Muffins Obtained with Some Vegetal Powders as Fat Replacers

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Bulletin UASVM Animal Science and Biotechnologies 75(1)/ 2018

Print ISSN 1843-5262; Electronic ISSN 1843-536X

DOI:10.15835/buasvmcn-asb: 000317

Abstract

Chia seeds and watermelon rind powder were used to produce low-fat muffins in which butter has been replaced at different levels. The utilization of the fat replacers has increased the moisture content and water activity of the samples. The initial moisture content was ranging from 24.41% in control sample to 31.89% in muffins with 100% butter replacement by using the watermelon rind paste. The water activity presented values between 0.863-0.899 during storage at ambient temperature for 10 days. Minerals analysis indicated that through the addition of the powders, an increase in the mineral content of the samples can be achieved. P was the most abundant mineral followed by K. The samples obtained by replacing the butter with vegetal powders can provide between 49.29 % - 58.51% phosphorus; 18.91 %-21.45% selenium and 15.04%-18.48% manganese from the recommended daily intake. These vegetal powders can be used as ingredients for partial or total replacement of fat in muffins due to their ability to improve the nutritional quality and to maintain the physical-chemical and sensory characteristics at level of acceptability.

Keywords: *chia seeds powder, watermelon rind powder, low fat muffins*

INTRODUCTION

Nowadays, consumers are much more informed about the food products they consume than past generations. This increase in knowledge increases proportionally the demand for more nutritious, qualitative and tasty foods. Consumers are more aware of food problems and monitor and adjust what they consume because they have become more concerned about improving their overall health through daily intake. It is also observed an increase in awareness of the adverse effects caused by high fat consumption and consequently, people have approached a diet based on low fat content (Akin, and Kirmaci, 2015).

Lately, consumers are turning their attention increasingly more on functional foods. These products, due to the bioactive functional compounds provide benefits on human health, besides the basic nutritional role (Coelho, and Salas-Mellado, 2014). Also, functional foodstuffs

may have significant roles in reducing the risk of chronic diseases (Al-Sheraji *et al.*, 2013).

Chia (*Salvia hispanica L.*) has been cultivated in Mexico since ancient times. Chia seeds were used by the Aztec tribes for food and for medicinal purposes (Saphier *et al.*, 2017). These seeds present a significant amount of lipids, from which approximately 60% are omega-3 fatty acids and 17-26% omega-6 fatty acids. Also, chia seeds contain dietary fiber and proteins with high biological value (Ixtaina *et al.*, 2011). According to Capitani *et al.* (2012) these seeds present a high antioxidant activity associated with its polyphenolic content and with the presence of tocopherols.

Watermelon belongs to the *Cucurbitaceae* family, species *Citrullus lanatus* and is recognized in the summer period as an excellent refreshing fruit due to its high water content (El-Badry *et al.*, 2014; Egbuonu, 2015). In Romania, the watermelon crop is considered important. Usually, watermelon pulp is the most consumed part of the fruit, while

the rind and the seeds are considered wastes. It is known that food wastes can have a negative environmental and public health impact. On the other hand, by-products which mainly consist of peels and seeds are considered important sources of valuable compounds (Morais *et al.*, 2015). According to Rimando and Perkins-Veazie (2005) watermelon rinds contain important amounts of citrulline, an amino acid with antioxidant capacity and roles in vasodilatation. Also, watermelon is an important source of vitamins, mineral salts and antioxidants compounds (phenolics and carotenoids) (Perkins-Veazie *et al.*, 2002 and 2007).

The aim of this study was to obtain muffins with low fat content and enriched nutritional value by replacing butter with powders obtained from chia seeds and watermelon rind.

MATERIALS AND METHODS

The muffins ingredients were wheat flour, corn starch, skimmed milk, butter (65% fat), eggs, sugar, baking soda, salt, emulsifier, chia seeds and watermelon rind powder. All the ingredients were procured from local markets. Watermelon fruit was washed to remove impurities after which it was sliced and the rind was collected. The respective rind was milled with a knife mill GRINDOMIX GM 200, Retsch and then dehydrated at 50°C in the oven, POL-EKO model, until the sample reached a constant mass. Then the dehydrated sample was again milled to obtain the powder, which was kept in airtight container, at room temperature, prior to use. Also, the chia seeds were milled to obtain the powder.

Muffins were prepared by replacing butter with chia gel and watermelon rind paste in different concentrations and compared with control muffins. Chia powder and watermelon rind powder were hydrated with milk, in a ratio of 1:10, respectively 1:4 (for 30 minutes-1 hour) to obtain the fat replacers. Muffins were baked for 25 minutes at 180°C in an electric oven preheated to this temperature. After cooling for 10 min, muffins were removed from the moulds and were left at room temperature for 1 h. The muffins were stored at 20°C±3°C for 10 days in alimentary bags.

Moisture content of samples was determined by air-oven method according to SR 91:2007.

The water activity of products was determined using Novasina Labmaster aw.

Minerals content (Ca, Cu, Fe, K, Mg, Mn, P, Zn) was determined by Inductively Coupled Plasma Optical Emissions Spectrometry and for Se was used Atomic Absorption Spectrometry, technique FIAS-Furnace. Microwave Reaction System SOLV-Multiwave Pro with Rotor HF 16-100 (Anton Paar) was used for the sample mineralization. Approximately 1 g of sample was weighed in the reaction vessels of the mineralization system and 2 mL H₂O₂ (30%), 11 mL HNO₃ (65%) and 1 mL HCl (37%) were added. Concentrations of the minerals were analysed by using ICP-OES (Optima 8300 DV, Perkin Elmer) and AAS (PinAAcle900T, Perkin Elmer) at different wavelengths using argon as carrier gas: Ca-317.93; Cu-327.39; Fe-238.20; K-766.49; Mg-285.21; Mn-257.61; P-214.91; Zn-213.85; Se-196.03 nm.

Muffins were evaluated for sensory properties by 15 untrained panelists. They evaluated each sample for appearance, appearance in section, colour, porosity, taste and sweetness on 7-point scale, where 1=dislike extremely and 7=like extremely. The panellists received the muffin samples, coded, on a tray, a bottle of 500 mL with water and the evaluation sheet. Five samples for each formulation were tested in a random order at room temperature.

The extraction method used in this study is adapted from the methods used to determine the total polyphenol content of Psyllium (leaves, seeds and bran (Patel *et al.*, 2016) and of muffins with apple skin powder (Rupasinghe *et al.*, 2009). The dried sample (500 mg) was extracted with 10 mL of methanol:water:hydrochloric acid 0.12M = 70:29:1 (v/v/v) at room temperature for 24 hours. Then, the mixture was maintained on the ultrasonic water bath for 30 minutes at 25°C. The supernatant was collected and centrifuged at 8000 rpm for 10 minutes and was brought to dryness with Hei-VAP Precision Rotary Evaporator (Heidolph) under reduced pressure, at 40°C. The residue was taken up in 10 mL of methanol, filtered, and then filled to 10 mL with the same solvent.

The total polyphenolic content of the extracts obtained was determined by an adapted method from European Pharmacopoeia (2014), using Folin-Ciocalteu reagent. To 0.4 ml extract were added 1 mL Folin-Ciocalteu reagent, 15 mL purified water and 2 mL Na₂CO₃ 290 g/L. The mixture is maintained for 10 minutes on the ultrasonic water

Table 1. Recipe for control muffins (C), muffins with chia gel (CM) and muffins with watermelon rind paste (WM)

Ingredients (g)	Samples				
	C	CM1	CM2	WM1	WM2
Flour	90	90	90	90	90
Corn Starch	10	10	10	10	10
Eggs	60	60	60	60	60
Sugar	50	50	50	50	50
Butter	45	22.5	0	22.5	0
Milk	42	42	42	42	42
Baking Soda	3	3	3	3	3
Salt	1	1	1	1	1
Emulsifier (Emulbel ED)	0.18	0.18	0.18	0.18	0.18
Chia seeds gel	0	22.5	45	0	0
Watermelon rind paste	0	0	0	22.5	45

bath and then incubated at 40°C for 20 minutes. The absorbance at 760 nm with CECIL 1021 UV-VIS spectrophotometer was measured. Gallic acid was used as standard for the calibration curve. The total phenolic content (TPC) was expressed as milligram equivalent of gallic acid per 100 grams of dried sample (mg GAE/100 g d. s.). All analyses were performed in triplicate and the mean values are reported.

RESULTS AND DISCUSSIONS

The moisture content of the muffin samples was determined over a 10-day storage period and the results are shown in Table 1. It can be observed that the utilization of fat replacers has increased the moisture content of the samples. The highest humidity values were recorded for samples in which the butter was completely replaced. The production of muffins with high moisture can be attributed to the large quantities of water derived from the incorporated vegetal pastes and gels and to the high water affinity of the replacers used.

Similar values of humidity have been reported by Jauharah *et al.*, (2014) for muffins obtained by replacing wheat flour with corn baby powder. The sample obtained with wheat flour had an initial moisture content of 25.23%, but by replacing it with baby corn powder, the moisture increased, so for muffins with 30% flour replacement, a moisture content of 30.44% was obtained.

Similar results on the increase in moisture content were also reported for cookies obtained by

replacing butter with avocado puree and Oatrim (Wekwete, and Navder, 2007) and for the cakes made by replacing vegetable fat with Yuja pectin gel, which recorded humidity values ranging from 34-35% depending on the percentage of substitute used (Lim *et al.*, 2014).

From Table 2, it can be observed that the water activity values for all formulations with fat substitutes were higher compared to the control.

The muffin samples presented values of water activity between 0.863-0.899. These values greater than 0.7 – the limit for the moulds development (Andrade *et al.*, 2016), indicate for all samples a critical stability during storage for 10 days.

In order to avoid the development of microorganisms, the quality of the raw materials and the hygienic conditions during processing and in particular after obtaining the product must be taken into account.

Wekwete and Navder (2007) also noticed that the water activity was higher for cookies prepared with avocado puree as compared to the control sample.

For all the samples can be observed an increase of the water activity with the increase of the storage period. Similar results were reported by Bhise and Kaur (2015) for muffins made with fiber from oats, barley and psyllium. They presented water activity values between 0.81-0.92 for the control sample during storage at ambient temperature for 35 days. Values of water activity ranging from 0.87-0.90 were presented

Table 2. Physical-chemical characteristics of muffins

	Period (days)	C	CM1	CM2	WM1	WM2
moisture (%)	1	24.41	27.23	32.44	26.71	31.89
	3	24.11	26.52	31.72	26.64	31.52
	5	23.74	25.56	30.96	26.36	30.76
	7	23.26	25.22	29.91	26.06	29.83
	10	22.91	24.82	29.07	25.63	29.14
aw	1	0.863	0.874	0.891	0.864	0.879
	3	0.863	0.875	0.891	0.864	0.881
	5	0.864	0.876	0.891	0.869	0.881
	7	0.870	0.876	0.896	0.870	0.882
	10	0.873	0.878	0.899	0.873	0.882

Table 3. The mineral content of the muffins samples

Minerals (mg/100 g)	Samples				
	C	CM1	CM2	WM1	WM2
Ca	65.57	88.17	113.60	81.98	100.00
Cu	0.15	0.12	0.13	0.10	0.09
Fe	1.19	1.22	1.36	1.16	1.20
K	151.20	165.20	196.60	196.70	262.30
Mg	17.88	23.91	29.48	23.32	26.61
Mn	0.29	0.33	0.37	0.30	0.31
Zn	0.78	0.90	0.97	0.88	0.89
P	340.30	377.90	409.60	345.00	367.30
Se	0.01	0.01	0.01	0.01	0.01

by Andrade *et al.*, (2016) for muffins in which vegetable fat was reduced.

The results obtained by determining the mineral content by ICP-OES and AAS, FIAS furnace techniques are shown in Table 2.

For muffins with chia seeds gel a significant increase in P, Ca, Zn, K and Mg content as compared with the control was observed. The most abundant mineral salt presented in muffins was P, followed by K.

By using the watermelon rind powder, an increase in the mineral content of the samples can also be achieved. Appreciable amount of P, K and Ca were found in the muffins obtained with watermelon rind paste as fat replacer.

This by-product can contribute to the nutritional value improvement of the muffins. The samples obtained by replacing 100% butter with

watermelon rind paste were remarked for the highest K content.

Taking into account the daily reference intakes of minerals for adults according to the Regulation (EU) No 1169/2011, was calculated the contribution of these powders to achieve the recommended daily intake in these nutrients. The values obtained are presented in Figure 1.

The samples obtained with chia gel can provide 53.99 % (CM1), 58.51% (CM2) phosphorus; 18.91 % (CM1), 21.27% (CM2) selenium, 11.66% (CM1), 12.52% (CM2) copper and 16.34% (CM1), 18.48% (CM2) manganese from recommended daily intake.

The muffins with watermelon rind paste addition can provide 49.29% P (samples with partial replacement of butter) and 52.47% P (total replacement of butter) from recommended daily

Figure 1. Percent of minerals from recommended daily intake (% RDI)

Figure 2. Mean values for the sensory properties of muffins

Figure 3. Total polyphenolic content in muffins

intake. With regard to selenium, these samples can contribute with about 20%. Also, 15.04% and 15.62% magnesium intake can be provided. The amount of potassium that can be assured by muffins with 50% butter reduction is about 10%, and for those produced without butter, the intake is 13.12%.

In Figure 2 are presented the results of the sensory analysis.

All attributes varied by adding fat substitutes. Although the samples were prepared with the same amount of sugar, the results show that the vegetal powders addition has affected the sweetness perception. The lowest sweetness values were obtained for muffins with watermelon rind paste. This may suggest that watermelon powder used as a fat substitute can come with a specific, pronounced taste that can interfere with the correct perception of sweet taste. Some evaluators have indicated that the taste of muffins with watermelon rind paste is slightly astringent.

The appearance of the muffins was one of the attributes that did not vary significantly with the addition of fat substitutes.

The porosity of the analysed products was affected by the reduction of the butter content. This characteristic is mainly influenced by the quality and quantity of gluten from flour and its ability to form and retain the gases and at the same time by the presence of fats to disrupt the gluten network, in order to produce final products with a uniform structure and high volume.

The colour was another sensory characteristic influenced by the use of vegetable powders as fat substitutes. In the case of samples obtained with watermelon rind powder, the lowest values for colour were recorded.

Based on sensory analysis it can be stated that the reduction of fat by 50% provides acceptable results regarding the sensory properties compared to the total replacement of fat.

The results of the total polyphenol content determination in muffins are shown in Figure 3. The selected samples for the determination were those obtained by reducing the amount of butter by 50%, because according to the results of the sensory analysis it was found that these products were better accepted by the evaluators.

From the graphical representation can be observed that the utilization of fat substitutes based on vegetal products has resulted in an

increase of the total content of polyphenols. Muffins with chia gel have presented the highest content of polyphenols - 77.43 mg GAE/ 100 g d. s., followed by muffins with watermelon rind paste - 72.07 mg GAE / 100 g d.s. These results are due to the important polyphenolic content of the powders used. In one of our previous studies, the total content of polyphenols of these powders was determined, and the chia seeds powder showed a higher value compared with the watermelon rind powder.

In the preservation of polyphenols from muffins the temperature plays an important role. In a study of Górnas *et al.*, (2016) was observed that the baking in a conventional oven at temperature 220°C for 14 minutes had the best effect on polyphenols preservation. To deeply understand the effect of high temperature on polyphenols is necessary to determine their composition. For example, Górnas *et al.*, (2016) observed that the most unstable compounds in the muffins enriched by strawberry, sour cherry, raspberry or black currant pomace were anthocyanins. In contrast the flavonol glycosides were the most stable. In the very next future our intent is to investigate the polyphenols stability in muffins at baking temperature, especially due to the varied composition of these compounds in the vegetal powders.

CONCLUSION

The utilization of fat replacers has increased the moisture content of the samples. The highest humidity values were recorded for samples in which the butter was completely replaced. For all the samples was observed an increase of the water activity with the increase of the storage period.

Minerals content analysis indicated that through the addition of powders from watermelon rind and chia seeds, an increase in the mineral content of the samples can be achieved. Also, the utilization of fat substitutes based on vegetal powders increased the total polyphenols content of muffins.

The sensory analysis indicated that the reduction of butter by 50% can provide better acceptable results compared to the total replacement of fat.

These vegetal powders can be used as ingredients for replacement of fat in muffins or others baked products due to their ability to improve the

nutritional quality and to maintain the physical-chemical and sensory characteristics at level of acceptability.

Acknowledgements. Authors thank to SCIENT-Research Center for Instrumental Analysis, Bucharest, Romania for the facilities provided for the minerals analysis.

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