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Influencing of Guava Processing Residues Incorporation on Cupcake Characterization

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Abstract

The assessment of the structure components for innovative cupcake formulas integration with guava processing residues was targeted. Wheat flour was partially substituted both guava seeds and pomaces at 5-20% to prepare cupcake mixtures. The structure's ingredients were harmonically examined. Rheological parameters of among formulas were assayed using Mixolab device. Besides, total phenolics, antioxidant activity, physical and sensory characteristics in different substituted cupcakes were performed. Then, some quality parameters during storage were evaluated. Substituted wheat flour with both guava residues at 5% and 10% did not effect on the thermo-mechanical and organolyptical properties drastically. Amazingly, both guava seeds and pomaces had higher crude fiber, total phenolics and their antioxidants than wheat flour cupcake. Guava pomace-cupcake at 20% recorded the highest phenolics and antioxidants to be 2.34 mg GAE g^{-1} dw and 5.18 µmoL TE g^{-1} dw, respectively. Conversely, a negligible difference was found among guava residues at 5% and wheat flour cupcakes in physical and quality parameters. Substitution levels of 5 and 10% produced acceptable cupcakes which did not differ significantly than wheat flour cupcakes.

Keywords: Guava processing residues; Revalorization; Cupcake; Structure constitutes

Introduction

Egyptian guava (*Psidium guajava* L.) is abundance and reasonable price make it acceptable all society sectors. It is processed into different products such as juice, nectar and jam. These products are reminted so-called guava processing residues including guava pomaces (GP) and guava seeds (GS) up to 30% of guava fruits [1]. Strikingly, they have higher total phenolic compounds (TPC) and flavonoids than twelve tropical fruits residues [2]. Thus, it is a promising source of bioactive substances [3,4], and their biological benefits *in vitro* and *in vivo* [5]. Decidedly, guava residues were used in food processing industries, such as pasta and biscuits [6,7].

Undoubtedly, cake products are the most consumed bakery products. It always used in festivals and linked in consumer's mind as delicious products [8]. It faces a wide range of challenges related to deficiency in their bioactive substances and fiber [9]. In addition to marketing challenges include oxidation, staling, ingredients coast and shelf life stability [10]. Newly, incorporation of food processing residues in cake making may solve these problems [11], Potato peel Hermus and Russet verities [12], watermelon rinds and sharlyn melon peels [13] and flaxseeds [14], for instance. However, there is no available data about utilize of guava residues in cupcake making. Therefore, this study is aiming to evaluate the applicability and screening of structure components of wheat flour (WF) 72% substitution by both guava seeds and pomaces powder in cupcake making.

Material and Methods

Chemicals and reagents

1,1-diphenyl-2 picrylhydrazyl radical (DPPH) and 6-hydroxy-2,5,7,8-tetramethylchroman carboxylic acid (Trolox) from Sigma Aldrich, Germany. Folin-Ciocalteu reagent, Fluka, France. Gallic acid, Serva, New York. Tryptic glucose yeast agar (TGYA, code No. 4021452), Rose Bengal agar (RBA, code No. 401992) and Violet red bile agar (VRBA, code No. 402185), from Biolife, Italy.

Raw and baking materials

- Both GS and GP were obtained from Cairo Co. for Agricultural processing, industrial zone, El-Obour city, Egypt.
- Soft wheat flour (72% extraction) was obtained from Cairo South Co. of Milling, Cairo, Egypt.
- Baking ingredients of skim dry milk, sugar (sucrose; commercial grade), margarine, fresh whole egg, vanilla and baking powder were obtained from local market, Toukh City, Egypt.

Guava processing residues preparation

Fresh GP and GS were immediately transferred to the analytical laboratory and dried by oven (Tit Axon S.R.L via Canova, Italy) at 40-50°C for 12 h. Subsequently, they were milled by grinder (Severin, type 3871, Germany) and passed through a 60 mesh sieve to obtain fine homogenous powder. Then they were immediately packed in dark glass jars and kept at -18 ± 1°C until usage.

Cupcakes processing

The cupcake processing method was taken according to [15] according to the following sequence steps (Table 1): Shortening was melted thoroughly, and then sugar and salt were added with vigorous mixing.

Ingredients	Weight (g)
Soft wheat flour (72% extraction)	250
Sugar	125
Salt	3.5
Skimmed milk powder	25
Shortening	53.5
Fresh whole egg	110
Baking powder	12.5
Vanilla	2

Table 1: Raw ingredients of processed cupcake.

Whole egg was mixed with vanilla and whipped until got puff and smooth like-cream texture. Additionally, substituted WF with both GP and GS at 5-20% were individually mixed with 2.15% baking powder and 4.30% skimmed milk powder then gradually added to whipped egg mixture. This mixture was mixed gently until got homogenous dough using hand mixer (MK-H4-W, Panasonic. Co, Malaysia). After getting appropriate texture the dough was poured into paper cups and backed at 180 ± 5°C for 30-35 min. The baked cupcakes were cooled down at room temperature, then packed into aluminum foil bags and stored at room temperature. Samples were taken during the storage periods at 0, 5 and 8 day for analysis. Photos for external and cross-sections were taken directly after the end of baking using an Olympus digital camera 8 MP model FS-32.

Analytical techniques

Rheological parameters: The effect of both guava residues meals substitution in different levels on WF thermo-mechanical and rheological parameters were determined using MIXOLAB apparatus (20 AV MARCELLIN BERTHELOT, CHOPIAN, France) according to [16].

Organoleptic properties: The Organoleptic properties of different substituted cupcakes were carried out in a standardized test room in morning sessions (11:00-13:00 h) by 28 well trained panelists according to [17]. Cupcake samples were left to cool at room temperature for 1 h after baking, then cut with a sharp knife and subjected to panel test. The scores were distributed as follows: 40; crumb cells (10: uniformity, 10: cells size, 10: walls thickness and 10: color), 30; texture (10: moistness, 10: tenderness and 10: softness), 10; crust color, 10; flavor, 10; taste, and 100; overall acceptability.

Physicochemical characteristics

Physical characteristics: The normal weight of baked cupcakes was individually determined within 1 h after baking. Also, volume in different substituted cupcakes was determined by rape seeds displacement method according to [17], and specific weights were calculated for these formulas.

Chemical characteristics: Crude fat, protein and fiber in different formulas were immediately determined according to [17]. Also, TPC was calorimetrically determined using the Folin-Ciocalteau method according to [18]. Then, TF and AOA was determined using DPPH assay determined according to [19].

Monitoring of some quality parameters during different storage periods

Determination of TBA and staling properties: The amount of lipid oxidation in different cupcakes was determined by the 2-thiobarbituric acid (TBA) method according to [20]. Staling was measured by alkaline water retention capacity according to [17].

Microbiological attributes: Total aerobic bacteria count, coliform group and yeast and molds were periodically evaluated in cupcakes during different storage periods. Under sterile conditions, serial dilutions were prepared and inoculated then TGYA, RBA and VRBA were poured. All plates were incubated at 37°C for 48 h for aerobic and coliform bacteria and at 28°C for 3-5 days for yeast and molds.

Statistical analysis

Statistical analysis was carried out using SPSS program (ver. 19) with multi-function utility regarding to the experimental design at significance level of 0.05 for the whole results and multiple comparisons were carried out applying LSD according to [21].

Results and Discussion

Effect of wheat flour substitution by guava residues meal on rheological and thermo mechanical parameters

Mixolab allowed performing continuous rheological measurements of dough into a thermal-processing simulation [22]. Dough properties altered in different substitution levels for example, absorption increased with increasing of GP level. On the other hand, gluten, amylase and retrogradation decreased by more than GP 10%. The viscosity was not changed but mixing time was increased in WF-GP 5% then reduced again with increasing of GP level (Figure 1a). Adding of GS 5-20% decreased absorption, gluten, amylase, retrogradation, viscosity and mixing time owing to its lower content of starch and higher fat contents. The most pronounced effect of GS was observed at more than 15% (Figure 1b). Thereby, the low viscosity formulas had harder texture which may be useful in mechanical damage of products during transport and handling [23]. Particularly, both guava residues did not effect on gluten and retrogradation characteristics compared with WF. The effect of guava residues meal incorporation into WF on stability and water absorption was tabulated in Table 2.

The WF-GS 15 and 20% had higher stability than all formula to be 11.27 and 11.22 min, respectively followed by WF. Conversely, the WF-GP showed lower stability than all formulas especially WF-GP 15% to be 9.27 min. The higher fiber contents caused a decrease in dough stability [24]. Similarly, the WF-GS 10 and 15% showed lower water absorption than all formulas to be 51.80 and 51.20% (b14), respectively. The incorporation of WF with GP recorded higher water absorption than all formulas.

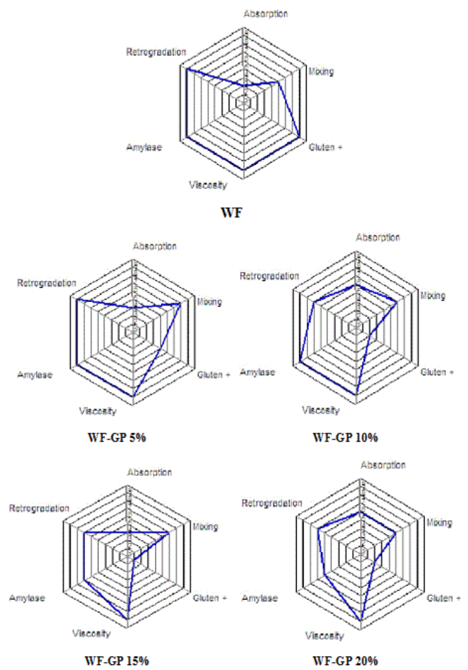

Figure 1a: A Mixolab typical target profile of wheat flour 72% (WF) and substituted WF in different substitution levels of GP at 5, 10, 15 and 20% (w:w).

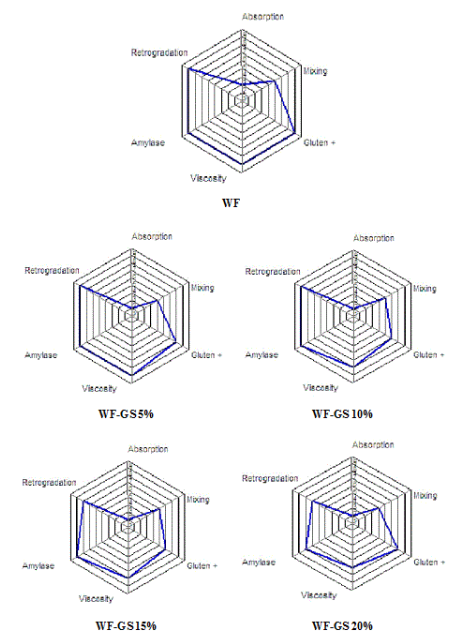

Figure 1b: A Mixolab typical target profile of wheat flour 72% (WF) and substituted WF in different substitution levels of GS at 5, 10, 15 and 20% (w:w).

Flour blends*	Substitution ratio (%)	Mixolab parameters	
		Water absorption (% b14)**	Stability (min)
WF	0	55	11.17
WF-GP	5	57	10.63
	10	58	9.95
	15	56.3	9.27
	20	58.6	9.97
WF-GS	5	54.2	10.98
	10	51.8	11.15
	15	51.2	11.27
	20	53.7	11.22

Table 2: Water absorption and stability of wheat flour only or substituted by guava residues meal (n=1). *These blends were composed of wheat flour substituted by guava residues in different concentration, **These data were basically calculated on 14 % moisture content in WF.

The thermo mechanical and rheological parameters of substituted WF mixing at arranges of 30C depended on residues type and substitution level (Figure 2a).

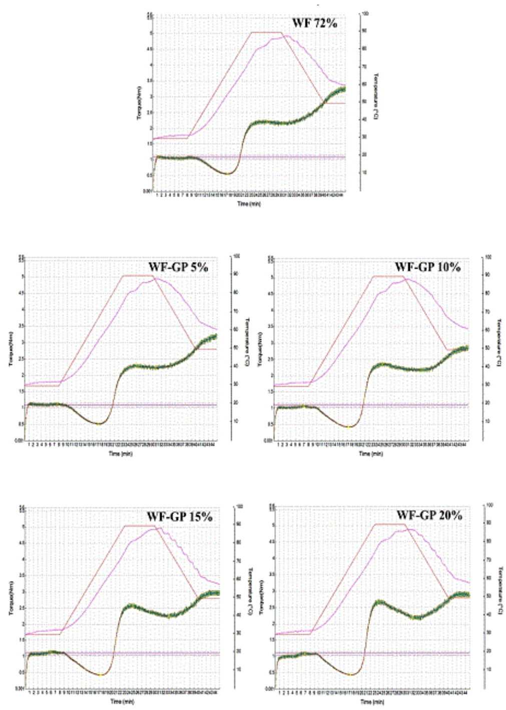

Figure 2a: Thermo-mechanical and rheological parameters of substituted wheat flour (72%) in different substitution levels of GP at 5, 10, 15 and 20% (w:w).

Generally, the substitution 5% did not effect on dough time development, expect GP. Also, incorporation of GS at high substitution level decreased C_1 (maximum torque of the initial mixing stage). As for C_2 (protein weakening), negligible difference was observed among all formulas. For example the highest time was recorded in WF-GS 15%. This reflects on protein strength and weakening for each formula included WF [24,25]. For C_3 (starch gelatinization), the WF-GS 20% and WF-GP 20% were the highest and lowest torque to be 1.88 and 2.68 Nm. As manifested by C_3, a greater degree of starch gelatinization could be closely supported by the pasting property. However, WF-GP and WF recorded higher torque in C_4 and C_5: (physical breakdown of gelatinized starch and its retrogradation), respectively which may be due to starch properties during heating and cooling. At present and there seems to be, no work was found about thermo mechanical and rheological parameters of WF incorporated with food processing residues. Finally, [22] reported that, a good cake making flour should be low in C_3, C_4 and C_5 values.

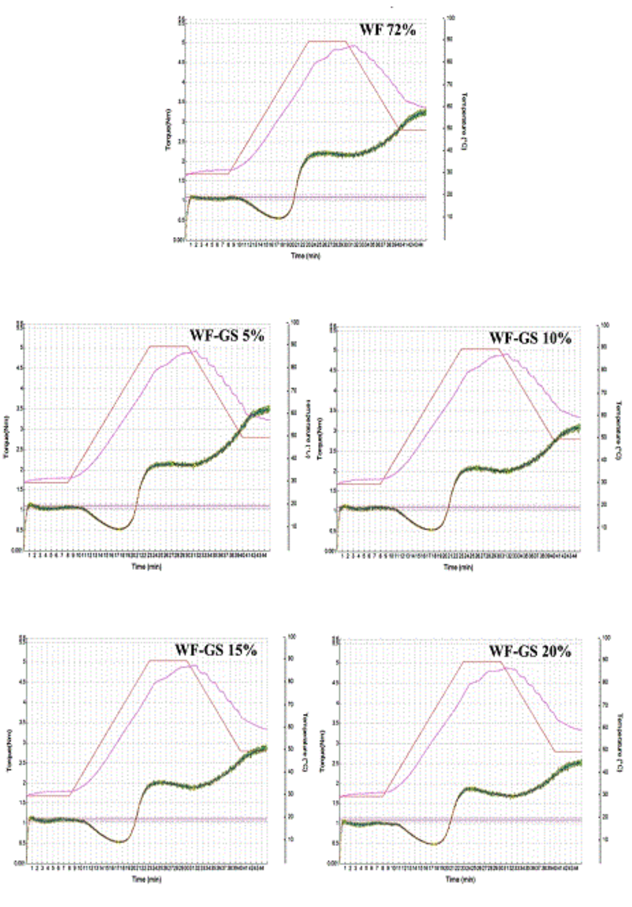

Figure 2b: Thermo-mechanical and rheological parameters of substituted wheat flour (72%) in different substitution levels of GS at 5, 10, 15 and 20% (w:w).

Organoleptic properties in different substituted cupcakes

The effect of substituted WF by GP and GS on cupcake organoleptic properties were studied, data were showed in Figure 3. Increasing of GP and GS significantly ($p<0.05$) affected on organoleptic properties. For example, the higher and the lower overall acceptability were observed for WF and WF-GS 20% cupcakes to be 95.11 and 59.39%, respectively (Figure 2b). The lowest concentration of both guava residues cupcakes was aftermost WF cupcakes. Generally, WF-GP and WF-GS 5% cupcake was followed by WF cupcake all properties except tenderness and taste. Virtually, WF-GS 20% cupcake recorded the lowest formula in color, uniformity, size and thickness properties. Conversely, WF-GS 20% cupcake was the lowest formula in texture, taste and flavor characteristics. Not only WF-GP 5% cupcake was similar to WF cupcake but also no significant differences ($p>0.05$) was observed between them in crumb size and uniformity. Thence, the addition of guava residues at 5- 15% did not influence organoleptic properties remarking cupcake external and cross sections compared to WF cupcake (Figure 4). The increasing of GP and GS (20%) led to a slight pale color, while did not influence on cupcake texture. However, these results agree with [13].

Physiochemical characterizations in different substituted cupcakes

Physical characteristics: The effect of guava residues capitalizing on cupcake physical properties was considered, data were illustrated in Table 3. Increasing of GP and GS substitution level increased weight property except of GS 10%. The WF-GP as different concentrations was higher weight than other formulas, for instance. As for volume and specific volume characteristics, significant differences ($p<0.05$) were exhibited between WF and all cupcakes. The WF cupcake demonstrated the highest volume and specific volume to be 108.00 cm^3 and 2.62 $cm^3\ g^{-1}$, respectively; it was followed by GS 5%. Accordingly, increasing either GP or GS levels could bind more water led to increasing weight. On the other hand, increasing such levels decreased the volume and specific volume thanks to influence on gluten net with low strength and gas retention. These results are in agreements with previous studies [13].

Chemical characteristics: GS meal offset protein and fat ratio in cupcake formulas compared with either WF or GP meal (Table 3). The WF-GS 15% and WF were higher protein content than all formulas (9.05 and 8.97%, respectively), for instance. The GS 20% was the highest in crude fat contents to be 13.48%. Addition of both guava residues with different concentration purposed to significantly increase in crude fibers compared to WF cupcake. For example, the WF-GP and WF-GS (20%) were higher fibers than other formulas. These results are in agreement with some previous studies [10-13].

Polyphenolic compounds and their antioxidant activity

As for TPC and relative AOA of all cupcake formulas were investigated; data were presented in Table 3. No significant differences ($p>0.05$) in TPC were observed between WF and both guava residues cupcakes at 5%-10%, conversely AOA. Increasing of substitution levels may have caused increases in TPC and AOA especially from GP, due to their contents of these components. Not only, WF-GP (20%) showed the highest TPC, but also they also recorded the highest AOA compared with other cupcakes to be (2.34 mg GAE g^{-1} dw, 5.18 μmol TE g^{-1} dw and 1.44 mg QE 100 g^{-1} dw, respectively). Nevertheless WF cupcake showed lower AOA than different formulas. The AOA may have enhanced the shelf-life stability and restrain the oil oxidation. Ideally, incorporated of guava residues did not significantly influence on TF expect GS at 20%. These results are in agreement with previous studies using other food residues [10].

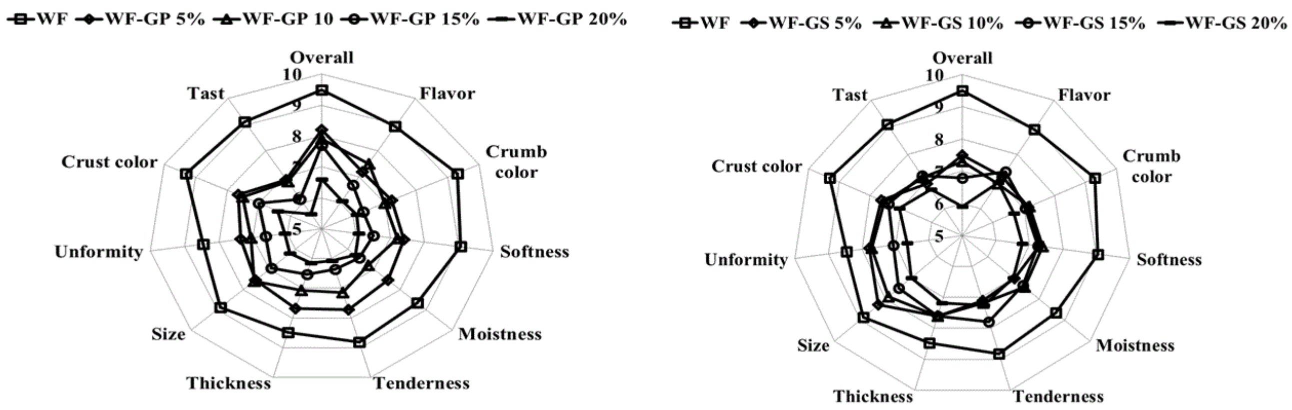

Figure 3: Organoleptic properties of WF and different substituted WF cupcakes with both GP and GS.

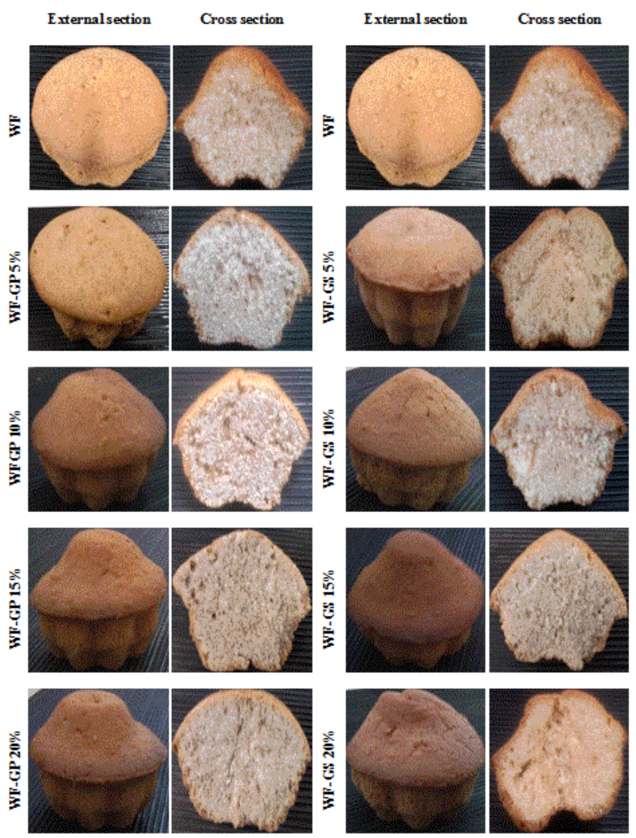

Figure 4: The effect of WF substitution by guava residue [pomace (WF-GP) and seeds (WF-GS)] at 5-20% on whole cupcake morphological features as shown in external and cross sections. Cupcake was backed at 180 ± 5°C for 30-35 min.

Monitoring of some quality attributes in cupcake formulas

Microbiological attributes: The TBC and Y&M significantly ($p<0.05$) increased during storage period as shown (Table 4). Remarkably, combined cupcake with both GP and GS meals was lower TBC than WF-cupcakes especially GP due to their antimicrobial activity. For example, WF-GS 5% and WF-GP 10% was lower TBC than other formulas at zero and five days. The WF-GP 20% was the lowest TBC and Y&M formula to be 4.93 and 3.51 log cfu g^{-1}, respectively. However, CG was not detected in all cupcake formulas during storage period.

TBA determination: The oxidative rancidity level is an important indicator for stored foods quality. Therefore, TBA was determined during storage period; data were summarized in Table 5.

Obviously, TBA significantly increased during storage period in all cupcake formulas. The deterioration was significantly higher in WF than either GP or GS cupcakes as observed after 8 days to be 0.333 malonaldehyde kg^{-1}. Generally, TBA of WF-GP was the most stable during storage period; it was followed by WF-GS, owing to their content of AOA (see Table 3). The watermelon rinds and sharlyn melon peels extracts [13] and marjoram extracts [26] were affirmed to retard cake oil oxidation.

Staling determination: The staling values of different cupcake formulas gradually decreased significantly ($p<0.05$) during storage periods (Table 5). The lower reduction in staling values equal a high freshness, then it was achieved in WF and both guava residues 5-10% cupcakes. Obtained results showed that substituting by GP or GS (15-20%) recorded the highest staling values at the end of storage. Thus, WF cupcake recorded the lowest staling at the end of storage to be 212%. However, [13] used watermelon and sharlyn lemon peel to significantly retard cakes staling.

Cupcake formulas**	Substitution ratio (%)	Characterizations (Mean ± SD)							
		Weight (g)	Volume (cm^3)	Specific volume (cm^{3}g^{-1})	Crud Fat*	Crud Fiber*	Crud Protein*	TPC mg GAE g^{-1}	AOA µmol TE g^{-1}
WF	0	41.29 ± 0.47b	108.00 ± 1.00f	2.62 ± 0.01f	9.79 ± 1.84abc	0.70 ± 0.25a	8.97 ± 0.17c	1.43 ± 0.18ab	0.55 ± 0.39a
WF-GP	5	49.47 ± 1.30d	76.67 ± 2.52c	1.55 ± 0.02abc	8.15 ± 1.14a	1.34 ± 0.23abc	7.49 ± 0.57abc	1.30 ± 0.13ab	1.55 ± 0.37bcd
	10	52.82 ± 1.10e	78.00 ± 1.00c	1.48 ± 0.05ab	8.82 ± 1.15ab	1.53 ± 0.17bcd	8.40 ± 0.77abc	1.53 ± 0.08bcd	1.87 ± 0.47cde
	15	52.82 ± 2.00e	92.33 ± 7.23d	1.75 ± 0.08d	7.72 ± 0.85a	2.33 ± 0.15e	6.70 ± 0.52abc	1.88 ± 0.20cde	3.30 ± 0.60g
	20	53.49 ± 1.04e	96.33 ± 2.08e	1.80 ± 0.02d	7.64 ± 1.40a	4.75 ± 0.45f	6.00 ± 0.33a	2.34 ± 0.40f	5.18 ± 0.35h
WF-GS	5	43.84 ± 1.66abc	97.17 ± 0.76e	2.22 ± 0.08e	10.74 ± 2.03bc	1.04 ± 0.18ab	8.47 ± 2.13ab	1.25 ± 0.10ab	1.54 ± 0.36bcd
	10	38.35 ± 1.23a	54.33 ± 2.52a	1.42 ± 0.10a	11.71 ± 1.79cd	1.36 ± 0.15abc	7.49 ± 0.87abc	1.08 ± 0.11a	1.74 ± 0.21bcde
	15	44.03 ± 1.49bc	74.67 ± 2.08c	1.70 ± 0.09cd	13.47 ± 0.26d	2.07 ± 0.13de	9.05 ± 1.27c	1.97 ± 0.05def	2.21 ± 0.23def
	20	45.86 ± 0.98c	67.00 ± 2.00b	1.46 ± 0.07a	13.48 ± 0.91d	4.19 ± 0.09f	7.76 ± 1.43abc	1.93 ± 0.30de	3.44 ± 0.34g

Table 3: Physicochemical characterizations of WF and different substituted WF cupcakes with guava residues (Mean ± SD), (n=3). **Cupcakes were processed with different concentration from guava residues: see material and methods, *Data were calculated as percentages (%), Data were calculated on dry weight basis, a, b, c: Means with the same letter in the same column are not significantly different (p>0.05).

Cupcake formula	Substitution ratio (%)	Microbiological parameters/Storage period (Mean ± SD)					
		TC (log cfu g^{-1})			Y&M (log cfu g^{-1})		
		0 day	5 day	8 day	0 day	5 day	8 day
WF	0	2.08 ± 0.14Ad	2.76 ± 0.33Bb	5.23 ± 0.03Cc	nd	1.54 ± 0.26Aa	3.71 ± 0.35Bb
WF-GP	5	2.07 ± 0.18Ad	2.89 ± 0.21Bc	5.28 ± 0.08Cc	nd	2.05 ± 0.05Af	3.80 ± 0.46Bc
	10	2.03 ± 0.09Ad	2.00 ± 0.20Ba	5.14 ± 0.34Cbc	nd	1.87 ± 0.05Ade	3.93 ± 0.07Bd
	15	1.89 ± 0.28Abc	2.86 ± 0.37Bbc	5.12 ± 0.02Cb	nd	1.93 ± 0.15Ae	3.51 ± 0.33Ba
	20	1.81 ± 0.32Ab	2.96 ± 0.11Bc	4.93 ± 0.48Ca	nd	2.04 ± 0.12Af	3.42 ± 0.14Bg
WF-GS	5	1.65 ± 0.16Aa	2.97 ± 0.16Bc	5.32 ± 0.00Cc	nd	1.84 ± 0.02Ad	4.00 ± 0.08Be
	10	1.92 ± 0.18Ac	3.08 ± 0.07Bcd	5.07 ± 0.05Cb	nd	2.00 ± 0.01Ae	3.81 ± 0.11Bc
	15	1.99 ± 0.14Acd	3.01 ± 0.29Bcd	5.29 ± 0.03Cc	nd	1.67 ± 0.05Ab	3.92 ± 0.14Bd
	20	2.10 ± 0.15Ad	2.89 ± 0.08Bc	5.12 ± 0.18Cb	nd	1.70 ± 0.27Ac	4.11 ± 0.16Bf

Table 4: Microbiological attributes of WF and different substituted WF cupcakes with guava residue during storage periods (Mean ± SD), (n=3). Cupcakes were processed with different concentration from guava residues: see material and methods, A, B, C: means with the same letter in the same row are not significantly different (p>0.05), a, b, c: means with the same letter in the same column are not significantly different (p>0.05), nd: Not Detected.

Cupcake formula*	Substitution ratio (%)	Quality indicators/storage period (Mean ± SD)					
		TBA [malonaldehyde kg^{-1}]			Staling [%]		
		0 day	5 day	8 day	0 day	5 day	8 day
WF	0	0.166 ± 0.01Ac	0.260 ± 0.03Bef	0.330 ± 0.03Cd	329 ± 7.07Cab	280 ± 2.83Ba	212 ± 8.49Aa
WF-GP	5	0.125 ± 0.01Aa	0.156 ± 0.04Ba	0.218 ± 0.04Ca	327 ± 21.21Ca	311 ± 1.41Bab	295 ± 7.01Abc
	10	0.133 ± 0.01Aa	0.179 ± 0.03Bb	0.208 ± 0.05Ca	425 ± 12.73Cbc	352 ± 16.97Bbc	321 ± 12.73Acd
	15	0.148 ± 0.01Ab	0.205 ± 0.07Bcd	0.234 ± 0.08Cb	441 ± 1.41Ccd	405 ± 9.90Bc	349 ± 24.04Ad
	20	0.151 ± 0.02Ab	0.221 ± 0.02Bde	0.234 ± 0.04Cb	441 ± 26.87Ccd	424 ± 22.63Bc	371 ± 9.81Ade
WF-GS	5	0.177 ± 0.01Ad	0.195 ± 0.05Bc	0.322 ± 0.06Cd	385 ± 15.56Cbc	313 ± 4.24Bab	294 ± 16.07Abc
	10	0.179 ± 0.01Ad	0.244 ± 0.04Be	0.276 ± 0.03Cc	405 ± 9.90Bbc	330 ± 5.66Aab	312 ± 28.28Acd
	15	0.205 ± 0.02Ae	0.268 ± 0.04Bef	0.281 ± 0.03Cc	346 ± 25.46Cab	334 ± 5.66Bb	322 ± 19.80Acd
	20	0.216 ± 0.01Ae	0.250 ± 0.05Be	0.273 ± 0.04Cc	438 ± 8.49Cc	382 ± 14.14Bbc	334 ± 2.63Acd

Table 5: Monitoring of TBA and staling of WF and different substituted WF cupcakes with guava residues during storage periods (Mean ± SD), (n=3). *Cakes were processed with different concentration from guava residues: see material and methods, A, B, C,...: means with the same letter in the same row are not significantly different (p>0.05), a, b, c,...: means with the same letter in the same column are not significantly different (p>0.05).

Conclusion

A successful and innovative cupcake formulas production with both GP and GS residues was developed. Guava residues cupcakes in di erent substituted levels recorded higher ber, TPC and TF than WF cupcakes. Substituted WF with both guava residues at 5% and 10% did not in uence on thermo-mechanical properties and rheological properties drastically. e GP and GS are providing AOA to increase the shelf-life stability and reduced oil rancidity. Substitution of WF by 5% to 10% could be recommended to produce cupcake an acceptable by consumers. Adding more than 10% from guava residues could be not applicable due to their negative e ects on cupcake characteristics. However, it could be recommended that using of GP and GS should be encouraged in food industries to utilize local raw materials economically to produce high functional food products.

Conflicts of Interest

Author has declared that there is no conflict of interest.

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