



Date Seed, Oat Bran And Quinoa Flours as Elements of Overall Muffin Quality

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Abstract

Muffins are desirable bakery products both for their sensorial properties and for ease to be baked with numerous ingredients. Flours of date seed (D), oat bran (O) and quinoa (Q) with different insoluble dietary fibre contents were used in this study, as substitutions to wheat flour either individually (10%, w/w) or as combinations (5% each, w/w) in muffin samples. Suggested combined usage of ingredients aimed to increase the dietary fibre content of muffins while pertaining their overall quality attributes. Total moisture, ash and protein, dietary fibre, weight loss %, volume, specific volume, weight, colour and textural parameters were tested. Results revealed that, quinoa and oat bran flour substituted samples(QO) had the highest cake volume (84.5 ml) and specific volume (2.63 ml/g). Date seed and quinoa flour substitution (DQ) was the best combination with the closest hardness values to control (muffins with 100% wheat flour) samples (0.6 N), rather than an increase. Springiness (2.40 N) and cohesiveness (0.81 mm) were also close to that of control. Samples having date seed flour and quinoa (DQ) and date seed flour and oat bran flour (DO), had also the highest fibre contents, respectively. Thus, combining different fibrous ingredients instead of using them individually efficiently prevented the muffin quality loss. The best combination achieved was the date seed flour with quinoa flour (DQ) giving promising results to achieve healthier muffin production.



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Introduction


Cakes are popular and frequently consumed by almost all levels of society for their desirable sensory

properties and convenience. They differentiate mainly by their porous structure and high moisture content from the commonly consumed baked

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products such as bread, biscuits, etc. Muffins belong to the greasy cakes group rather than foam-type cakes and prepared as individual-sized portions that are smaller than cakes with no need to cut into slices. They are obtained by preparing a batter from wheat flour, sugar, oil, egg, milk and aroma products.^{1, 2} The current market trend for muffins is increasing in parallel to the interest in customizable bakery, though consumers highly expect affordable and healthier options at the same time.

Overall cake quality is mostly related to volume besides a flexible, smooth and soft texture.³ Moreover, generally cakes enable the incorporation of different ingredients into their formulations.⁴ Most studies in the field of muffins have focused on the physicochemical properties, shelf life and effects on quality characteristics when one or more sources of dietary fibres are added.⁵⁻⁹ Attempts for use of dietary fibre in food products have both health and nutrition standpoints.¹⁰ Dietary fibres are composed of various complex compounds such as polysaccharides, oligosaccharides, lignins found in plants that cannot be digested like other nutrients. Recent studies revealed that certain diseases defined as "diseases of the civilization (constipation, haemorrhoids, large bowel cancer, obesity)" were related to the lack of dietary fibre consumption. Mainly, consumption of dietary fibre has been associated with preventing or decreasing the causes of some diseases that have been associated with colon health. Moreover, dietary fibre has been proven to be effective on myocardial infarction, fatal coronary heart disease, some types of cancer, weight gain, diabetes, insulin resistance and metabolic syndrome.¹¹

Although different dietary fibres have been used in numerous studies, use of different dietary fibres as combinations was only investigated in products such as extruded breakfast products¹² and psyllium, oat flour and inulin in pasta.^{13, 14} Oat (*Avena sativa*) is a very common cereal having positive health effects on serum cholesterol such as attenuation of blood glucose with its soluble fibre β -glucan. Oat flour and/or fibre has been used in numerous studies as a dietary fibre source for cakes or muffins.¹⁵⁻¹⁸ Quinoa is a pseudocereal having high nutritional value with higher amounts of vitamins and minerals in comparison to most cereals, protein (13–14%) and dietary fibre.¹⁷ It has been used commonly in bakery products and particularly gluten-free

formulations.¹⁹⁻²² Although it has distinct advantages in terms of its nutritional properties, the use of quinoa flour in combination with oat flour has been proposed as a method for improving functionality.¹⁷ Date seeds although slightly differing among different date varieties, is richer in protein and fat in comparison to date flesh, being also a very rich source of dietary fibre (73.1 g/100 g), phenolics and antioxidants.²³ In a previous study, wheat flour has been substituted by date seed flour and date seed hydrolysates in muffin formulations and physicochemical effects have been investigated.⁵

Although some recent studies evaluated the effects of individual uses of different types of fibres in muffins,^{15, 16, 38, 39} the studies on the combined soluble and insoluble fibre usage is limited, the only in rice flour cakes;²⁴ extruded breakfast products¹² and pasta.^{13, 14} Therefore, this study aims to fill in the gap in literature by evaluating either individual or combined usage of different uncommon such as date seed flour, quinoa flour and oat bran flours with dietary fibre in muffins by emphasizing the changes in their quality.

Materials and Methods

The Preparation of Muffins

Date seed flour, oat bran, and quinoa are used as different sources of dietary fibres. Fibres were used as flour substitutes (10%, w/w) and used both single and dual combinations. Muffin preparation was made according to the method by Ambigaipal and Shahidi (2015). Milk, sugar, eggs, oil and baking powder (purchased from a local market in Istanbul, Turkey) were mixed and baked in baking cups with a diameter of 10 cm and each of the muffin samples weighed about 35 g before baking. For each formulation, a total of 3 muffins were baked and the production was performed twice. Wheat flour (Sinangil Flour, Turkey), Oat bran flour (Ada Sultan, Turkey), quinoa (Dimyat Gold, Turkey) were obtained from a local market and quinoa was grinded in a laboratory mill (IKA GmbH, Germany) to pass through 214 μ m sieve as flour. The details of muffin formulations are given in Tables 1.a and 1.b.

Baked cakes were cooled down to room temperature and then stored in zipped plastic bags and a portion of ground samples were stored at -18°C until analysis.

Table 1. a: Muffin formulations

Ingredients	Control muffin	Muffins with %10 substitution
Wheat flour (g)	65	58.5
Substitution source (g)	-	6.5
Sugar (g)	37.5	37.5
Baking powder (g)	3	3
Milk (ml)	60	60
Sunflower Oil (ml)	20	20
Eggs (ml)	50	50

Table 1. b: Muffin sample combinations

	Control	D	Q	O	DQ	DO	QO
Wheat flour	100%	90%	90%	90%	90%	90%	90%
Date seed flour	-	10%	-	-	5%	5%	-
Quinoa flour	-	-	10%	-	5%	-	5%
Oat bran flour	-	-	-	10%	-	5%	5%

Proximate Analyses

Total moisture, ash and protein determination tests were performed using AOAC methods 925.10, 923.03 and 920.87, respectively.²⁵

Total Dietary Fibre

Total amount of dietary fibre was measured using the total Dietary Fibre Assay Kit (TDF-100; Sigma-Aldrich, USA) based on AOAC Method 960.52 enzymatic-gravimetric method.

Muffin Quality Evaluation

Muffins were left for about 1.5 hours at room conditions for cooling after baking and then total volume was measured by the rape seed displacement method number 10-05 of AACC International.²⁶ Specific volumes were calculated by dividing the muffin volume values to their weight (ml/g). Weight loss in muffins was measured using the below formula;

$$\text{Weight loss\%} = \frac{W_i - W_f}{W_i} \times 100 \quad \dots(1)$$

W_i is the muffin batter weight before baking (g), whereas W_f is the final weight of the muffin sample after cooling.

Top height of the muffins were measured with a calliper, in mm.

Texture profile analysis (TPA)

TPA of the muffins (cut in slices of 25 mm width from the centre) were measured using the texture analyser (Stable Micro Systems TA-XT Plus, Godalming, Surrey, UK) with the aluminium cylinder probe (35 mm in diameter) and parameters of 50 N maximum load, 55 mm/minutes of pre-test speed and test speed of 120 mm/min. (2 mm/s) and 25% compression ratio, according to the AACC Method Number 74-09 (AACC, 2000). Hardness (N), springiness, adhesiveness, chewiness (N) and resilience were from the Texture Profile Analysis (TPA) graph. Measurements were made on the day after baking of muffins in two replicates.

Colour

Colour density (L^* , a^* , b^*) measurements were made using Chromameter (CR-400, Konica Minolta Holdings Inc., Tokyo, Japan) in cakes in slices of 2.5 cm width. All measurements were made at three different points.) Colour change was calculated using the following formula.

$$\Delta E = [(L_o - L^*)^2 + (a_o - a^*)^2 + (b_o - b^*)^2]^{1/2} \quad \dots(2)$$

In the equation L_o , a_o and b_o values belong to the control muffin and were taken as reference values.

Statistical Analysis

Differences among muffin formulations using the factors of fibre sources (3 types) and their condition of combination (2 types) were assessed by One Way Analysis of Variance (ANOVA) using the SPSS statistics software (version 10.0) at 95% level of significance. Further post-hoc tests were conducted using the Duncan's Multiple Range Test and Pearson correlation coefficients between characteristics ($p < 0.01$ and $p < 0.05$) were calculated using the same software.

Results and Discussion

Proximate Analyses of Raw Materials

Compositions of flours used as raw materials in the study were given in Table 2.

Total moisture and ash contents of flours with dietary fibre differed between 6.2 and 8.6% and 1.09-3.23 %, respectively. Dietary fibre constituents were different for all samples. Although soluble fibre contents are quite similar in flour samples, insoluble fibre content and total fibre content changed as follows: date seed flour > oat bran flour > quinoa > wheat flour. Date seeds have been reported to have high dietary fibre content

by different researchers such as 73.1g/100g²³ or 76.58 g/100 g dry weight²⁷ similar to the present results. The insoluble fibre content has also been reported as 67.26 g/100 g dry weight previously.²⁷ Quinoa flour has been shown to have 8.1% moisture and 13.5% protein contents, previously.²⁸ Different wheat flour sources (wheat flour, cake flour, multi-purpose flour, whole grain wheat flour etc.) have been used in cake, cupcake and muffin studies. According to these sources present wheat flour was similar to the previous reports in literature with the moisture and ash³⁷ or had slightly lower moisture and higher protein (wheat flour moisture 14%, protein 9.8%)⁸. Cake flour used in another study¹⁷ has 0.65% ash and 13.5% moisture. Oat bran proximate composition has been reported to be affected by the variety, cultivation conditions and extent of the milling process applied during the processing, change from 15%–18% for protein and 10%–40% total dietary fibers.⁴¹ While total fibre content is parallel to previous findings (24.4%), total protein content in present study (10.4%) seemed to be lower than the previous literature and thought to be affected by the dry milling conditions of the oat bran.

Table 2: Proximate analyses of ingredients

Ingredients	Total moisture, %	Total ash, % (d.b.)	Total protein, % (d.b.)	Soluble fibre %	Insoluble fibre %	Total fibre %
Wheat flour	8.6±0.2 ^a	1.09±0.01 ^b	11.1±1.2 ^b	3.8±0.7 ^{ab}	0.5±0.0 ^d	4.3±0.4 ^c
Date seed flour	6.2±0.3 ^b	1.58±0.02 ^b	9.2±0.6 ^{ab}	1.3±0.0 ^b	69.8±2.4 ^a	71.1±2.2 ^a
Oat bran flour	7.2±0.2 ^{ab}	3.23±0.00 ^a	10.4±1.3 ^{ab}	5.0±1.1 ^a	19.3±1.2 ^b	24.4±1.0 ^b
Quinoa flour	8.6±0.1 ^a	1.62±0.02 ^b	13.5±1.5 ^a	3.5±0.8 ^{ab}	3.8±0.9 ^c	7.3±0.7 ^c

Values in the table represent mean values and standard deviation of 2 replicates

Different letters in each column shows that there is a statistically significant difference between the samples ($p < 0.05$)

Proximate Composition of Muffin Samples

Proximate composition of muffin samples were given in Table 3. Dietary fibres affected the moisture contents of muffin samples significantly (28.2-31.2%) ($p < 0.05$). Only Q samples had similar moisture levels with control samples while DQ samples were slightly higher in the moisture measured ($p < 0.05$). Remaining muffin samples had significantly lower levels of moisture ($p < 0.05$). According to literature, addition of date flour⁵ and cocoa fibre³¹ had a slightly increasing effect on moisture in comparison

to control muffins. Quinoa flour and whole oat flour also have been reported to have a moderately high level of water absorption properties.¹⁷ In cookies with quinoa and chia flour, in contrast, moisture levels were lower than control samples and this was suggested to be related with the higher moisture retention capacity by quinoa and chia flour.²²

Difference among the ash contents of the muffin samples was statistically insignificant as neither individual nor combined addition of fibre sources

had a significant effect on the ash contents ($p > 0.05$). In literature, ash contents have been reported to be increased with date flour addition into muffin samples, ranging from 1.12% to 1.15% (d.b.) depending on the level of substitution level of wheat flour (2.5 or 5%).⁵

Table 3: Proximate analyses of muffin samples

Samples	Moisture content, %	Ash content, % (d.b.)	Protein content, % (d.b.)	Dietary fibre % (d.b.)
Control	30.5 ± 0.0 ^b	1.10 ± 0.01 ^a	13.53 ± 0.15 ^a	1.2 ± 0.0 ^c
D	29.2 ± 0.3 ^c	1.25 ± 0.35 ^a	8.12 ± 0.01 ^e	6.9 ± 1.5 ^b
Q	30.2 ± 0.3 ^b	1.50 ± 0.01 ^a	9.23 ± 0.01 ^d	1.1 ± 0.1 ^c
O	29.2 ± 0.3 ^c	1.73 ± 0.18 ^a	11.69 ± 0.27 ^b	7.4 ± 0.7 ^b
DQ	31.2 ± 0.3 ^a	1.50 ± 0.01 ^a	10.22 ± 0.71 ^c	10.4 ± 1.2 ^a
DO	28.2 ± 0.3 ^d	1.63 ± 0.18 ^a	9.32 ± 0.13 ^d	7.2 ± 0.1 ^b
QO	28.5 ± 0.0 ^d	1.38 ± 0.18 ^a	13.38 ± 0.25 ^a	6.8 ± 0.7 ^b

Values in the table represent mean values and standard deviation of 2 replicates. Different letters in each column shows that there is a statistically significant difference between the samples ($p < 0.05$).

Among the measured protein contents of the samples (changing from 8.12% to 13.53%) differing significantly ($p < 0.05$), only QO samples had the protein content as high as the control sample. In general, samples with the pair use of fibre sources had significantly higher protein content in comparison to the ones with individual fibre sources. In parallel to present results, research have revealed that combination of two or more food materials (eg. cereals and legumes) increased nutritional properties of the final food products.⁴⁰

Dietary fibre contents of the muffin samples increased significantly after use of different fibre sources, in comparison to control ($p < 0.05$), the only exception was quinoa flour. The measured amount of fibre changed from 1.2 % in control samples to 10.4% in DQ samples. Combined use of fibre sources gave slightly higher fibre contents than their individual usages.

Previous literature revealed that, fibre sources with high insoluble fibre contents ended up with a higher dietary fibre content in the end product when they were used either with soluble and insoluble fibres in gluten-free formulations.²⁴ This also supported our results as the highest fibre contents were measured in muffin combinations comprising date seed flour (DQ and DO). These results might be related with

the highest amount of insoluble fibre content it has, among all ingredients. Changes observed in the measured fibre from the fibre containing flour as raw ingredient to muffin samples, might be related with the effect of heat, as it has been reported as a factor that might change soluble to insoluble fibre ratio and also the measured total dietary fibre content. Particularly, observed increase in fibre content is attributed to the formation of fibre-protein complexes that are heat resistant and are collected as fibre.²⁹

Quality of Muffin Samples

Overall quality parameters of the muffin samples were depicted in Table 4. Weight or weight loss measurements of the samples were not significantly different than each other ($p > 0.05$), this findings were in parallel to the literature findings which found no differences in weight measurements in different fibres incorporated cakes.³⁰ Weight loss is generally related with the water loss of cake systems. Therefore, the dietary fibre sources acted as successful water loss barriers for the muffins. Volumes of muffin samples decreased significantly ($p < 0.05$) for all samples except for QO after fibre source addition.

In literature similar various trends have been investigated after fibre addition.^{9, 16}

Table 4: Muffin quality properties

Samples	Weight loss%	Weight (g)	Height (mm)	Volume (ml)	Specific volume (ml/g)
D	10.36±0.27 ^a	31.4±0.1 ^a	18.6±0.7 ^a	75.3±0.4 ^{bc}	2.40±0.01 ^{ab}
Q	8.71±0.51 ^a	32.0±0.2 ^a	14.2±1.2 ^{cd}	63.8±1.1 ^{cd}	2.00±0.01 ^b
O	10.31±1.29 ^a	31.4±0.4 ^a	14.5±0.1 ^{cd}	61.0±1.4 ^d	1.94±0.03 ^b
DQ	10.11±1.37 ^a	31.5±0.5 ^a	17.4±0.6 ^{ab}	66.5±5.5 ^{cd}	2.11±0.03 ^b
DO	7.97±0.71 ^a	32.2±0.3 ^a	13.6±1.4 ^d	67.8±0.4 ^{cd}	2.10±0.02 ^b
QO	8.17±0.34 ^a	32.1±0.1 ^a	13.8±1.1 ^d	84.5±2.1 ^{ab}	2.63±0.01 ^a
Control	9.41±0.50 ^a	31.7±0.2 ^a	15.8±0.3 ^{bc}	91.3±0.3 ^a	2.88±0.01 ^a

Control: Control muffin, no flour substitution; D: 10% date seed flour substitution; Q: 10% substitution with quinoa flour, O: 10% substitution with oat bran flour; DQ: 5% date seed flour and 5% quinoa flour substitution; DO: 5% date seed flour and 5% oat bran flour substitution; QO: 5% quinoa flour and 5% oat bran flour substitution. Different letters in each column in same colour shows that there is a statistically significant difference between the samples ($p > 0.05$).

Generally, fibre addition has also been reported as a factor to decrease the volumes in cakes and explained generally as a disorganization of starch-gluten network.³¹ It is known that during baking, expansion of air bubbles entrapped in the batter matrix due to the temperature increase and chemical leavening is the basic mechanism under the measured cake volume. Moreover, coalescence, protein denaturation, and starch gelatinization also affects cake structure.²⁴ In contrast, there are some findings that found oat fibre addition improved the volumes of layer cakes.³⁰ Therefore type of fibre is a significant factor for volume measurements.¹⁶ Differences in muffin formulations have been reported to be more effective on muffin volume and density due to the increase in batter viscosity and high water binding capacity of fibres, while muffin diameter and weight loss were less affected.⁸ Oat fibre is a source of insoluble fibres that contained cellulose, hemicellulose, and lignin. In another study, gluten-free layer cakes, the highest cake volume was obtained when the inulin and oat used in combination and it has been suggested that the collapsed structure may have been strengthened by the oat flour.²⁴ Therefore, similar effect was seen in QO samples, to sustain a better volume in comparison to all other treatments to give similar volume properties to control muffins. The specific volume mainly has been proposed to be related with the extent swelling of the muffin dough.³²

Specific volumes of the muffins changed significantly between 1.94 and 2.88 ml/g ($p < 0.05$). Only in QO

and D samples, specific volume was measured as being similar to that of control samples. Quinoa flour substitutions have been shown to increase the specific volumes / volumes of gluten-free bread samples, in previous studies.^{19,20} Volume and specific volume measurements correlated very well (0.938) (shown in Table 5) as the weight differences are insignificant, similar to previous studies.³⁰ According to another study, specific volume values similar to control samples were measured only in lower level of (5%) pea and oat fibre incorporated cake samples.¹⁵ In some literature sources dietary fibre addition has been interrelated with the increased softness in cake crumbs to result in a negative correlation with the specific volume, by dietary allowing more amount of water into the cake structure.⁸ However, this finding was not detected in this present study.

The height of the muffin samples changed between 13.6 and 18.6 mm. The maximum height was measured in date seed added muffin (D). Quinoa and oat flour seemed to make a decreasing effect on the muffin heights. The height of the muffins significantly correlated negatively with hardness (-0.757) and chewiness (-0.809). In literature the height of the muffins is a significant indicator to depict the muffin quality and generally fibre usage has been reported to affect the dough structure, by causing a decrease in level of CO₂ retention.³⁸ having a negative influence on CO₂ retention.

Textural parameters of muffin samples are shown in Table 5. Hardness of muffin samples changed

between 0.6 and 2.9 N, difference among them being significant ($p < 0.05$). The hardest sample was QO sample (2.9 N). Increase in hardness after fibre source incorporation to cakes is in parallel to the previous findings using oat fibre in literature.²⁴ Previously, increase in hardness has been linked

to the differences in the water binding capacities of fibre sources used. For example, if the water binding capacity of the fibre is high, wheat flour could not find the necessary amount of water to develop the gluten-protein network, and therefore the product becomes rigid to give higher hardness.^{15, 33}

Table 5: Muffin TPA

SAMPLES	HARDNESS (N)	SPRINGINESS	COHESIVENESS	CHEWINESS (N)	RESILIENCE
D	0.6±0.0 ^d	1.04±0.04 ^b	0.84±0.02 ^a	0.77±0.20 ^c	0.48±0.01 ^{ab}
Q	1.3±0.2 ^b	2.36±0.44 ^a	0.85±0.02 ^a	1.94±0.20 ^{ab}	0.49±0.02 ^a
O	1.1±0.1 ^{bc}	2.51±0.05 ^a	0.82±0.01 ^{ab}	2.36±0.18 ^a	0.47±0.01 ^{abc}
DQ	0.6±0.1 ^d	2.40±0.28 ^a	0.81±0.05 ^{ab}	0.61±0.21 ^c	0.44±0.04 ^{bc}
DO	2.6±0.4 ^a	0.97±0.03 ^b	0.78±0.03 ^b	1.93±0.24 ^{ab}	0.43±0.03 ^c
QO	2.9±0.3 ^a	1.18±0.26 ^b	0.78±0.01 ^b	2.12±0.05 ^{ab}	0.44±0.01 ^{bc}
CONTROL	0.7±0.1 ^{cd}	2.28±0.39 ^a	0.85±0.02 ^a	1.49±0.06 ^b	0.49±0.01 ^a

Control: Control muffin, no flour substitution; D: 10% date seed flour substitution; Q: 10% substitution with quinoa flour, O: 10% substitution with oat bran flour; DQ: 5% date seed flour and 5% quinoa flour substitution; DO: 5% date seed flour and 5% oat bran flour substitution; QO: 5% quinoa flour and 5% oat bran flour substitution

Values in the table represent mean values and standard deviation of 2 replicates

Different letters in each column shows that there is a statistically significant difference between the samples ($p < 0.05$).

Interestingly, increased hardness was not evident for D and DQ samples and their hardness levels (0.6 N) were not significantly different from the control sample (0.7 N) ($p > 0.05$). This effect may be explained with these fibre sources allowing more free water to be available in the muffins.⁶ D samples had also statistically similar specific volume values with control samples. Parallel trend between specific volume and hardness was evident in previous studies, as well.¹⁵ Almost all samples (except DO and QO) had been statistically similar to control muffins for cohesiveness. This attribute was also positive, since generally the low cohesiveness has been attributed to the crumbling property.²⁸ For DQ muffins, specific volumes were slightly lower, although their higher moisture in comparison to all other samples, might be related with their lower hardness.

Generally, increase in hardness and cohesiveness together with decreased resilience has been reported.^{24, 34} In the present study, hardness was

found to correlate significantly with cohesiveness (-0.691) and chewiness (0.634) ($p < 0.01$) (correlation data given in Table 6). However, no significant correlation was detected between hardness and resilience ($p > 0.01$). Only for those samples that are significantly harder and less resilient (DO and QO), a statistically significant decrease in cohesiveness was evident. It has been reported that this decrease might be linked to the loss of intermolecular interaction among ingredients.³⁵ Dateseed flour and oat bran flour have the highest amount of insoluble fibre contents, therefore their use in combination might have been effective on those properties as these have been mainly attributed to the insoluble fibre in previous studies.²⁴ Chewiness is not primary, but a secondary texture parameter measuring the extent of difficulty in chewing and it is generally parallel to hardness. Resilience and springiness are significant parameters for muffin quality to depict the degree to which the sample recovers after compression.³⁴

Table 6: Correlation coefficients between the quality parameters of muffin samples

	Height	Hardness	Spring.	Cohes.	Chew.	Resil.	Volume	Weight loss	Specific Volume
Height	1.000								
Hardness	-0.757**	1.000							
Spring.	0.085	-0.555*	1.000						
Cohes.	0.343	-0.691**	0.676**	1.000					
Chew.	-0.809**	0.634**	0.173	0.007	1.000				
Resil.	0.173	-0.509*	0.658**	0.935**	0.151	1.000			
Volume	-0.019	0.205	-0.358	-0.269	-0.307	-0.278	1.000		
Weight loss	0.575*	-0.639*	0.170	0.283	-0.403	0.008	-0.071	1.000	
Specific Volume	0.109	0.104	-0.218	-0.122	-0.312	-0.067	0.938**	-0.060	1.000

Spring: Springiness; Cohes: Cohesiveness; Chew: Chewiness; Resil: Resilience

** . Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

DQ sample were the best combination of fibres among muffins, with statistically no change in hardness, cohesiveness and springiness. In addition, those samples were significantly less chewy in comparison to control samples.

Colour

Crust colour measurements of samples (taking the control sample (C) as reference) are summarized in Table 7.

Table 7: Colour measurements of muffin samples

Sample	ΔE -Crust	b*-Crust	a*-Crust	L*-Crust	ΔE -Crumb	b*-Crumb	a*-Crumb	L*-Crumb
D	16.3±1.9 ^a	10.1±1.7 ^c	14.6±0.7 ^c	46.0±1.0 ^c	27.0±0.6 ^a	13.7±0.4 ^b	11.1±0.3 ^a	49.0±0.6 ^b
Q	4.8±1.2 ^c	26.5±0.4 ^a	18.0±0.9 ^{ab}	57.5±1.2 ^a	4.9±0.9 ^d	23.6±1.3 ^a	2.2±0.2 ^b	67.7±0.8 ^a
O	2.6±0.5 ^{cd}	24.7±0.5 ^a	17.1±0.8 ^{abc}	53.3±2.5 ^{ab}	11.2±2.0 ^c	18.9±0.8 ^{ab}	3.7±0.2 ^b	62.3±2.1 ^a
DQ	10.7±0.1 ^b	14.9±0.8 ^{bc}	15.7±0.1 ^{bc}	48.9±0.2 ^{bc}	20.3±1.0 ^b	15.8±0.5 ^b	8.9±0.2 ^a	54.9±1.0 ^{ab}
DO	12.9±0.2 ^{ab}	13.1±0.3 ^c	14.6±1.3 ^c	47.9±1.1 ^c	32.0±0.9 ^a	9.6±0.6 ^{bc}	9.0±0.2 ^a	44.3±0.7 ^b
QO	3.0±0.6 ^{cd}	21.5±3.3 ^{ab}	17.9±2 ^{ab}	54.0±1.4 ^a	14.6±1.6 ^c	21.5±0.3 ^{ab}	4.4±0.2 ^b	58.2±1.6 ^{ab}
Control	0±0	24.0±0.3 ^a	18.5±1 ^a	57.6±1.1 ^a	0±0	23.1±0.6 ^a	1.6±0.0 ^b	72.4±0.7 ^a

Control: Control muffin, no flour substitution; D: 10% date seed flour substitution; Q: 10% substitution with quinoa flour, O: 10% substitution with oat bran flour; DQ: 5% date seed flour and 5% quinoa flour substitution; DO: 5% date seed flour and 5% oat bran flour substitution; QO: 5% quinoa flour and 5% oat bran flour substitution

Different letters in each column in same colour shows that there is a statistically significant difference between the samples ($p > 0.05$).

Crust colour parameters of muffin samples differ significantly ($p < 0.05$). Crust colour in bakery products is mostly affected by the Maillard reactions, but dietary fibre substitutions are not at that extend to affect quantity of sugars and amino acids. However, possible colour changes were proposed to be related with the changes in pH, where fibre was acting as

a buffer that changes the water availability to give those reactions.³⁰ In the crust, lightness (L*) value was significantly lower than the control samples, only in dateseed flour incorporated sample (D, DO and DQ), even at lower levels of substitution (5%) as used in fibre combination treatments. Redness parameter (a*) was also significantly different

for only date seed flour substituted samples. Significant change in colour parameters of muffins after date seed flour incorporation was also stated by the previous studies.^{5, 36} Q, O and QO muffins were statistically similar to control samples in yellowness (b^*) ($p>0.05$). Date seed flour on the other hand, decreased the yellowness significantly either individual or in pairs ($p<0.05$). In Q, O and QO samples, total colour change was very low in comparison to D containing samples. The original colour of the fibre source has a significant effect on the colour of cereal product produced.^{8, 34, 36} In crumb, the colour differences are more profound. Similar to the crust, incorporation of date seed flour darkened the crumb colours significantly with decreased L^* values ($p<0.05$) and increased the redness and decreased yellowness. As expected, then effect of fibre sources in the crumb more easily noticed when compared to the crust since the effect of high temperature and caramelization more limited in the crumb.⁸

Conclusion

In conclusion, as usage of some different fibre sources in combination (date seed and quinoa

flour substituted samples, DQ), gave better results for muffin quality; combined usage of different fibre sources might suggested as an efficient way to overcome the disadvantages of dietary fibre sources on muffin quality. Future studies might focus on further possible fibre combinations and physicochemical properties in detail.

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Conflict of Interest

Authors state no conflict of interest for the study.

References

1. Tacer-Caba Z, Nilufer-Erdil D, Ai Y. Chemical Composition of Cereals and Their Products. In: Cheung PCK, Mehta BM, eds. *Handbook of Food Chemistry. Springer Berlin Heidelberg*; 2014:1-23.
2. Conforti F. Cake manufacture. In: Zhou W, ed. *Bakery products: Science and technology*. John Wiley & Sons, Ltd; 2006:393-410.
3. HadiNezhad M, Butler F. Effect of flour type and baking temperature on cake dynamic height profile measurements during baking. *journal article. Food and Bioprocess Technology*. August 01 2008;3(4):594-602. doi:https://doi.org/10.1007/s11947-008-0099-1
4. Bhise S, Kaur A, Fortifying muffins with psyllium husk fibre, oat fibre and barley fibre to improve quality and shelf life. *Carpathian Journal of Food Science and Technology*. 2015; 7(2):5-16.
5. Ambigaipalan P, Shahidi F. Date seed flour and hydrolysates affect physicochemical properties of muffin. *Food Bioscience*. 2015/12/01/ 2015;12:54-60. doi:https://doi.org/10.1016/j.fbio.2015.06.001
6. Lebesi DM, Tzia C. Effect of the addition of different dietary fiber and edible cereal bran sources on the baking and sensory characteristics of cupcakes. *journal article. Food and Bioprocess Technology*. July 01 2011;4(5):710-722. doi:https://doi.org/10.1007/s11947-009-0181-3
7. Masoodi FA, Sharma B, Chauhan GS. Use of apple pomace as a source of dietary fiber in cakes. *journal article. Plant Foods for Human Nutrition*. March 01 2002;57(2):121-128. doi:https://doi.org/10.1023/a:1015264032164
8. Struck S, Gundel L, Zahn S, Rohm H. Fiber enriched reduced sugar muffins made from iso-viscous batters. *LWT - Food Science and Technology*. 2016/01/01/ 2016;65:32-38. doi:https://doi.org/10.1016/j.lwt.2015.07.053
9. Sudha ML, Baskaran V, Leelavathi K. Apple pomace as a source of dietary

- fiber and polyphenols and its effect on the rheological characteristics and cake making. *Food Chemistry*. 2007/01/01/ 2007;104(2):686-692. doi:https://doi.org/10.1016/j.foodchem.2006.12.016
10. Foschia M, Peressini D, Sensidoni A, Brennan M, Brennan C. Synergistic effect of different dietary fibres in pasta on in vitro starch digestion? *Food Chemistry*. 2015/04/01/ 2015;172:245-250. doi:https://doi.org/10.1016/j.foodchem.2014.09.062
 11. Liu RH. Whole grain phytochemicals and health. *Journal of Cereal Science*. 2007/11/01/ 2007;46(3):207-219. doi:https://doi.org/10.1016/j.jcs.2007.06.010
 12. Brennan MA, Lan T, Brennan CS. Synergistic effects of barley, oat and legume material on physicochemical and glycemic properties of extruded cereal breakfast products. *Journal of Food Process and Preservation*. 2016/06/01 2015;40(3):405-413. doi:https://doi.org/10.1111/jfpp.12617
 13. Foschia M, Peressini D, Sensidoni A, Brennan CS. The effects of dietary fibre addition on the quality of common cereal products. *Journal of Cereal Science*. 2013/09/01/ 2013;58(2):216-227. doi:https://doi.org/10.1016/j.jcs.2013.05.010
 14. Foschia M, Peressini D, Sensidoni A, Brennan MA, Brennan CS. How combinations of dietary fibres can affect physicochemical characteristics of pasta. *LWT - Food Science and Technology*. 2015/04/01/ 2015;61(1):41-46. doi:https://doi.org/10.1016/j.lwt.2014.11.010
 15. Aydogdu A, Sumnu G, Sahin S. Effects of addition of different fibers on rheological characteristics of cake batter and quality of cakes. *Journal of Food Science and Technology-Mysore*. 2018/02/01 2018;55(2):667-677. doi:https://doi.org/10.1007/s13197-017-2976-y
 16. Bhise S, Kaur A. Fortifying muffins with psyllium husk fibre, oat fibre and barley fibre to improve quality and shelf life. Article. *Carpathian Journal of Food Science & Technology*. 2015;7(2):5-16.
 17. Inglett GE, Chen D, Liu SX. Pasting and rheological properties of quinoa-oat composites. *International Journal of Food Science and Technology*. 2015;50(4):878-884. doi: https://doi.org/10.1111/ijfs.12722]
 18. Soong YY, Tan SP, Leong LP, Henry JK. Total antioxidant capacity and starch digestibility of muffins baked with rice, wheat, oat, corn and barley flour. *Food Chemistry*. 2014/12/01/ 2014;164:462-469. doi:https://doi.org/10.1016/j.foodchem.2014.05.041
 19. Elgeti D, Nordlohne SD, Föste M, *et al*. Volume and texture improvement of gluten-free bread using quinoa white flour. *Journal of Cereal Science*. 2014/01/01/ 2014;59(1):41-47. doi:https://doi.org/10.1016/j.jcs.2013.10.010
 20. Alvarez-Jubete L, Auty M, Arendt EK, Gallagher E. Baking properties and microstructure of pseudocereal flours in gluten-free bread formulations. *Journal article. European Food Research and Technology*. November 25 2009;230(3):437. doi:https://doi.org/10.1007/s00217-009-1184-z
 21. Wang S, Opassathavorn A, Zhu F. Influence of quinoa flour on quality characteristics of cookie, bread and Chinese steamed bread. *Journal of Texture Studies*. 2015;46(4):281-292. doi:https://doi.org/10.1111/jtxs.12128]
 22. Goyat J, Passi S, Suri S, Dutta H. Development of chia (*salvia hispanica*, L.) and quinoa (*chenopodium quinoa*, L.) seed flour substituted cookies-physicochemical, nutritional and storage studies. *Current Research in Nutrition and Food Science Journal*. 2018;6(3):757-769.
 23. Al-Farsi MA, Lee CY. Nutritional and functional properties of dates: A review. *Critical Reviews in Food Science and Nutrition*. 2008/10/21 2008;48(10):877-887. doi:https://doi.org/10.1080/10408390701724264
 24. Gularte MA, de la Hera E, Gómez M, Rosell CM. Effect of different fibers on batter and gluten-free layer cake properties. *LWT - Food Science and Technology*. 2012/10/01/ 2012;48(2):209-214. doi:https://doi.org/10.1016/j.lwt.2012.03.015
 25. AOAC-International. AOAC International Official Methods of Analysis. *Association of Official Analytical Chemists*; 2002.
 26. AACC. Approved Methods of the AACC 10th edn. ed. *American Association of Cereal Chemists International Press*; 2000.
 27. Gullon B, Pintado ME, Barber X, Fernández-López J, Pérez-Álvarez JA, Viuda-Martos M. Bioaccessibility, changes in the antioxidant

- potential and colonic fermentation of date pits and apple bagasse flours obtained from co-products during simulated in vitro gastrointestinal digestion. *Food Research International*. 2015/12/01/ 2015;78:169-176. doi:https://doi.org/10.1016/j.foodres.2015.10.021
28. Romano A, Masi P, Bracciale A, Aiello A, Nicolai MA, Ferranti P. Effect of added enzymes and quinoa flour on dough characteristics and sensory quality of a gluten-free bakery product. *European Food Research and Technology*. 2018;doi:https://doi.org/10.1007/s00217-018-3072-x
 29. Maphosa Y, Jideani VA. Dietary fiber extraction for human nutrition—A review. *Food Reviews International*. 2016/01/02 2016;32(1):98-115. doi:10.1080/87559129.2015.1057840
 30. Gómez M, Moraleja A, Oliete B, Ruiz E, Caballero PA. Effect of fibre size on the quality of fibre-enriched layer cakes. *LWT - Food Science and Technology*. 2010/01/01/ 2010;43(1):33-38. doi:https://doi.org/10.1016/j.lwt.2009.06.026
 31. Pomeranz Y, Shogren M, Finney K, Bechtel D. Fiber in breadmaking--effects on functional properties. *Cereal Chemistry*. 1977;
 32. Topkaya C, Isik F. Effects of pomegranate peel supplementation on chemical, physical, and nutritional properties of muffin cakes. *Journal of Food Processing and Preservation*. 2019;43(6):e13868. doi:10.1111/jfpp.13868
 33. Chang R-C, Chia-Yen L, Shiao S-Y. Physico-chemical and sensory properties of bread enriched with lemon pomace fiber. *Czech Journal of Food Sciences*. 2015;33(2) doi:https://doi.org/10.17221/496/2014-CJFS
 34. Martínez-Cervera S, Salvador A, Muguerza B, Moulay L, Fiszman SM. Cocoa fibre and its application as a fat replacer in chocolate muffins. *LWT - Food Science and Technology*. 2011/04/01/ 2011;44(3):729-736. doi:https://doi.org/10.1016/j.lwt.2010.06.035
 35. Gómez M, Ronda F, Caballero PA, Blanco CA, Rosell CM. Functionality of different hydrocolloids on the quality and shelf-life of yellow layer cakes. *Food Hydrocolloids*. 2007/03/01/ 2007;21(2):167-173. doi:https://doi.org/10.1016/j.foodhyd.2006.03.012
 36. Bchir B, Rabetafika HN, Paquot M, Blecker C. Effect of pear, apple and date fibres from cooked fruit by-products on dough performance and bread quality. *Food Bioprocess Technology*. 2014/04/01 2014;7(4):1114-1127. doi:https://doi.org/10.1007/s11947-013-1148-y
 37. Ocheme A, Olajide E, Chinma CE, Yakubu CM, Ajibo UH. Proximate composition, functional, and pasting properties of wheat and groundnut protein concentrate flour blends. *Food Science & Nutrition*. 2018; 6(5): 1173-1178. doi: https://doi.org/10.1002/fsn3.670
 38. Ortega-Heras M, Gómez I, de Pablos-Alcalde S, González-Sanjosé ML. Application of the just-about-right scales in the development of new healthy whole-wheat muffins by the addition of a product obtained from white and red grape pomace. *Foods*. 2019, 8(9), 419. doi: https://doi:10.3390/foods8090419
 39. Oluwajuyitan TD, Ijarotimi OS, Fagbemi TN. Nutritional, biochemical and organoleptic properties of high protein-fibre functional foods developed from plantain, defatted soybean, rice-bran and oat-bran flour. *Nutrition & Food Science*. 2020, doi: https://doi.org/10.1108/NFS-06-2020-0225
 40. Yohannes TG, Makokha AO, Okoth JK, Tenagashaw MW. Developing and nutritional quality evaluation of complementary diets produced from selected cereals and legumes cultivated in Gondar province, Ethiopia. *Current Research in Nutrition and Food Science Journal*. 2020, 8(1), 291-302. doi: http://dx.doi.org/10.12944/CRNFSJ.8.1.27
 41. Duță DE, Culețu A, Mohan G. Reutilization of cereal processing by-products in bread making. In: Sustainable Recovery and Reutilization of Cereal Processing By-Products(pp. 279-317). 2018, Woodhead Publishing.