice powder as the fiber absorbs the moisture. Also, candies with high water content are more susceptible to bacterial growth and other chemical changes, leading to flavor deterioration.[21] Cinnamon powder has an appreciable amount of fiber and protein.[5] Ginger also has an appreciable amount of fiber, that is, 4.53 g/100 g approximately.[4] Matcha tulsi hard candy has the lowest moisture content as more powder is incorporated. Also, candies with high water content will melt easily and are more susceptible to bacterial growth and other chemical changes leading to flavor deterioration.[10] Similar trends were observed for protein, fat, carbohydrates, total sugars, and reducing sugars. The values for protein, fat, and ash of the hard candies were significantly different ($p < 0.05$) from each other due to the varying amounts of protein and fat contents of the spice powders incorporated. The ash content is due to the higher amount of minerals present in the cinnamon powder,[22] ginger powder,[4] and matcha.[23] Matcha tulsi hard candy possesses a high amount of protein content owing to the protein present in the leaves, that is, 20.64 g/100 g approximately.[23]

Phytochemical Analysis of Hard Candies. The results of the phytochemical analysis are shown in Table 5. A significant difference ($p < 0.05$) was seen for total phenolics, flavonoids, and carotenoids for the hard candies. The values

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were significantly higher for spice-incorporated hard candies as compared to control hard candy which contains only matcha powder. This is due to the high polyphenolic content of matcha. Matcha contains higher amount of polyphenols, flavonoids, and carotenoid compounds.[23] Cinnamon[5] ginger[4] and tulsi[6] also have a good content of these components. Total catechins were found to be 255.21 ± 1.38, 248.20 ± 1.54, and 287.09 ± 1.78 mg/g for matcha ginger, matcha cinnamon, and matcha tulsi hard candy, respectively. Matcha (powdered green tea) has the most abundant quantity of catechins as it is non-fermented which preserves the catechins.[23] Green tea has 300−400 mg/g of flavanols that play a vital role in human health as it acts as a strong antioxidant.[24] The vitamin C content was found to be 5.88 ± 0.24, 5.59 ± 0.24, and 5.52 ± 0.36 for matcha ginger, matcha cinnamon, and matcha tulsi, respectively. It is found that the vitamin C content present in candies was good enough to serve as food material for human consumption. The visual representation of the standardized candies is shown in Figure 1.

A: Matcha (control) hard candy
B: Matcha cinnamon hard candy
C: Matcha ginger hard candy
D: Matcha tulsi hard candy

Figure 1. Visual appearance of hard candies.

Antioxidant Profile of Hard Candies. The results obtained for the antioxidant activity of hard candies by the DPPH, FRAP, and ABTS assays are presented in Table 5. A significant difference ($p < 0.05$) in the antioxidant activities was there in matcha, matcha ginger, matcha cinnamon, and matcha tulsi hard candies. The highest antioxidant activity, as shown by DPPH, ABTS, and FRAP assay, is exhibited by matcha tulsi hard candies. The antioxidant activity is due to the presence of polyphenols, and in matcha, 90% of polyphenols are flavan-3-ols which include catechins. Catechins largely contribute to the high antioxidant activity of hard candies. It was confirmed by a study that the concentration and structure of catechins determine the antioxidant potential of matcha and its products. The structural characteristics, viz., number and position of hydroxyl groups on the ring and the presence or absence of galloyl moiety majorly contribute to the antioxidant potential of catechins. The hydroxyl groups on the ring mainly interact with the biological matter through hydrogen or electron transfer and hydrogen bonding. These reactions are required during the antioxidant activity processes.[25]

Catechins exhibit antioxidant activity through various mechanisms including redox-sensitive transcription factor inhibition, scavenging reactive oxygen species, inducing phase 2 detoxification enzyme productions, and pro-oxidant enzyme inhibition.[25] The antioxidant activity of matcha cinnamon hard candies is due to the combined effect of matcha catechins and cinnamon powder. The cinnamon bark also shows great antioxidant potential against DPPH radicals and ABTS radical cations.[26] The flavonoids, such as cinnamaldehyde and eugenol, of cinnamon also show free-radical scavenging activity and thus contribute to antioxidant activity.[7] The highest antioxidant activity was found for matcha tulsi hard candies. This may be due to the high phenolic content of matcha tulsi hard candy. The phenols present in tulsi, viz., eugenol, rosmarinic acid, and so forth have antioxidant activity and the ability to scavenge free radicals.[27] The antioxidant activity of ginger-incorporated matcha hard candy is due to the presence of gingerol and shogaol which have anti-inflammatory properties.[28] It was indicated that ginger exhibited scavenging activity against DPPH and ABTS free radicals due to the phenolic compounds with different polarity, chemical behavior, and functional groups which shows the role of phenolic compounds in free-radical scavenging activity.[29] The scavenging activity of tulsi is due to its high polyphenolic content and antioxidant capacity.[6,27] Antioxidants play a vital role as health-protecting agents especially in foodstuffs as they respond to free radicals and thus eliminate them. They can also delay or prevent food spoilage. So, antioxidants hold a special place in the food industry.[30]

■ CONCLUSIONS

Herbal infusion in matcha-based hard candy was attempted in the current work. The best formulation was GC5 (2% ginger powder) for matcha ginger hard candy, CZ10 (0.9% cinnamon powder) for matcha cinnamon hard candy, and TC7 (3% tulsi powder) for matcha tulsi hard candy. The proximate, sensory, and phytochemical analyses of hard candies showed that there was a significant difference between control hard candy (4% matcha powder) and spice-infused matcha hard candy. Thus, the matcha and spice-infused hard candies are a good source of all the nutrients and have an appreciable antioxidant profile. Antioxidants hold a special place in the food industry as they scavenge free radicals and thus eliminate the risk of several diseases, opening up possibilities for analyzing the potential of the developed candies to be projected as functional food.

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Notes

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