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Research Article
Influence of Spent Coffee Ground as Fiber Source on Chemical, Rheological and Sensory Properties of Sponge Cake

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Abstract

Background and Objective: Since spent coffee grounds (SCGs) represented the main by-product from instant coffee industry, the aim of the present study was to evaluate the use of these residues as functional food ingredient in sponge cake. **Materials and Methods:** Baked control sample (100% wheat flour) and three supplemented blends (98% wheat flour+2% SCGs, 96% wheat flour+4% SCGs and 94% wheat flour+6% SCGs) were subjected to chemical, rheological, texture, freshness, volatile, sensory and color analysis. **Results:** The SCGs are a promising source for dietary fiber (51.86%), protein (8.97%) and fat (13.89%) with a well-known negligible glycaemic sugar content. Supplemented sponge cake recipes with SCGs (2, 4 and 6%) reduced the degree of browning due to the lower glycaemic sugar content as well as the protein content in comparison to the control sample. A significant difference in the organoleptic properties were showed in all cake samples containing SCGs ($p \geq 0.05$), which again may belong to the lower content of reduced sugars in SCGs. Volatiles extracted and identified using Solid Phase Micro-Extraction (SPME)/GC-MS have a lower content of furans, furanones and pyrazines in supplemented recipes due to the effect of lower glycemic sugar content. The higher dietary fiber content of SCGs increased volume, weight and the rheological properties of the sponge cake in addition to softened the texture. **Conclusion:** Innovative sponge cake proved to have excellent nutritional and functional properties to be used for patients with obesity related diseases.

Key words: Spent coffee grounds, sponge cake, chemical composition, rheological characteristics, sensory properties

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

One of the most popular and consumed beverages all over the world is coffee. According to ICO (International Coffee Organization), about 8.5 billion kg of coffee was produced[1] in 2014. Instant coffee constitutes a main product derived from coffee that widely used for decades. The production process of instant coffee depends upon roasting the beans followed by extracting the soluble fraction with hot water at high pressure, whereas 0.33-0.45 kg of instant coffee is produced from each 1 kg of Robusta green coffee beans[2]. Meanwhile, a huge amounts of by-product (45-50%) are generated and known as spent coffee grounds (SCGs); i.e., the production of every 1 kg of instant coffee generated 2 kg of wet SCGs with a total annual generation of 6 million t globally[3,4]. So, it was a necessity and priority to find a proper way to dispose this by-product, whereas several researchers have evaluated a potential use of SCGs, mainly as animal feed, compositing material, biofuels and recently as a source of antioxidant dietary fiber[5-7].

The SCGs contain ashes (0.5%), fat (24.3%) in addition to bioactive compounds e.g., caffeine (0.2%) and chlorogenic acid (0.01%)[8]. From the nutritional point of view, protein content is concerned, whereas SCGs showed a significant concentration ranged from 11.2-16.9% as non-extracted components in coffee beans[9]. Similar to coffee beans, carbohydrates presented the main constituents in SCGs, whereas total dietary fiber presented the major component of this class (47.3 g/100 g SCGs) followed by polysaccharides (13.1%), while free monosaccharides e.g., glucose found in a low concentration (0.04 g/100 g SCGs) which means the lower presence of glycaemic sugars[8]. Hemicellulose, cellulose, galactomannan and lignin are the main constituents of dietary fibers of SCGs formed through the polymerization of mannose, galactose, glucose and arabinose[10].

Lower glycaemic index as well as lower caloric content of the food became a main concerns for the consumers nowadays in addition to the dietary fiber content and their role in the balanced nutrition. Weight loss and the favorable effects toward obesity-related diseases e.g., diabetes, represent the main healthy benefits of the lower glycaemic foods[11]. Therefore, the aims of the present study were to evaluate the possibility of using SCGs as innovative functional food ingredient in bakery products based on its higher nutritional value with the ability to reduce the risk of obesity and diabetes, in addition to afford a higher sensory properties and quality to the final product.

MATERIALS AND METHODS

Materials: Wheat flour (72% extraction) was obtained from the north Cairo Flour Mills Company, Egypt. Spent coffee grounds (SCGs) were kindly supplied by Misr Cafe, 10th. of Ramadan industrial city, Egypt, then stored at -20°C up to use. Skimmed milk powder, eggs, shortening, ground sugar, baking powder and vanilla were purchased from a local market, Dokki, Giza, Egypt.

Preparation of flour supplemented with SCGs: In comparison with a control sample (100% wheat flour), three flour blends were prepared as follows: 98% wheat flour+2% SCGs, 96% wheat flour+4% SCGs and 94% wheat flour+6% SCGs. These samples were kept in air tight containers and stored in refrigerator at 4°C until required.

Rheological properties: The farinogram properties of dough supplemented blends were evaluated according to AACC[12].

Preparation and evaluation of sponge cakes: Sponge cakes were produced according to the method described by Bennion and Bamford[13] with slight modifications. Baking powder (3 g) and flour (100 g) were mixed together (mix A); while sugar (75 g), whole fresh eggs (125 g), shortening (15 g), skimmed milk (50 g) and vanilla (2 g) were blended for 6 min at a high speed (mix B). Mix A was added gradually to mix B and beaten for 3 min at low speed. Dough samples (100 g) were baked at 180ºC for 35 min. Sponge cake samples were cooled for 30 min at room temperature, then stored in polyethylene plastic bags till further analysis.

Analytical methods: All analysis were performed in triplicates. Moisture, ash, protein, fat and fiber contents of wheat flour, SCGs and sponge cake samples were determined according to AACC[12]. Total carbohydrate contents have been calculated by difference.

Baking physical quality of sponge cakes: Volumes (cm^3) and weights (g) of the prepared sponge cake samples were recorded in triplicates followed by calculated the specific volume (g cm^{-3}) according to the method described in AACC[12].

Texture analysis: Texture profile analysis (TPA) was carried out using a testing system (Brookfield, CT3-10 kg, USA) equipped with a cylinder probe (TA.AACC36) at room temperature. Cake samples (115 mm length, 75 mm width and 50.5 mm depth) were compressed twice to 20% of its original height in order to have a two bite texture profile curve at a speed of 2.5 mm sec^{-1} and trigger load of 9.00 N g. The TPA parameters of the control and supplemented samples with SCGs were evaluated in triplicate using double compression tests.

Sensory evaluation of cakes: Control and supplemented cake samples were assessed by 15 panelists for the acceptability of sensory parameters; color, taste, odor, texture, appearance and overall acceptability as described by Bodyfelt *et al.*[14].

Color determination: Color parameters (L*, a* and b*) of wheat flour, SCGs and cake samples (crust and crumb) were determined using a tristimulus colorimeter with the CIE-LAB color space (Hunter, Lab Scan XE-Reston VA, USA) in the reflection mode[15].

Freshness of cakes: Cake samples were kept in polyethylene bags at room temperature and tested for freshness during storage for 0, 1 and 3 days using Alkaline Water Retention Capacity test (AWRC) according to the method of Yamazaki[16] and Kitterman and Rubenthaler[17].

Headspace solid-phase microextraction (HS-SPME): About 10 g of cakes samples were trapped into a 20 mL SPME vial, sealed with silicone septum. The SPME device coated with a 100 µm layer of polydimethylsiloxane (Supelco, Bellefonte, PA, USA) was used for extraction of the volatiles. The extraction was performed at 60°C for 30 min and the trapped volatiles were immediately introduced into the gas chromatography injector. The above method was reported and optimized by Farouk *et al.*[18].

Gas chromatography-mass spectrometry analysis (GC-MS): A Trace GC Ultra Chromatography (Thermo Scientific, USA) equipped with 60 m×0.25 mm×0.25 µm thickness TG-5MS capillary column (Thermo Scientific, USA) and coupled to a ISQ-Mass (Thermo Scientific, USA) was used in order to separate cakes aroma components. Analysis was carried out using helium as the carrier gas with a flow rate 1.0 mL min^{-1}. The column temperature was maintained initially at 50°C for 3 min, then increased at rate 4°C/min to 140°C with hold time 5 min and finally then to 260°C at rate of 6°C /min with 5 min isothermal hold. The injector port temperature 180°C, ion source temperature was 200°C and the transition line temperature was 250°C. The ionization voltage applied was 70 eV, while the mass range was from 40-450 m/z. The isolated peaks were identified by comparison with the MS computer library (NIST library version 2005), authentic compounds and published data. The quantitative determination was carried out based on GC peak areas. Retention index values were calculated using the retention times of a homologous series of C_6-C_{26} n-alkanes[19].

Statistical analysis: The obtained results were evaluated statistically using one-way analysis of variance as reported by McClave and Benson[20]. Significant differences between the values were defined at $p \leq 0.05$.

RESULTS

Chemical composition of SCGs: The chemical characteristics of SCGs are summarized in Table 1. Moisture content was 7.47% based on dry weight basis, whereas the initial moisture content of the received SCGs applied in this study was 58.98±0.32%. The content of ashes was 2.77±0.01%, while lipids presented in a significant amount in SCGs (13.89±0.05%) as shown in Table 1. Otherwise, protein was detected in a concerned concentration in SCGs (8.97±0.11%). Again, carbohydrates represented the main constituent in SCGs as in coffee beans (66.9±0.54%) quantified as crude fibers (51.86±0.32%) and polysaccharides (Table 1).

Nutritional and chemical composition of innovative cakes: With respect to nutritional value in terms of protein content, the innovative cakes with SCGs (2, 4 and 6%) did not show any significance difference ($p \geq 0.05$) in comparison to control one (Table 1). The same effect observed concerning the fat content of both control and innovative cakes, whereas nearly the same values obtained for all samples (Table 1). A significant increase was observed in the dietary fiber content of innovative cakes due to addition of SCGs, in comparison to the control sample.

Color attributes and evaluation of browning degree of innovative cakes: The effects of SCGs addition on the browning degree during baking are evident from Table 2. With respect to different CIE-LAB characteristics presented in Table 2, the degree of browning was more intensive for the control sample at both crust and crumb, in comparison to the innovative cakes.

Fig. 1(a-d): Photos of cakes produced from wheat flour and its supplement with SCGs, (a) Control100% wheat flour, (b) Wheat flour+2% SCGS, (c) Wheat flour+4% SCGS and (d) Wheat flour+6% SCGS

Table 1: Chemical composition of raw materials and cakes of mixed wheat flour with SCGs (on dry weight basis)

	Raw materials		Cakes			
Constituents (%)	Wheat flour	SCGs	Control	+2% SCGs	+4% SCGs	+6% SCGs
Moisture	11.90±0.10	7.47±0.32	25.76±0.19	26.30±0.22	27.02±0.29	27.88±0.32
Protein	12.05±0.25	8.97±0.11	8.23±0.15	157.32±0.13	6.05±0.17	6.78±0.10
Fat	1.12±0.03	13.89±0.05	16.10±0.09	16.10±0.07	16.17±0.10	16.37±0.12
Ash	0.70±0.06	2.77±0.01	1.06±0.03	1.10±0.05	1.13±0.03	1.16±0.04
Carbohydrate	85.68±0.65	66.90±0.54	73.71±0.65	74.26±0.71	0.75±0.62	273.98±0.79
Crude fiber	0.45±0.04	51.86±0.32	0.90±0.01	1.22±0.02	1.65±0.05	1.71±0.07

Table 2: Effect of mixing wheat flour with SCGs on hunter color parameters of cake

			Cake crust			
Color parameters	Wheat flour	SCGs	Control	+2% SCGs	+4% SCGs	+6% SCGs
L*	92.33±1.16	20.73±0.32	69.68±2.03	66.06±1.77	56.93±1.56	58.98±1.72
a*	0.45±0.01	2.01±0.19	14.90±0.88	11.12±0.75	10.56±0.33	9.21±0.38
b*	9.53±0.22	2.59±0.09	31.80±1.95	35.44±1.36	30.62±1.71	30.86±1.92
Cake crumb						
L*	92.33±1.16	20.73±0.32	61.35±1.90	59.42±2.52	50.18±1.97	54.26±1.74
a*	0.45±0.01	2.01±0.19	10.98±0.71	7.62±0.93	7.36±0.65	6.18±0.82
b*	9.53±0.22	2.59±0.09	28.35±1.35	30.11±1.62	26.56±1.97	26.74±0.90

Sensory properties of cake: The sensory properties of cakes produced from wheat flour and its supplemented mixtures with SCGs at different levels (2, 4 and 6%) which were evaluated for color, taste, odor, texture, appearance and overall acceptability as shown in Table 3 and illustrated in Fig. 1. Significant differences in the organoleptic properties were observed in all cake samples containing SCGs when compared with control cake sample. Samples prepared with 2 and 4% of SCGs showed significantly higher sensory scores than sample supplemented with 6% SCGs.

Volatile sensory active compounds: Data in Table 4 showed the list of identified volatiles compounds for control sample and sample supplemented with 2% SCGs, the best from

Table 3: Effect of supplemented cake with SCGs on its sensory properties

Samples	Color (20)	Taste (20)	Odor (20)	Texture (20)	Appearance (20)	Overall acceptability (100)
Control	18.95±0.51[a]	19.11±1.10[a]	18.10±0.61[a]	19.15±0.32[a]	18.80±0.17[a]	92.01±3.20[a]
With 2% SCGs	17.21±0.53[b]	18.45±0.91[a]	17.50±0.56[b]	19.00±0.35[a]	18.32±0.19[a]	89.05±3.62[a]
With 4% SCGs	15.41±0.51[c]	18.15±0.81[a]	17.32±0.54[b]	19.44±0.54[a]	17.50±0.22[a]	86.00±3.56[b]
With 6% SCGs	15.11±0.56[c]	16.50±0.95[b]	17.24±0.35[b]	18.78±0.62[a]	16.32±0.35[b]	81.06±3.50[c]
LSD at 5%	1.218	1.341	1.210	1.345	1.403	4.781

Significant at 0.05 probability level. There is no significant difference between the same letters of the mean value±standard deviation

Table 4: Volatile constituents of sponge cake and its supplemented mix with 2% SCGs

		Area (%)	
Compounds	RI	Control	2% SSCGs
2-Methyl butanal	641	0.26	0.312
3-Methyl butanal	650	0.54	0.62
Acetic acid	660	4.42	6.70
2-Propanone-1-hydroxy-	662	0.57	0.84
2,3-Butanediol	769	0.05	0.74
Hexanal	779	1.91	2.81
2-Methyl Pyrazine	828	8.24	5.70
2-Furfural	852	4.83	2.22
2-Furfuryl alcohol	863	3.81	2.48
Pyrazine, 2,5-dimethyl-	905	11.88	8.14
Pyrazine, 2,6-dimethyl-	913	0.40	0.11
2-Furfural, 5-methyl-	966	2.02	1.77
Hexanoic acid	970	0.31	1.67
2-Pentyl furan	993	1.25	1.89
Trimethyl pyrazine	1005	0.74	0.31
2-Acetyl pyrrole	1045	0.29	0.11
2,5-dimethyl-4-hydroxy-3(2H)-furanone	1077	5.74	5.55
1-(6-methyl-2-pyrazinyl)-1-ethanone	1088	1.62	2.48
Nonanal	1107	0.33	0.74
2,3-Dihydro-3 ,5-dihydroxy-6-methyl-4(4H)-pyranone	1161	25.98	27.04
Decanal	1204	0.12	3.70
5-hydroxy-2-methylfurfural	1251	23.74	18.89
Total		99.05	94.82

Table 5: Effect of mixing SCGs powder with wheat flour on rheological properties of farinograph

		Wheat flour mixed with		
Farinograph parameters	Wheat flour	2% SCGs	4% SCGs	6% SCGs
Water absorption (%)	57.5	58.8	59.5	61.5
Arrival time (min)	1.5	2.0	2.5	3.0
Dough development time (min)	2.0	2.5	3.0	3.0
Dough stability (min)	8.0	6.0	5.0	4.5
Mixing tolerance index (BU)	25.0	30.0	40.0	45.0
Dough weakening (BU)	20.0	30.0	40.0	40.0

sensory evaluation point of view. In both samples, furans and pyrazines are the most abundant classes quantitatively and qualitatively, among the detected volatiles. Strecker's aldehydes; 3-Methylbutanal and 2-methylbutanal were found in comparable concentrations with other aliphatic aldehydes e.g., nonanal and decanal, while hexanal was detected in higher concentrations in both samples (Table 4). 2,3-Dihydro-3,6-dihydroxy-8-methyl-4H-pyran-4-one was found as the most abundant individual compound in the both samples.

Rheological properties of dough: Data in Table 5 showed the effect of adding SCGs at three levels (2, 4 and 6%) to wheat flour on the rheological properties of dough as evaluated by a Farinograph. Supplemented with SCGs increased the values of water absorption as well as dough development time and arrival time, in comparison to wheat flour. Measure of the time need for the curve to stay at or above 500 BUS is known as dough stability which decreased by the addition of SCGs. Higher scores of stability value which used as an indication of flour strength, suggested stronger dough. Meanwhile, the resistivity of wheat flour to the mixing is referred to the mixing tolerance index parameter. Dough stability decreased from 6-4.5 min as SCGs level in-creased, while weakening increased from 20-40 BU as well as mixing tolerance index, 25-45 BU (Table 5).

Baking quality of cakes: Data in Table 6 presents the physical characterization of the control and supplemented cakes. SCGs supplementation resulted in production of sponge cakes with significantly higher volume, weight and specific volume in comparison to the control sample. Additionally, as the SCGs level increased in cake, weight, volume and specific volume were significantly increased compared to those of the control sample.

Freshness of cake: Freshness of cake samples during storage at room temperature was investigated and reported in Table 7. Supplemented cake sample with 6% SCGs had the highest values of AWRC; however, a stable decrease could be noted during 0, 24, 48 and 72 h of storage to 398, 382, 368 and 315%, respectively. Such decline in AWRC values was noticeable also for the control sample as well as the other supplemented ones at the same storage period.

Texture profile analysis (TPA): Data in Table 8 showed the TPA parameters values of the cake samples. Hardness (maximum force of the first compression) of control cake sample (20.93 N) was higher than cake of mixed wheat flour with 2, 4 or 6 % SCGs (ranged between 14.06-17.16 N). While adhesiveness of cake (control) was lower than cakes of mixed wheat flower with SCGs at different mixing level. Also, slight differences were observed between resilience and cohesiveness of control cake sample and supplemented ones, where they ranged between 0.03-0.09 and 0.15-0.32, respectively. Springiness of testing cakes slightly decreased in mixed wheat flour with SCGs at different mixing level (2.48-3.65 mm) compared to cake of control sample (8.52 mm). Also, mixing wheat flour with SCGs in cake at different mixing level exhibit a similar trend like springiness, where gumminess ranged between 1.95-4.95 N while cake of control sample reached to 8.14 N. Chewiness was maximized in cake of control sample

Table 6: Effect of supplemented cake with SCGs on its baking quality

Samples	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)
Control	237 ± 4.15^b	653 ± 8.95^d	2.76 ± 0.11^b
With 2% SCGs	239 ± 5.22^b	677 ± 11.50^c	2.83 ± 0.13^a
With4% SCGs	245 ± 6.01^a	701 ± 15.00^b	2.86 ± 0.18^a
With 6% SCGs	251 ± 5.45^a	725 ± 13.15^a	2.89 ± 0.15^a
LSD at 0.05	7.654	18.540	0.323

Significant at 0.05 probability level. There is no significant difference between the same letters of the mean value±standard deviation

Table 7: Effect of supplemented cake with SCGs on its freshness during storage

		Cake mixed with		
Storage time (h)	Cake control	2% SCGs	4 % SCGs	6% SCGs
AWRC at zero time	380.00	382.00	391.00	398.00
AWRC after 24 h	354.00	362.00	373.00	382.00
R.D (%) after 24 h	6.84	5.24	4.60	4.02
AWRC after 48 h	336.00	347.00	359.00	368.00
R.D (%) after 48 h	11.58	9.16	8.18	7.54
AWRC after 72 h	314.00	310.00	339.00	315.00
R.D (%) after 72 h	306.00	312.00	321.00	329.00

AWRC: Alkaline water retention capacity, R.D (%): Rate of decrease (%)

Table 8: Effect of supplemented cake with SCGs on its texture profile properties

		Cake mixed with		
Texture profile parameters	Cake control	2% SCGs	4% SCGs	6% SCGs
Hardness (n)	20.93	15.62	14.06	17.16
Adhesiveness (mJ)	4.20	7.20	9.80	11.00
Resilience	0.09	0.04	0.03	0.04
Cohesiveness	0.32	0.16	0.15	0.23
Springiness (mm)	8.52	2.71	2.48	3.65
Gumminess (n)	8.14	3.04	1.95	4.95
Chewiness (mJ)	69.40	8.20	4.80	16.30

Control (100% wheat flour), wheat flour+2% SCGs and wheat flour+4% SCGs, wheat flour+6% SCGs

(69.40 mJ), while it was minimized in cakes of mixed wheat flour with SCGs at different mixing level (ranged between 4.80-6.30 mJ).

DISCUSSION

The chemical composition of SCGs makes them a promising and potential ingredient to be used in foods and nutraceuticals. Drying of SCGs was performed with respect to the fact that, contamination with spoilage micro-organisms represented the main issue arise when agri-food wastes/by products are not sufficiently dehydrated, lead to fermentation with accompanied with acidification[21]. Therefore, storing under -20°C until processing or drying to moisture content lower than 10% is recommended from the technological and quality points of view[22]. The initial moisture content recorded for SCGs (53.0-69.8%) is in agreement with Cruz *et al.*[9] and compared favorably with values for spent espresso grounds (65.3±0.4%) previously reported by Scully *et al.*[23].

Ash content of SCGs is in concordance with a previous study conducted by Mussatto *et al.*[24] who found a lower ash content in SCGs suggested that brewing conditions during industrial coffee extraction result in enormous loss of minerals and ash. Due to the hydrophilic nature of inorganic compounds and minerals found in roasted coffee, the ash content is reduced during conventional brewing[9,22] from 4.6 to 0.8-3.5%.

Coffee beans contained a moderate lipids amount (11-20% on dry weight basis). However, they are hardly extracted by hot water resulting in the presence of lipids in a significant amount in SCGs. Linoleic acid, palmitic acid, oleic acid and stearic acid constitute the main coffee bean lipids which contributed to the sensory profile of coffee[25].

The protein content in SCGs with respect to the extraction conditions seems to be a concerned component but low in comparison to the values reported by Mussatto *et al.*[24] and Ravindranath *et al.*[26] for this coffee residue (about 14%w/w on dry basis).

Content of crude or dietary fiber is in line with the findings of Vardon *et al.*[27]. According to Martinez-Saez *et al.*[8], insoluble fiber constitute the main component of SCGs dietary fiber (88%) which is predictable with respect to brewing processing and extract the majority of soluble fiber during the production of instant coffee. Dietary fiber including gums, lignin, hemicellulose, cellulose, pectins and mucilages is known as the edible part of plants that is resistant to absorption and digestion in the human small intestine, with partial or complete fermentation in the large intestine[28].

With respect to the chemical composition presented in Table 1, SCGs showed a thermal resistance after submit to baking at 180°C for 35 min, which is higher than those reported by Martinez-Saez *et al.*[8], whom baked biscuits containing SCGs at 185°C for 16 min with a thermal stability. Generally, SCGs seem to be a natural source of protein, elements, rich in dietary fiber which have an antioxidant activity with low glycaemic index and thermally stable during food processing[29]. Therefore, SCGs could be presented as a functional safe ingredient in the food industry.

Color attributes are affected mainly by the degree of browning during baking. In the beginning of nonenzymic browning which generated due to proteins/amino acids and sugars interaction, an increase in a* and b* could be observed, cause of the increase in redness and yellowness, respectively. However, as a result of secondary reactions, products with more intensive green and blue color notes are formed only later. Presence of higher glycaemic sugar content in the control sample as well as the protein content, enabled the higher generation of Amadori compounds, i.e., faster evolution for the early stage of Maillard reaction, which lead to more browning[15]. Non-enzymatic browning or Maillard reaction was reported to have many negative consequences e.g., loss of nutritive values, loss of food quality and health risks[30]. Lately, some advanced glycation end products (AGEs) which generated at the late stages of Maillard reaction have been reported to be toxic and were suggested to be responsible for different types of diseases, especially kidney disorder and diabetes, through the combination with receptor of AGE (RAGE)[31].

According to organoleptic evaluation, control as well as the best sensorial sample (supplemented with 2% SCGs) were submitted to SPME/GC-MS analysis. In both samples, furans and pyrazines are the most abundant quantitatively and qualitatively, among the detected volatiles which is in agreement with Takei[32] and Rega *et al.*[33]. The content of pyrazines and furans in the volatile fraction of the control sample was higher as they are produced from higher glycaemic sugar content. The resulting fraction of pyrazines was lower in the supplemented sample due to decrease in protein and free amino acids content following the addition of SCGs.

2-Methylbutanal and 3-methylbutanal are Strecker's aldehydes contributed to malty / chocolate notes originating from leucine and isoleucine formed during thermal processing from ingredient precursors[34]. Lipid degradation pathways are responsible for the generation of some volatile compounds e.g., aliphatic aldehydes such as hexanal, nonanal and decanal in addition to 2-pentylfuran which is well-known as a degradation product for linoleic acid and is responsible for fatty and fruity notes[35]. 2,3-Dihydro- 3,6-dihydroxy-8-methyl-4H-pyran-4-one which was the major volatile constituent, is described as a Maillard reaction product generated through 2,3-enolization pathway and a precursor of maltol, whereas 1,2-enolisation pathway lead to hydroxymethyl furfural[36].

Obviously, the odor and taste acceptability were affected by the presence of more glycaemic reduced sugars, obviously because of characters e.g., roasted, sweet and caramel, which are perceived as the main and very positive sensory attributes[15,37]. Surprisingly, the texture of supplemented samples seems to be nearly as the control or better than it, which could be due to the excellent emulsifying activity and emulsion stability of SCGs reported previously by Ballesteros *et al.*[10]. The SCGs seem to be a promising functional ingredient with a great potential to be used as emulsifiers in different food products especially those require a prolonged emulsion stability including dairy, beverages, baking, sweets and feeds.

Fibers which are the main constituent of SCGs have a great effect on the rheological properties of the resulted sponge cake. It was found that, increase in fiber content leads to higher water holding capacity and increase in dough development time. These results are in agreement with previous studies which showed a quick development of gluten and hydration of endosperm as a consequence[38-40]. Most commercial bread flours have a stability value of up to 10 min[41]. Decreasing of dough stability and increasing of weakening as well as mixing tolerance index upon addition of SCGs, may owing to either the reduction of gluten against the increase in fiber content from SCGs or the interaction between fibrous materials and gluten, which influence the dough mixing properties as reported by Peymanpour *et al.*[42]. The significant changes in physical properties reported in Table 6, may be due to high fiber content in SCGs as well as the emulsifying properties reported by Ballesteros *et al.*[10]. Upon storage, differences in alkaline water retention capacity of examined fresh cakes might be related to the difference in quantitative distribution of protein fractions and physicochemical properties of SCGs. From the obtained data of texture profile analysis, it could be concluded that mixing wheat flour with SCGs was able to decrease hardness, resilience, cohesiveness, springiness, gumminess and chewiness of cake.

With respect to the above discussed results, applications of SCGs in food products e.g., sponge cake, as a promising source for fibers, not only enrich the nutritional value of the final product but also presented a solution for using such by-products which generated from instant coffee industry with 6 million t annually.

CONCLUSION

The SCGs could be used with wheat flour to prepare cake characterized with its good sensorial properties, higher nutritive value as a source of essential unsaturated fatty acids, fiber, minerals, polyphenolic compounds and antioxidants, in addition to their positive effect on the rheological characteristics.

SIGNIFICANCE STATEMENT

This study discovered the potential use of spent coffee grounds (SCGs) as a promising source of fibres in foods, especially sponge cake. Incorporation of SCGs in sponge cakes recipes affected significantly the nutritional and functional properties of the final product. This study will help the researchers and food technologists to uncover the critical properties and applications of SCGs in order to be used extensively in food industry and nutrition. Additionally, presented a solution to dispose about 6 million t of such residues globally and annually in a proper way.

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