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A comparative study on quality characteristics of cookies incorporated with roasted chicory powder and inulin as sugar replacers

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Consumer demand is increasing for low-calorie, high-fibre functional foods. Cookies are considered better for functional ingredient incorporation as it is in ready-to-consume form with good shelf life and they have gained extensive consumer preference. The current study was undertaken to formulate cookies with the incorporation of roasted chicory powder and inulin, and to compare the nutritional profile as well as physical properties of the cookies. The roasted chicory powder was incorporated in 5, 10, and 15% levels and inulin was incorporated in the levels of 5, 10, 15, 25, 50, 75, and 100% replacing sugar in butter cookies and multigrain cookies. The cookies were evaluated for sensory attributes, nutrient profile and physical properties. The cookies with 5% roasted chicory powder and 50% inulin as sugar replacers were organoleptically accepted. Inulin incorporation had a tremendous impact on the fibre content of the product. But the addition of chicory in the cookies resulted in a better nutrient profile apart from increasing the fibre content considerably. Studying the physical properties of the cookies, inulin/chicory incorporation resulted in a significant increase in the spread ratio.

Keywords: Cookies, Dietary fibre, Inulin, Roasted chicory powder, Sugar replacers.

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Introduction

Chicory (*Cichorium intybus)* is a perennial herbaceous plant with appreciable nutritive value. Chicory root is known to have phytonutrients like coumarins, flavonoids, sesquiterpene lactones, tannins, alkaloids, vitamins, minerals, and volatile oils[1]. Fresh chicory roots have a bitter taste. Boiling, drying, baking or roasting, and soaking in water or citric acid solution as a pretreatment removes the bitterness[2]. Chicory is a good source of inulin which is present as a carbohydrate reserve in the roots of the plant. Roots of chicory have more than 70% inulin content and thus, commercially inulin is extracted from chicory[3].

Inulin is a white, odourless, unflavored bland powder that could combine easily with any food ingredient without altering its characteristic attributes. It's a polysaccharide made of β (2,1)-linked fructosyl residues mostly ending with glucose residues[4]. The β-2-1 fructosyl in inulin resists digestion but can be fermented by the beneficial bacteria in the colon[5].

Due to its prebiotic properties and technological applications such as sugar and fat replacer and dietary fibre enrichment, inulin has gained importance in the food sector[6]. Inulin can be used in food for its nutritional advantages or technological properties, or to obtain both benefits. The use of inulin as a fibre enrichment ingredient often leads to an improved taste and texture[7]. Inulin gives more crispness and expansion to extruded snacks and cereals, and it is also used to increase shelf life. Inulin also helps to keep bread and cakes moist and fresh for longer. Its solubility allows fibre incorporation in watery systems such as drinks, dairy products, and table spreads[8].

The objective of the current study was to formulate cookies using roasted chicory powder and inulin as sugar replacers and to compare their nutritional profile and physical properties.

Materials and Methods

Roasted chicory powder, inulin, and all the other required ingredients were procured from local markets in Chennai during the study period i.e., November 2019.

Preparation of cookies

The composition of the cookies is presented in Table 1. Butter, vanilla essence, and sugar were mixed, to which roasted chicory/ inulin was added in

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Table 1 — Composition of cookies

Butter cookies		Multigrain cookies	
Ingredients	Quantity (g)	Ingredients	Quantity (g)
Maida (Refined Wheat flour)	65	Whole wheat flour	25
		Pearl, Kodo, Proso, Foxtail millet	40 (10 g of each)
Butter	50	Butter	50
Sugar	30	Sugar	30
Baking powder	2.5	Baking powder	2.5
Vanilla essence (mL)	2.5	Vanilla essence (mL)	2.5

Roasted chicory powder was incorporated at levels of 5, 10, and 15% by replacing sugar
Inulin was incorporated at levels of 5, 10, 15, 25, 50, 75, 100% by replacing sugar.

Table 2 — Coding of cookies

Butter cookies	Roasted chicory incorporation	Multigrain cookies	Roasted chicory incorporation
Control	BRC00	Control	MRC00
Variation 1 (5%)	BRC05	Variation 1 (5%)	MRC05
Variation 2 (10%)	BRC10	Variation 2 (10%)	MRC10
Variation 3 (15%)	BRC15	Variation 3 (15%)	MRC15
Butter cookies	Inulin incorporation	Multigrain cookies	Inulin incorporation
Variation 1 (5%)	BIN05	Variation 1 (5%)	MIN05
Variation 2 (10%)	BIN10	Variation 2 (10%)	MIN10
Variation 3 (15%)	BIN15	Variation 3 (15%)	MIN15
Variation 4 (25%)	BIN25	Variation 4 (25%)	MIN25
Variation 5 (50%)	BIN50	Variation 5 (50%)	MIN50
Variation 6 (75%)	BIN75	Variation 6 (75%)	MIN75
Variation 7 (100%)	BIN100	Variation 7 (100%)	MIN100

varying proportions (Table 2) to replace sugar. It was whipped with a whisk for about 2-3 minutes, till creamy and light. Respective flour (maida/multi-grain) and baking powder were sifted together. The flour mix and butter mix were slowly added and mixed gently with a spoon till all the ingredients were well combined into a dough.

This dough was refrigerated for 30 minutes. Preheated the oven to 180ºC. The baking tray was lined with butter paper. The dough was divided into equal balls. Each ball was flattened gently and placed on the baking sheet 2 inches apart and baked for 12- 15 minutes. The baking tray was placed in the cooling racks and allowed to reach room temperature. The cookies were stored in an air-tight container. Fig. 1 represents the prepared cookies. The codes of the cookies and their variation are provided in Table 2.

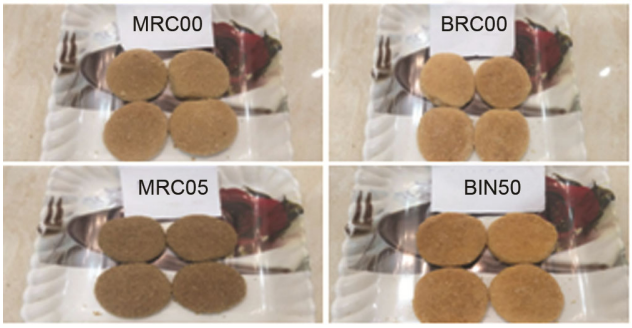

Fig. 1 — Cookies prepared.

Sensory analysis

Sensory evaluation is a scientific discipline that analyses and measures human response to the composition of food and drink[9]. Thus, the organoleptic study was carried out for all the variations of cookies on a 9 –point hedonic scale rating by 15 semi-trained panellists. Each panellist was given a sensory evaluation sheet and the cookies were rated for parameters such as colour, flavour, texture, taste, crunchiness, breakability, mouthfeel, after taste, and overall acceptability.

Nutritional composition

Moisture, ash, protein, fat, total dietary fibre, iron, calcium, and phosphorous content was determined by using AOAC methods[10]. The carbohydrate content of food was determined by calculating the percent remaining after all the other components have been measured: %carbohydrates = 100 - %moisture - %protein - %lipid - %mineral. Total calorie was computed using the formula: Energy value (Kcal) = 4 (g protein + g carbohydrates) + 9 (g fat) + 2 (g fiber)

Physical properties

Spread ratio, diameter, thickness, weight, volume, density and specific volume was determined as per standard methods[11].

Statistical analysis

To analyze any significant difference in the sensory attributes of the products prepared one-way ANOVA was applied. All the determinants for proximate analysis and physical properties were carried out in triplicates and with five sample cookies respectively. The results were expressed as Mean±SD. To test the significant differences between the experimental samples on their nutrient profile and physical characteristics t–test (two tail) was applied.

Results and Discussion

Sensory attributes of the Cookies

The overall acceptability defines the sum of all the sensory attributes of a product. Sensory scores of cookies incorporated with roasted chicory powder are shown in Table 3. Among the prepared butter cookies with the incorporation of roasted chicory powder, the overall acceptability (7.07±1.03) was highest for BRC05. One way ANOVA revealed that the color [F(3,56)= 8.67, P=8.07003E-05]texture [F(3,56)= 3.80, P=0.02] crunchiness [F(3,56)= 3.64, P=0.02], taste [F(3,56)=31.38, P=4.93E-12], flavor [F(3,56)=24.90, P=2.29E-10], after taste [F(3,56)= 49.86, P=7.96E-16] and overall acceptability [F(3,56)= 30.55, P=7.82E-12] were the attributes with significant (P <0.05) difference among the chicory incorporated butter cookies.

In the multigrain category, the overall acceptability of MRC05 was higher. Other variations had slight bitterness and aftertaste. One way ANOVA showed that the attributes: color [F (3,56) =2.95, P=.04], taste [F (3,56) =4.14, P=.01], flavor[F (3,56) =2.891, P=.04], after taste [F(3,56)=2.99, P=.04] and overall acceptability [F(3,56)=5.08, P=.003] exhibited significant (P <0.05) difference among the samples.

Sensory scores of butter cookies incorporated with inulin are represented in Table 4. The cookies prepared with 50% inulin replacement (BIN50) had the highest overall acceptability. BIN50 had a wide range of acceptance over colour, taste, flavour, mouth feel, after taste, texture, crunchiness, and breakability when compared with the other variations and control. One way ANOVA revealed that parameters such as color [F(7,112)= 3.09, P=.01], taste [F(7,112)= 3.59, P=.001], flavor [F(7,112)=3.68, P=.001], mouth feel [F(7,112)=4.42, P=.00023], crunchiness [F(7,112)=2.46, P=.022], after taste [F(7,112)= 4.52, P=.0002], breakability [F(7,112)=1.91, P=.07], and overall acceptability [F(7,112)=4.63, P=.0001] exhibited a significant (P <0.05) difference among the variations of butter cookies incorporated with inulin.

Table 3 — Sensory scores of cookies incorporated with roasted chicory powder

Attributes	BRC00	BRC05	BRC10	BRC15	MRC00	MRC05	MRC10	MRC15
Colour	8.1±0.60	7.1±1.03	6.3±1.11	6.0±1.77	8.0±0.85	7.5±0.74	7.5±1.06	6.9±1.22
Taste	8.1±0.88	7.5±0.83	5.4±1.05	4.8±1.47	7.9±0.92	7.3±1.11	6.9±0.88	6.6±1.05
Texture	8.0±0.76	7.9±0.80	7.0±1.56	6.8±1.67	7.7±1.03	7.5±0.83	7.5±0.92	6.9±1.03
Flavour	7.9±0.88	7.5±1.01	5.6±1.40	4.7±1.39	7.5±1.06	7.0±0.80	6.8±1.01	6.5±1.19
Mouth feel	7.7±1.10	7.7±0.80	5.8±1.82	5.5±2.00	7.6±0.83	7.1±0.92	7.0±0.80	6.8±1.37
Crunchiness	6.9±1.49	7.5±1.19	6.5±1.60	6.5±1.72	7.7±0.98	7.1±0.92	7.3±1.11	7.0±1.13
Breakability	7.1±1.16	7.5±1.19	6.4±1.68	6.4±1.76	7.4±1.06	7.3±0.88	7.5±1.25	6.9±0.96
After taste	7.9±1.10	7.1±0.88	4.5±1.13	3.7±1.28	7.5±1.06	6.8±1.19	6.5±1.41	6.3±1.22
Overall acceptability	7.9±0.88	7.3±1.05	5.5±1.06	4.7±1.22	7.8±0.77	7.5±0.92	7.0±0.93	6.6±0.99

Values are Mean±SD of 15 individual sensory scores

Table 4 — Sensory scores of butter cookies incorporated with inulin

Attributes	BRC00	BIN05	BIN10	BIN15	BIN25	BIN50	BIN75	BIN100
Colour	8.1±0.60	7.1±0.74	6.9±0.88	6.9±1.36	7.4±0.99	7.4±0.99	6.7±1.05	6.8±1.21
Taste	8.1±0.88	6.9±0.88	7.0±0.76	7.2±0.86	7.6±0.83	7.6±0.91	7.0±1.46	6.5±1.34
Texture	8.0±0.76	6.8±0.86	6.8±0.77	7.1±1.16	7.3±0.81	7.7±0.88	6.7±1.22	6.3±1.18
Flavour	7.9±0.88	6.8±1.01	6.9±0.70	7.0±0.93	7.4±0.91	7.8±0.86	7.0±1.07	6.5±1.41
Mouth feel	7.7±1.10	7.1±0.88	7.1±0.83	6.9±1.28	7.3±0.30	7.9±0.92	6.8±0.94	6.1±1.13
Crunchiness	6.9±1.49	7.0±0.93	6.8±0.77	6.7±0.88	7.2±1.08	7.5±0.83	6.7±1.05	6.7±1.54
Breakability	7.1±1.16	7.3±1.03	7.1±0.88	7.1±1.22	7.5±0.92	7.6±0.91	6.7±1.58	6.7±1.44
After taste	7.9±1.10	6.8±0.94	7.1±0.83	6.5±0.64	7.2±0.94	7.6±0.83	6.7±1.45	6.3±1.05
Overall acceptability	7.9±0.88	7.1±1.06	6.9±0.70	7.0±0.85	7.4±1.12	8.1±0.70	6.7±0.96	6.6±1.30

Values are Mean±SD of 15 individual sensory scores

Table 5 — Sensory scores of multi-grain cookies incorporated with inulin

Attributes	MRC00	MIN05	MIN10	MIN15	MIN25	MIN50	MIN75	MIN100
Colour	8.0±0.85	7.5±1.13	7.3±0.90	6.9±0.74	7.7±0.80	7.8±0.77	6.9±1.39	6.6±1.30
Taste	7.9±0.92	7.1±1.00	7.3±0.72	6.5±0.64	7.7±0.90	7.9±0.70	6.7±1.28	6.7±1.10
Texture	7.7±1.03	7.1±0.80	6.9±0.92	6.7±0.62	8.0±0.76	7.9±0.80	6.7±1.11	6.8±0.94
Flavour	7.5±1.06	6.0±0.74	6.9±1.03	7.3±0.90	7.7±0.70	8.1±0.83	6.8±1.37	6.6±1.35
Mouth feel	7.6±0.83	7.0±0.76	6.7±0.88	7.1±1.00	7.6±0.99	8.0±0.70	6.3±1.23	6.4±1.45
Crunchiness	7.7±0.98	7.1±1.16	6.7±0.70	7.0±0.93	7.8±0.77	8.1±0.63	6.3±1.28	6.3±1.59
Breakability	7.4±1.06	7.7±0.98	6.8±0.77	7.1±1.13	7.7±0.70	7.8±0.77	6.5±1.55	6.5±1.46
After taste	7.5±1.06	7.0±0.85	7.9±0.83	7.3±0.80	7.8±0.68	8.1±0.80	6.6±1.40	6.8±0.86
Overall Acceptability	7.8±0.77	7.7±0.82	7.8±0.68	7.3±0.70	7.7±0.80	8.2±0.60	6.6±1.45	6.9±1.13

Values are Mean±SD of 15 individual sensory scores

Sensory scores of multi-grain cookies incorporated with inulin are shown in Table 5. In the multigrain category with inulin as a sugar replacer, the overall acceptability was highest for cookies with 50% inulin (MIN50). MIN50 had a wide range of acceptance over colour, taste, flavour, mouth feel, after taste, texture, crunchiness, and breakability when compared with the other variations and control. The texture was ranked highest for MIN25 (25% incorporation) followed by MIN50. One-way ANOVA revealed that there was a significant (P <0.05) difference among the samples in the attributes of color [F (7,112) = 3.67, P=.001], flavor [F (7,112) = 3.66, P=.001] and breakability [F (7,112) =3.50, P=.002], taste [F (7,112) =5.43, P=2.2E-05], texture [F (7,112) = 6.19, P=3.92E-06] and after taste [F(7,112)= 4.93, P=6.91E-05].

The sensory results of the current study with 50% inulin incorporated cookies were comparable with the research of Handa *et al.*[12], who developed multi-grain cookies containing 60% FOS, 20% finger millet, and 30% sorghum and reported an overall acceptability score of 7.3±0.5 on a nine-point scale acclaiming that the FOS incorporated cookies were comparable to conventional cookies concerning their sweet taste and overall flavour.

Nutritional composition of cookies

Moisture, ash, protein, fat, carbohydrates, calories, dietary fibre, iron, calcium, and phosphorous content were analyzed for the cookies with the most acceptable sensory score (BRC05, MRC05, BIN50, MIN50) and compared with control cookies (BRC00 and MRC00) and the results of the same are depicted in Table 6.

Moisture

Cookies are shelf-stable products and the moisture content is generally low. The moisture content of butter cookies was in the range of 1.74 - 2.93% and that of multigrain cookies was 1.28 - 3.41%. There was a 23% - 34% decrease in moisture content on the incorporation of chicory powder (MRC05 and BRC05) whereas, on the incorporation of inulin, there was a significant increase in moisture content compared to their respective control cookies.

The result of the current study was in agreement with Handa *et al.*[12], who reported the moisture content of cookies as 2.2 - 2.6%. Jha *et al.*[13], also reported similar moisture content (2.30%) in cookies. The result of the current study was also by Sofyan *et al.* [14], who reported the moisture content of cookies as 2.12 - 2.94%.

Ash

The ash content of BRC00, BRC05, and BIN50 butter cookies was 1.23±0.01, 1.30±0.001, and 1.08±0.004% respectively. The ash content of multigrain cookies MRC00, MRC05, and MIN50 was 1.67±0.02%, 1.70±0.001%, and 1.47±0.02% respectively.

This result is similar to Joytsna & Sowmya[15], who reported their findings as 1.50±0.02% ash content in multigrain cookies. Another study[13] too had reported similar ash content (1.03 - 1.56%) for multigrain cookies.

Upon incorporation of roasted chicory, there was a significant increase in ash content which could be attributed to the nutrient profile of chicory powder. A decline in ash value was recorded in inulin-added samples and this needs further investigation.

Protein

The protein content for butter cookies was in the range of 6-7% and that of multigrain cookies was 10-11%. There was a significant increase (14%) in protein content after replacing sugar with roasted chicory powder. There was no impact in the protein content on adding inulin.

Table 6 — Nutritional composition of cookies (on dry weight basis)

Parameters	BRC00	BRC05	BIN50	MRC00	MRC05	MIN50
Moisture (%)	2.65±0.23	1.74±0.20* (-34.34%)[1]	2.93±0.14** (10.56%)[1] (68.39%)[2#]	1.66±0.19	1.28±0.15 (-22.89%)[3]	3.41±0.10** (105.4%)[3] (166.4%)[4#]
Ash (%)	1.23±0.01	1.30±0.01* (5.69%)[1]	1.08±0.01** (-12.19%)[1] (-16.92%)[2#]	1.67±0.02	1.70±0.01 (1.79%)[3]	1.47±0.02** (-11.97%)[3] (-13.52%)[4#]
Protein (%)	6.40±0.16	7.33±0.10* (14.53%)[1]	6.48±0.06 (1.25%)[1] (-11.59 %)[2#]	10.06±0.06	11.46±0.19* (13.91%)[3]	10.16±0.06 (0.99%)[3] (-11.34%)[4#]
Fat (%)	24.34±0.10	27.18±0.18* (11.66%)[1]	29.21±0.11** (20%)[1] (7.46%)[2#]	25.20±0.11	27.34±0.10* (8.49%)[3]	30.17±0.13** (19.72%)[3] (10.35%)[4#]
Total dietary fibre (%)	0.21±0.10	0.98±0.16* (366%)[1]	13.33±0.10** (6247%)[1] (1260%)[2#]	2.55±0.19	3.29±0.18* (29.01%)[3]	15.78±0.10** (518%)[3] (379.6%)[4#]
Carbohydrates (%)	65.17	61.47 * (-5.67%)[1]	45.57** (-30%)[1] (-25.86%)[2]	58.86	54.93* (-6.67%)[3]	36.61** (-37.80%)[3] (-33.30%)[4]
Total calories (Kcal)	504.86	521.82* (3.35%)[1]	503.35 (-0.29%)[1] (-3.53%)[2]	507.58	518.2* (2.09%)[3]	499** (-1.69%)[3] (-3.7%)[4]
Iron (mg/100g)	0.53±0.02	0.86±0.02* (62.26%)[1]	0.53±0.02 (-38.72%)[2#]	1.71±0.17	2.91±0.17* (70.18%)[3]	1.70±0.17 (-41.58%)[4]
Calcium (mg/100g)	45.15±0.05	58.37±0.12* (29.28%)[1]	45.24±0.02 (-22.49%)[2#]	55.23±0.12	67.17±0.17* (21.61%)[3]	55.22±0.08 (-17.79%)[4]
Phosphorous (mg/100g)	113.88±0.53	144±0.48* (26.44%)[1]	112±0.48** (-1.65%) [1] (-22.67%)[2#]	216±0.48	259.2±0.42* (20%)[3]	216.4±0.47 (-16.51%)[4]

Values are Mean±SD of triplicate analysis;[1]Depicts the per cent increase or decrease between BRC00 and BRC05/ BIN50; [2]Depicts the percent increase or decrease between BRC05 and BIN50; [3]Depicts the percent increase or decrease between MRC00 and MRC05/MIN50; [4]Depicts the percent increase or decrease between MRC05 and MIN50;*Indicates significant difference (P <0.05) on incorporation of roasted chicory powder with control on student t test two tailed;**Indicates significant difference (P <0.05) on incorporation of inulin with control; [#]Indicates significant difference (P <0.05) on incorporation of inulin with roasted chicory powder. Per cent increase/decrease = change in amount/ original amount *100

Ivanisova *et al.*[16], reported the protein content of cookies with 5% chicory fibre as 7.15±0.16%. In a research study[15], the protein content of multigrain cookies was reported in the range of 10±0.03 - 13.50±0.04%. A study performed by Arshad *et al.* [17], found that the protein content of cookies made with wheat germ flour was in the range of 11.8-16.2%.

Fat

Fat is the principal component of cookies as it contributes to texture. The total fat content of BRC00, BRC05, and BIN50 was 24.34±0.10, 27.18±0.18, and 29.21±0.11% respectively. On incorporation of roasted chicory powder (BRC05) and inulin (BIN50), there was an 11.66 and 20% significant (P <0.05) increase in the fat content compared to the control butter cookies (BRC00).

The total fat content of multigrain cookies MRC00, MRC05, and MIN50 was observed as 25.20±0.11, 27.34±0.10, and 30.17±0.13% respectively. MRC05 had 8.49% higher fat content compared to MRC00. On comparing inulin incorporated multigrain cookie (MIN50) with roasted chicory incorporated multigrain cookie (MRC05), it was found that the fat content of MIN50 was higher (10.33%).

The results were comparable to another study[16] on cookies with chicory fibre incorporation reporting a fat value of 24.12 – 24.85%. This result was also as per Pal *et al.* [18], who had reported the fat content of multigrain cookies made with oat and green gram flour to be 27.62-29.15%.

Total dietary fibre

The total dietary fibre for butter cookies was in the range of 0.21 - 13.33%. A study conducted by Handa

et al.[12], reported the total dietary fibre content of cookies as 0.6%. The dietary fibre for multigrain cookies was 2.55 - 15.78%. A study done by Sharma *et al*.[19], reported the dietary fibre content of cookies made using minor millet in the range of 12.36 - 34.34%.

Replacement of sugar with inulin or chicory had resulted in a tremendous increase in fibre content. On comparing MIN50 and MRC00, it was found that the total dietary fibre of MIN50 was fivefold higher. Control butter cookies had a negligible amount of fibre whereas the 50% inulin replacement of sugar resulted in a fibre-rich product. Therefore, cookies with chicory or inulin can considerably be a good source of fibre.

Carbohydrates

The carbohydrate content of butter cookies BRC00, BRC05, and BIN50 was found to be 65.17, 61.47, and 45.57% respectively. The carbohydrates content of multigrain cookies MRC00, MRC05, and MIN50 was found to be 58.86, 54.93, and 36.61% respectively. This result was comparable with other researchers[12] who had reported the carbohydrate content to be 54-69%. Another study[19] reported the carbohydrate content of cookies made with minor millets as 44-63%.

The carbohydrates content had significantly decreased by 5-6% on sugar replaced with 5% chicory and there was a 30-37% decrease on replacing 50% sugar content with inulin.

Total calories

The calorific value of the cookies was in the range of 499- 521 Kcal. The total calories of control cookies and inulin-added cookies were similar. On incorporation of roasted chicory, there was a 2- 3% increase in total calories compared to control cookies.

Iron

The butter cookies had iron content in the range of 0.53- 0.99 mg/100g, and the multigrain cookies had 1.71–2.91 mg/100g. On incorporation of roasted chicory, there was a significant increase (62-70%) in the iron content due to the appreciable mineral profile of chicory root.

In a research study, Shipra *et al*.[20], reported the iron content of multigrain sweet cookies in the range of 0.48-3.43 mg/100mg. In a study[17] iron content of cookies made with wheat-germ flour was in the range of 1-3 mg/100g.

Calcium and Phosphorus

The calcium content of butter cookies was in the range of 45- 58 mg/100g and that of multigrain was 55-67 mg/100g. Calcium content in the range of 45-51 mg/100g was reported for multigrain cookies in a research study[21]. There was a 21 and 29% increase in calcium content on chicory incorporation in butter and multigrain cookies respectively. Inulin incorporation did not affect calcium content.

The multigrain cookies had better phosphorus content compared to butter cookies. On incorporation of roasted chicory powder, there was a 20 - 26% significant increase in phosphorus content. Chicory is a good source of minerals that had added value to the cookies.

Physical properties of cookies

The physical properties of the cookies are provided in Table 7.

Diameter and thickness

The diameter of the cookie is set by how long the cookie expands. The diameter of the cookies was in the range of 4.21 - 4.74 cm. The incorporation of roasted chicory resulted in a significantly higher diameter compared to control cookies. Sugars are not completely dissolved before baking, so the undissolved sugars will dissolve during the time of baking, thus increasing the diameter of the cookies. The thickness of the cookies was in the range of 0.97 – 1.02 cm. On incorporation of roasted chicory powder (MRC05), there was no significant difference in thickness.

The results of this study were comparable to the research study by Kulthi *et al.*[22], who developed and evaluated maida cookies incorporated with pearl millet flour at varying levels. The researchers reported the diameter of the cookies in the range of 4.46 - 4.94 cm, thickness in the range of 0.986- 1.33 cm, and spread ratio to be 3.44 – 5.05.

Spread ratio

One of the important characteristics to determine the quality of a cookie is the spread ratio. The spread ratio depends on the diameter and thickness of a product. The spread ratio of the cookies was in the range of 4.3-4.8. On incorporation of roasted chicory powder, there was a significant 10-11% increase in spread ratio, and inulin resulted in an 8-10% increase which corresponds with the increase in diameter of these cookies as discussed above.

Table 7 — Physical properties of cookies

Properties	BRC00	BRC05	BIN50	MRC00	MRC05	MIN50
Diameter (cm)	4.21±0.14	4.74±0.11* (12.58%)[1]	4.68±0.08** (11.16%)[1] (-1.2%)[2]	4.38±0.27	4.65±0.25* (6.16%)[3]	4.60±0.04 (5.02%)[3] (-1.07%)[4]
Thickness (cm)	0.97±0.02	0.98±0.02 (1.03%)[1]	0.98±0.02 (1.03%)[1]	1.02±0.07	0.98±0.02 (-3.92%)[3]	0.99±0.01 (-2.94%)[3] (1.02%)[4]
Spread ratio	4.33±0.18	4.84±0.07* (11.78%)[1]	4.78±0.10** (10.39%)[1] (-1.24%)[2#]	4.29±0.27	4.76±0.21* (10.96%)[3]	4.66±0.03** (8.62%)[3] (-2.10%)[4]
Volume ($cm^{3)}$	18.28±0.17	16.28±0.1* (-10.94%)[1]	17.44±0.29** (-4.59%)[1] (7.13%)[2#]	17.41±0.25	16.72±0.33* (-3.96%)[3]	18.32±0.21** (5.23%)[3] (9.57%)[4#]
Weight (g)	8.62±0.21	7.90±0.06* (-8.35%)[1]	7.71±0.24** (-10.56%)[1] (-2.41%)[2]	8.29±0.07	7.90±0.02* (-4.70%)[3]	8.55±0.26** (3.14%)[3] (8.23%)[4#]
Density (g/cm^3)	0.47±0.01	0.48±0.01 (2.13%)[1]	0.44±0.02 (-6.38%)[1] (-8.33%)[2]	0.48±0.01	0.47±0.01 (-2.08%)[3]	0.47±0.02 (-2.08%)[3]
Specific volume (cm^3/g)	2.12±0.05	2.06±0.02 (-2.83%)[1]	2.26±0.09 (6.60%)[1] (9.71%)[2#]	2.10±0.04	2.12±0.04 (0.95%)[3]	2.14±0.07 (1.90%)[3] (0.94%)[4]

Values are Mean±SD (5 cookies determinants); [1]Depicts the percent increase or decrease between BRC00 and RC05/ BIN50; [2]Depicts the percent increase or decrease between BRC05 and BIN50; [3]Depicts the percent increase or decrease between MRC00 and MRC05/MIN50; [4]Depicts the percent increase or decrease between MRC05 and MIN50; *Indicates significant difference (P <0.05) on incorporation of roasted chicory powder compared to control on student t test two tailed; **Indicates significant difference (P <0.05) on incorporation of inulin with control; [#]Indicates significant difference (p<0.05) on incorporation of inulin over roasted chicory powder.
Percent increase/decrease = change in amount/ original amount *100

This result can be compared to the study[12] that had replaced sugar with FOS in cookies and reported the spread ratio as 4.4-5.2. The result was also similar to Arshad *et al*.[21], who had reported the spread ratio of multigrain cookies in the range of 4.2-4.6. The solubility of sugar affects the diameter and thickness of cookies[12]. Since the solubility of roasted chicory is more than that of the sugar, the diameter of the cookies increased. The roasted chicory has a less extensive gluten network, and this has caused a decrease in the thickness of cookies and a higher spread ratio compared to the control cookies.

Volume and weight

The volume of the cookies was in the range of 16-18 cm^3 respectively. The weight of the cookies was in the range of 7-8 g. On incorporation of roasted chicory powder/ inulin as a sugar replacer, there was a statistically significant decrease in volume and weight. The result was similar to another study[16] which had reported the volume of cookies enriched with chicory fibre as 14-19 cm^3.

Density and specific volume

The density and specific volume show the relationship between the amount of solid and the fraction of air in a baked product. Products of higher density indicate a high level of moisture content. The cookies had a density in the range of 0.47-0.48±0.01g/cm^3. The specific volume of the cookies was similar.

Conclusion

In the current study roasted chicory powder and inulin were incorporated at varying levels replacing sugar in butter and multigrain cookies. Sensory analysis revealed that 5% chicory and 50% inulin as a sugar replacer in cookies had good acceptability. Roasted chicory powder can be incorporated in cookies only at lower levels due to its bitter taste. The incorporation of chicory or inulin resulted in a low carbohydrate, fibre-rich product. Roasted chicory substituting sugar resulted in a better nutrient profile whereas inulin had an impact only on carbohydrate and fibre content. The study recommends the usage of chicory or inulin as a functional ingredient and also as a potential sugar replacer in cookies.

Conflict of interest

The authors declare there is no conflict of interest regarding the publication of this research paper.

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