APST

Asia-Pacific Journal of Science and Technology

https://www.tci-thaijo.org/index.php/APST/index

Published by the Research and Graduate Studies,
Khon Kaen University, Thailand

Development of sugar-free brownies using inulin, sucralose, and stevia

Natthakan Rungraeng[1,2,*], Rarinthorn Thammakulkrajang[3] and Supaluck Kraithong[4]

[1]School of Agro-Industry, Mae Fah Luang University, Chiang Rai, Thailand
[2]Innovative Food Packaging and Biomaterials Unit, Mae Fah Luang University, Chiang Rai, Thailand
[3]Department of Food Technology, Maejo University-Phrae Campus, Phrae, Thailand
[4]School of Food Science and Engineering, South China University of Technology, Guangzhou, China
[*]Corresponding author: natthakan.run@mfu.ac.th

Received 1 July 2021
Revised 10 January 2022
Accepted 8 February 2022

Abstract

This work determined the effects of inulin level and baking conditions on the textural properties of sugar-free brownies using inulin, and identified the most suitable low-calorie sweetener to use in the brownies by comparing ground stevia leaf, sucralose, and a mixture of the two. Brownies were prepared with varying levels of inulin (0, 62.5, and 125 g), baking times (20, 25, and 30 min), and baking temperatures (170, 180, and 190°C). The textural properties of the brownies made with 62.5 g of inulin, baking times of 20 and 25 min, and baking temperatures of 180 and 190°C were similar to those of the control sample (conventional brownie). Therefore, these baking times and temperatures were used to prepare the brownies for subsequent experiments. Ground stevia leaf (10 g), sucralose (0.42 g), and a mixture of both sweeteners (5 g of stevia and 0.21 g of sucralose) were added to the selected brownie formulas. The brownies obtained using 0.42 g of sucralose and 62.5 g of inulin with 25 min baking time at 180°C gave the highest consumer acceptability (6.10; $p < 0.05$). The findings of this work can be further applied to formulate various healthy food and bakery products in the future.

Keywords: Low-calorie sweetener, Bakery products, Healthy food, Sugar substitutes

1. Introduction

Confectionery, snacks, and bakery products such as cakes, brownies, chocolates, and puddings are widely consumed due to their unique taste and flavor [1]. However, limiting the dietary intake of high-calorie sugars, such as sucrose, through such products is considered critical due to health awareness and associated health problems [2]. Nevertheless, the quality characteristics, particularly the textural and sensory properties, of confectionery products are largely dependent on the amount of added sugar, thus reducing sugar impacts product acceptability. Therefore, several low-calorie sugar substitutes or artificial sweeteners, including aspartame, saccharin, cyclamate, sucralose, inulin, and stevia, are increasingly being used to maintain or improve the texture, sensory attributes, and mouthfeel of confectionery and bakery products [3,4]. Response surface methodology (RSM) is one of the statistical methods that has been employed for optimizing food processing and identifying the best conditions for food product development. This technique is used to optimize many food products such as bakery, extruded products, and gluten-free bread [5].

Inulin is a polysaccharide that is naturally stored in fruits and vegetables. It is a type of dietary fiber commonly known as fructan. Inulin molecules are composed of multiple fructose units linked by β-(2-1) fructosyl-fructose bonds, with a glucose moiety at the reducing end [6]. This structure is mostly linear, although a small number of branched units with β-(2-6) linkages can still be found [7]. In terms of the functional properties and the health-promoting effects, this sweetener is extensively used for decreasing calories, increasing dietary fiber, and obtaining prebiotic effects in various food products (both dairy and non-dairy foods) because it is a bulking agent that can be used as a fat replacement and for textural modification, as well as for organoleptic improvement [8]. Sucralose is one of the most-consumed artificial sweeteners and is known as a non-nutritive or low-calorie sweetener. It is also recognized as an organochlorine sweetener and it is a synthetic trichlorinated disaccharide with the chemical name 1,6-dichloro-1,6-dideoxy-β,d-fructofuranosyl-4-

chloro-4-deoxy-α,d-galactopyranoside [9]. Sucralose provides intense sweetness (it is about 600 times sweeter than sucrose) with few calories. Thus, it is widely used in beverages, dietary products, drugs, and low-calorie food products [10]. Stevia (*Stevia rebaudiana*) is a perennial plant originally found in the southeastern United States that has become a vital economic crop. Stevia consists of two major sweetening agents, namely stevioside and rebaudioside. Besides its intense sweetness, the plant also has substantial health and therapeutic benefits, such as for treating chronic diseases like diabetes and hypertension [11]. The plant has been reported to consist of abundant phytochemical compounds, including vitamins, phytosterols, triterpenes, essential oil components, and polyphenols [12]. In the food industry, stevia is used as a sweetener and to increase the nutritional value of many foods and beverages, such as cookies, juices, and carbonated drinks [13].

The aims of this study were to investigate the effects of inulin on the structural properties of sugar-free brownies using RSM and to find the most suitable low-calorie sweetener for the developed brownies. This research was separated into two parts. In the first step, the effects of inulin, baking temperature, and baking time on the textural properties of the product were evaluated. The best conditions from this part were then used in the subsequent experiments. Thereafter, the textural properties, color attributes, moisture content, and sensory qualities of the brownies prepared using different sweeteners (sucralose, ground stevia leaf, and a mixture of the two) were determined.

2. Materials and methods

2.1 Preparation of brownies

Dark chocolate (175 g) and butter (175 g) were heated in a microwave oven (800 W) for a minute until melted. The mixture was then whisked for 30 seconds using a hand whisk before adding sucrose (250 g), and then stirred for another minute. Next, beaten eggs (180 g) were added. All the ingredients were mixed thoroughly for a minute, then all-purpose flour (115 g) was added and stirred until smooth. The batter was poured into an aluminum baking tray (16.5 × 24 cm) and baked for 30 min at 190°C. The baked sample was then used as a control.

2.2 Response surface methodology

The sugar-free brownies were prepared in the same manner except that the sucrose portion was substituted with either 0, 62.5, and 125 g of inulin and different baking times (20, 25, and 30 min) and temperatures (170, 180, and 190°C). The hardness, springiness, and chewiness of the obtained brownies obtained were evaluated and compared using a three-factor Box-Behnken design, as shown in Table 1.

A polynomial regression model (non-linear relationship) was used to develop an empirical model for predicting the hardness of the brownie samples. The model was developed in Minitab 16 as follows:

$$Y = \beta_0 + \beta_1 X + \beta_2 X^2 + \ldots + \beta_h X^h + \epsilon$$

where Y is a response variable, X is a predictor variable, h is the polynomial degree, and ϵ is a constant.

Table 1 The levels of each factor according to the Box-Behnken design.

Treatment	Baking time (min)	Temperatures (°C)	Inulin (g)
1	20	170	62.5
2	30	170	62.5
3	20	190	62.5
4	30	190	62.5
5	20	180	0
6	30	180	0
7	20	180	125
8	30	180	125
9	25	170	0
10	25	190	0
11	25	170	125
12	25	190	125
13	25	180	62.5
14	20	180	62.5
15	30	180	62.5

To ensure that the sweetness level of the developed brownies atched that of the control brownies, the sweetness of all formulations was calculated using the Magnitude Estimation method [14]:

$$\textit{desired sweetness (approx. 250)} = \textit{sweetness intensity} \times \textit{amount used (g)}$$

The amount of sweetener to use was calculated accordingly. The details are shown in Table 2.

2.3 Textural characteristics of brownies

The textural attributes of the brownie samples were determined using a Texture Analyzer (Stable Micro Systems, Godalming, UK). Compression testing was conducted using a cylindrical probe (P/100) with a test speed of 45 N/s. The samples were cut into a circular shape, with a height of 2 cm and a diameter of 75 mm.

Table 2 Sweeteners used in the brownies.

Sweetener	Sweetness intensity	Amount used (g)	Desired sweetness
Sucrose (control)	1	250	250
Ground stevia leaf	25	10	250
Sucralose	600	0.42	250
Stevia and sucralose	25 and 600	5 and 0.21	250

2.4 Moisture content

The moisture content was measured according to the standard AOAC method [15].

2.5 Color analysis

The color attributes of the brownies were measured using a colorimeter (Miniscan EZ, USA). Color parameters were L* (0 = black and 100 = white), a* (-a* = greenness and +a* = redness), and b* (-b* = blueness and +b* = yellowness). A white calibration tile was used to calibrate the colorimeter.

2.6 Sensory evaluation

The evaluation of the sensory characteristics in terms of appearance, sweetness, texture, taste, and overall acceptability was carried out using a 9-point hedonic scale, where 1 = dislike extremely and 9 = like extremely. All brownie samples were prepared and then stored at 5°C for 48 h before serving to 30 untrained panelists.

2.7 Statistical analysis

In this study, the means were compared using Duncan's Multiple Range Tests (DMRT). Analysis of variance (ANOVA) was used to identify any significant difference between variables. The significance level was fixed at $p < 0.05$. The statistical analysis was achieved using Minitab software.

3. Results and discussion

3.1 Regression analysis and response surface plot

The regression analysis showed that the inulin content and the quadratic terms, including Temperature × Temperature and Inulin × Inulin, significantly affected the hardness of the brownies. Conversely, baking time showed no significant effect on the hardness ($p > 0.05$). For the quadratic equation, the correlation between baking conditions (i.e., baking time, temperature, and inulin content) for predicting the hardness of the brownies was developed as follows:

$$\text{Hardness} = 24479 - 258.5\ \text{Temperature} - 45\ \text{Time} - 9.62\ \text{Inulin} + 0.668\ \text{Temperature} \times \text{Temperature} - 0.84\ \text{Time} \times \text{Time} + 0.02475\ \text{Inulin} \times \text{Inulin} + 0.498\ \text{Temperature} \times \text{Time} + 0.0406\ \text{Temperature} \times \text{Inulin} - 0.0545\ \text{Time} \times \text{Inulin}$$

In general, parameters with a positive coefficient will have a positive effect on hardness, increasing the hardness. On the other hand, a factor with a negative coefficient will have a negative effect on the value. Using the regression equation, the hardness value can be predicted for a particular inulin content, baking time, and temperature with a regression coefficient of 0.9152. As shown in the surface plot (Figure 1), both inulin content and baking temperature affect the hardness. The hardness of the control brownies was 17.61 N (target value) so 62.5 g of inulin and baking temperatures of 180 and 190°C with baking times of 20 and 25 min were selected for the subsequent studies. Because these conditions gave the same hardness as the control ($p > 0.05$).

3.2 Textural characteristics of brownies

The textural properties of the brownie samples from the first experiment (explained in section 2.2) are shown in Table 3. The inulin level, baking time, and temperature influenced the hardness, springiness, and chewiness of the brownie samples. Most of the samples exhibited differences in hardness and chewiness compared to the control. The baking time did not show any significant effect on the hardness (according to the results of the regression analysis). However, from analysis of textural properties, the following three formulations resulted in brownies with texture similar to the control: (1) 62.5 g of inulin, 20 min baking time, and 180°C baking temperature, (2) 62.5 g of inulin, 25 min baking time, and 180°C baking temperature, and (3) 62.5 g of inulin, 20 min baking time, and 190°C baking temperature.

The textural properties of the brownie samples containing different low-calorie sweeteners are presented in Table 4. The sweetener (sucralose, stevia, and the mixture of stevia and sucralose), baking time, and baking temperature affected the texture of the brownies. Nevertheless, the hardness (27.7 to 28.0 N) and chewiness (9.7 to 10.7 N×mm) of the brownie samples that were made from (1) sucralose and inulin, with a baking time of 20 min and baking temperature of 190°C and (2) sucralose and inulin, with baking time of 25 min and temperature of 180°C were not significantly different from those of the control ($p > 0.05$; hardness = 23.0 N ; chewiness = 6.2 N×mm; Table 4). Notably, sucralose and inulin tended to give brownies with a softer texture compared to those made using stevia and inulin ($p < 0.05$). The same observation was also reported in a previous study [16], where the authors found that the sugar-free reduced-fat dairy dessert prepared using a combination of sucralose and inulin showed lower hardness than the sample formulated using stevia alone or stevia combined with inulin. This was attributed to the presence of stevia and inulin improving the network structure of starchy foods. On the other hand, the presence of sucralose could cause a weakening of the starch network and an increase of syneresis in some food products.

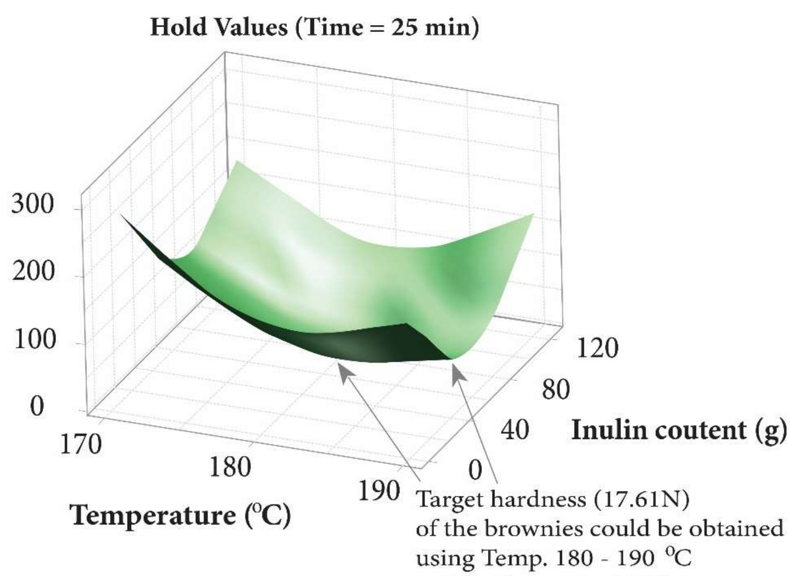

Figure 1 Surface plot illustrating the effect of temperature and inulin level on the hardness of the brownies.

Table 3 Textural parameters of the brownies prepared using different inulin levels, baking times, and temperatures.

Inulin (g)	Time (min)	Temperatures (°C)	Hardness (N)	Springiness	Chewiness (N×mm)
0	20	180	183.84±2.60^{ef}	0.73±0.12^{efg}	82.06±2.02^{fg}
	30	180	189.71±2.30^{ef}	0.48±0.09^{a}	59.81±1.42^{ef}
	25	170	324.82±2.83^{g}	0.76±0.12^{fg}	163.69±1.35^{h}
	25	190	176.68±1.65^{def}	0.80±0.14^{g}	90.41±9.26^{g}
62.5	20	170	123.81±4.50^{cde}	0.51±0.13^{abc}	34.95±3.29^{bcde}
	30	170	91.36±4.96^{abc}	0.64±0.19^{bcdef}	29.55±2.59^{abcd}
	20	190	54.20±1.86^{abc}	0.52±0.18^{ab}	14.64±5.47^{ab}
	30	190	121.25±3.67^{cde}	0.68±0.08^{defg}	47.78±17.76^{cde}
	25	180	23.36±1.44^{ab}	0.54±0.13^{abcd}	3.02±2.46^{a}
	20	180	78.25±1.86^{abc}	0.49±0.06^{ab}	20.34±1.09^{abc}
	30	180	125.97±1.45^{cde}	0.54±0.06^{abcd}	24.32±1.45^{abc}
125	20	180	99.49±2.40^{bcd}	0.55±0.09^{abcd}	19.63±5.33^{abc}
	30	180	37.23±0.22^{ab}	0.66±0.11^{cdefg}	11.42±2.46^{ab}
	25	170	246.24±0.34^{f}	0.59±0.34^{abcde}	79.98±4.39^{fg}
	25	190	193.85±4.40^{ef}	0.59±0.03^{abcde}	54.44±13.22^{def}
Control			17.61±5.65^{a}	0.59±0.05^{abcde}	5.21±1.11^{ab}

All values are means ± standard deviation. $^{a–h}$Means with the same superscript letters within a column are not significantly different at $p < 0.05$.

Table 4 Textural properties of brownies prepared with ground stevia leaf, sucralose, and both.

Sweetener	Time (min)	Temperature (°C)	Textural properties		
			Hardness (N)	Springiness	Chewiness (N×mm)
Stevia	20	180	163.7±1.1^{c}	0.63±0.01^{ab}	24.6±1.2^{ab}
	20	190	166.8±4.3^{c}	0.67±0.13^{ab}	59.9±1.0^{c}
	25	180	206.8±1.9^{c}	0.68±0.22^{ab}	85.6±3.4^{de}
Sucralose	20	180	86.8±1.8^{b}	0.77±0.14^{cd}	39.8±7.3^{b}
	20	190	27.7±4.7^{a}	0.70±0.20^{bcd}	9.7±3.6^{a}
	25	180	28.0±9.3^{a}	0.78±0.11^{d}	10.7±1.6^{a}
Stevia and sucralose	20	180	219.4±4.4^{c}	0.67±0.04^{b}	102.4±12.1^{e}
	20	190	117.8±1.7^{bc}	0.55±0.19^{a}	41.9±4.2^{cd}
	25	180	206.9±5.8^{c}	0.68±0.04^{bc}	71.8±5.0^{b}
Control			23.0±3.3^{a}	0.56±0.05^{a}	6.2±0.2^{a}

All values are means ± standard deviation. $^{a–e}$Means with the same superscript letters within a column are not significantly different at $p < 0.05$.

3.3 Moisture content

The results showed that the sweeteners used in this study had a considerable effect on the moisture content of the product (Table 5): all the brownies prepared using sweeteners exhibited higher moisture content compared to the control ($p < 0.05$). The increase in the moisture content when using sweetener could be due to the higher moisture in the sweetener compared to the lesser sugar contained in the control [17]. The findings were also in line with the data reported in the literature [18], whereby cookies made with different sweeteners (maple syrup, xylitol, corn syrup, and honey) showed differences in moisture content. These differences may impact the textural or sensory characteristics as well as the month-feel of the samples.

Table 5 Physical properties of brownies prepared with stevia leaf, sucralose, and both.

Sweetener	Time (min)	Temperature (°C)	Moisture content (%)	Color parameters		
				L*	a*	b*
Stevia	20	180	14.69±0.35^{ab}	34.78±0.05^{b}	9.34±0.03^{bc}	9.44±0.01^{d}
	20	190	20.97±1.63^{e}	31.21±2.22^{bc}	8.89±1.90^{bc}	9.30±2.75^{d}
	25	180	16.25±0.71^{bc}	40.59±1.99^{a}	10.49±1.34^{b}	16.00±1.87^{b}
Sucralose	20	180	19.59±0.46^{de}	11.08±0.19^{d}	25.88±0.36^{a}	19.10±0.33^{a}
	20	190	20.12±0.44^{de}	30.13±2.39^{bc}	9.81±0.60^{bc}	8.98±0.42^{d}
	25	180	16.64±1.62^{c}	41.78±0.86^{a}	10.25±0.22^{b}	9.91±0.36^{d}
Stevia and sucralose	20	180	15.13±0.87^{abc}	34.60±0.94^{b}	8.69±0.90^{bc}	8.66±0.95^{d}
	20	190	19.14±0.83^{d}	32.30±0.10^{bc}	9.41±0.01^{bc}	9.85±0.69^{d}
	25	180	18.72±0.29^{d}	33.62±1.62^{b}	6.07±0.14^{c}	4.67±0.24^{e}
Control			13.68±0.58^{a}	39.80±1.85^{a}	11.25±1.83^{b}	14.41±0.45^{c}

All values are means ± standard deviation. $^{a–e}$Means with the same superscript letters within a column are not significantly different at $p < 0.05$.

3.4 Color attributes

The sweeteners used in this study significantly affected all color parameters (Table 5). The lightness, redness, and blueness of the brownie samples were noticeably decreased with the sweeteners ($p < 0.05$). Akesowan [19] also reported that the lightness of reduced-fat chiffon cakes decreased with increasing erythritol-sucralose content. In addition, Khattab et al. [20] also found that the a* and b* color values of a shortened cake were reduced with increasing levels of steviolbioside, a sweetening agent found in stevia. These results were attributed to the Maillard reaction, which is a reaction between amino acids (especially L-amino acids lysine, glycine, tryptophan, and tyrosine), sugars, and heat.

3.5 Sensory characteristics

The sensory scores for the brownie samples are presented in Table 6. The highest sensory scores for all terms were found in the control sample ($p < 0.05$). Generally, sensory properties are affected by various product characteristics, including the color of the product and the textural qualities [17]. Nevertheless, the brownie sample made with sucralose and inulin, with a baking time of 25 min at 180°C, had the highest overall acceptability (6.10) among the brownie samples except the control ($p < 0.05$). This could be attributed to better scores in other sensory terms, such as appearance (6.47) and texture (6.10) ($p < 0.05$). Additionally, the other textural properties of the samples, hardness and chewiness, did not differ significantly from those of the control sample ($p < 0.05$).

Table 6 Sensory attributes of the developed brownies.

Sweetener	Time (min)	Temperature (°C)	Sensory scores				
			Appearance	Sweetness	Texture	Taste	Overall
Stevia	20	180	5.7±1.8^{b}	4.4±2.0^{abc}	4.5±1.7^{ab}	4.4±1.9^{a}	4.5±1.7^{ab}
	20	190	5.6±1.7^{b}	3.9±1.6^{ab}	4.5±1.7^{ab}	4.4±1.9^{a}	4.5±1.6^{ab}
	25	180	4.2±1.7^{a}	3.6±1.5^{a}	5.0±1.8^{b}	3.9±1.9^{ab}	4.5±1.8^{ab}
Sucralose	20	180	6.1±1.8^{b}	5.8±1.9^{e}	4.2±1.6^{a}	3.3±1.6^{a}	3.8±1.6^{a}
	20	190	6.0±1.7^{b}	5.8±1.7^{e}	3.6±1.8^{a}	6.3±1.7^{bc}	6.0±1.8^{c}
	25	180	6.5±1.3^{bc}	5.3±1.8^{de}	6.1±1.3^{c}	6.1±1.7^{b}	6.1±1.7^{c}
Stevia and sucralose	20	180	6.0±1.7^{b}	4.2±1.6^{ab}	5.1±1.6^{b}	5.6±1.8^{b}	5.9±1.7^{c}
	20	190	5.9±1.5^{b}	4.8±1.9^{bc}	4.8±1.2^{ab}	4.2±1.6^{ab}	4.6±1.7^{ab}
	25	180	4.7±2.0^{a}	3.9±1.9^{ab}	4.5±1.9^{a}	4.6±1.6^{a}	5.0±1.3^{c}
Control			7.1±0.7^{c}	6.2±1.9^{e}	6.2±1.4^{c}	7.1±1.0^{c}	6.4±1.0^{c}

All values are means ± standard deviation. $^{a–e}$Means with the same superscript letters within a column are not significantly different at $p < 0.05$.

4. Conclusion

In the first experiment, a quadratic equation was developed for predicting the hardness of the brownie samples. The model suggested that the formulations containing 62.5 g of inulin with baking times of 20 and 25 min and baking temperatures of 180 and 190°C would give the optimal sugar-free brownies. After the second experiments, it was found that two sets of brownies, namely those formulated with (1) sucralose and inulin, baked at 190°C for 20 min and (2) sucralose and inulin, baked at 180°C for 25 min, had similar textural properties to those of the control. In addition, sucralose, ground stevia leaf, and both considerably affected the moisture content, color attributes, and textural properties of the samples. Among all the brownie formulations, the brownies prepared using sucralose and inulin, with a baking time of 25 min at a baking temperature of 180°C gave the highest overall acceptability score (6.10). Thus, it can be concluded that inulin combined with sucralose is the most appropriate combination for making sugar-free brownies.

5. Acknowledgements

The authors would like to warmly thank National Research Council of Thailand and Mae Fah Luang University, Chiang Rai, Thailand for financial supports.

6. Conflicts of Interests

The authors declare no conflict of interest.

7. References

[1] Sia BT, Low SY, Foong WC, Pramasivah M, Khor CZ, Say YH. Demographic differences of preference, intake frequency and craving hedonic ratings of sweet foods among Malaysian subjects in Kuala Lumpur. Mal J Med Health Sci. 2013;9:55-64.

[2] Richardson AM, Tyuftin AA, Kilcawley KN, Gallagher E, O'Sullivan MG, Kerry JP. The impact of sugar particle size manipulation on the physical and sensory properties of chocolate brownies. LWT-Food Sci Technol. 2018;95:51-57.

[3] Aidoo RP, Afoakwa EO, Dewettinck K. Optimization of inulin and polydextrose mixtures as sucrose replacers during sugar-free chocolate manufacture-Rheological, microstructure and physical quality characteristics. J Food Eng. 2014;126:35-42.

[4] Wang R, Wan J, Liu C, Xia X, Ding Y. Pasting, thermal, and rheological properties of rice starch partially replaced by inulin with different degrees of polymerization. Food Hydrocoll. 2019;92:228-232.

[5] Alam MS, Pathania S, Sharma A. Optimization of the extrusion process for development of high fibre soybean-rice ready-to-eat snacks using carrot pomace and cauliflower trimmings. LWT-Food Sci Technol. 2016;74:135-144.

[6] Videla S, Vilaseca J, Antolín M, García-Lafuente A, Guarner F, Crespo E, et al. Dietary inulin improves distal colitis induced by dextran sodium sulfate in the rat. Am J Gastroenterol. 2001;96:1486.

[7] Morreale F, Benavent-Gil Y, Rosell CM. Inulin enrichment of gluten free breads: Interaction between inulin and yeast. Food Chem. 2019;278:545-551.

[8] Karimi R, Azizi MH, Ghasemlou M, Vaziri M. Application of inulin in cheese as prebiotic, fat replacer and texturizer: a review. Carbohyd Polym. 2015;119:85-100.

[9] Schiffman SS, Rother KI. Sucralose, a synthetic organochlorine sweetener: overview of biological issues. J Toxicol Environ Health B Crit Rev. 2013;16(7):399-451.

[10] Sharma A, Amarnath S, Thulasimani M, Ramaswamy S. Artificial sweeteners as a sugar substitute: are they really safe? Indian J Pharmacol. 2016;48:237-240.

[11] Rizwan F, Rashid HU, Yesmine S, Monjur F, Chatterjee TK. Preliminary analysis of the effect of Stevia (*Stevia rebaudiana*) in patients with chronic kidney disease (stage I to stage III). Contemp Clin Trials Commun. 2018;12:17-25.

[12] Arriola ND, Chater PI, Wilcox M, Lucini L, Rocchetti G, Dalmina M, et al. Encapsulation of *stevia rebaudiana* Bertoni aqueous crude extracts by ionic gelation-effects of alginate blends and gelling solutions on the polyphenolic profile. Food chem. 2019;275:123-134

[13] Salazar VAG, Encalada SV, Cruz AC, Campos MRS. *Stevia rebaudiana*: a sweetener and potential bioactive ingredient in the development of functional cookies. J Funct Foods. 2018;44:183-190.

[14] Cardoso JMP, Bolini HMA. Different sweeteners in peach nectar: ideal and equivalent sweetness. Food Res Int. 2007;40:1249-1253.

[15] AOAC International. Official methods of analysis. 17th ed. AOAC Int.: Gaithersburg, MD; 2000.

[16] Furlán LTR, Campderrós ME. The combined effects of Stevia and sucralose as sugar substitute and inulin as fat mimetic on the physicochemical properties of sugar-free reduced-fat dairy dessert. Int J Gastron Food Sci. 2017;10:16-23.

[17] Fradinho P, Nunes MC, Raymundo A. Developing consumer acceptable biscuits enriched with *Psyllium fiber*. J Food Sci Technol. 2015;52:4830-4840.

[18] Liang S, Were LM. Chlorogenic acid oxidation-induced greening of sunflower butter cookies as a function of different sweeteners and storage conditions. Food Chem. 2018;241:135-142

[19] Akesowan A. Quality of reduced-fat chiffon cakes prepared with erythritol-sucralose as replacement for sugar. Pak J Nutr. 2009;8:1383-1386.

[20] Khattab SN, Massoud MI, El-Razek AMA, El-Faham A. Physico-chemical and sensory characteristics of steviolbioside synthesized from stevioside and its application in fruit drinks and food. J Food Sci Technol. 2017;54:185-195.