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Preparation of resistant starch by Some Different Physical Methods and Utilization in Muffins Production

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Abstract

This study evaluated the Corn starch modified to resistant starch by heat–moisture treatment (RS1), autoclaving treatment (RS2) and microwave treatment (RS3). The effects of these treatments on the resistant starch content, also, muffins incorporated with resistant starch and its physical characteristics (including volume, specific volume, weight loss and penetration depth), color parameters and sensory attributes were investigated. The resistant starch contents were increased by all modified methods comparing with control sample (wheat flour). The addition of all RS treatment increased the instrumental texture (penetrometer) of the muffins, but the lowest Softness values were shown by the RS1-containing samples. RS2-containing muffins were recorded the highest degree of weight loss in muffin samples. On the contrary, RS3-containing muffins showed a lighter color (L*, Chroma and intensity value

significantly higher) in comparison to the control. Meanwhile, all muffin treatments did not differ significantly ($P \leq 0.05$) in appearance, texture and flavor. On the other hand RS2-containing muffins showed the lowest sensory acceptability. So it can be suggested that resistant starch by heat–moisture and microwave treatment can be used in preparation of bakery products with good sensory and physical characteristics.

Keywords: Corn starch, resistant starch, muffins, Texture, Colour and Acceptability.

Introduction

The growing consumer interest in health and its relationship with diet has led to a considerable rise in the demand for high-fiber and low caloric products. Starch is the major dietary source of carbohydrates. In terms of digestibility in vitro, starch is typically divided into three fractions: rapidly digesting starch, slowly digesting starch and resistant starch (RS), which escaping hydrolysis by amylolytic enzymes in the small intestines of healthy individuals. RS is considered the third type of dietary fiber, as it can improve insulin sensitivity and has fewer calories than regular starch (2 vs. 4 calories per gram). So, adding resistant starch to meals increases feelings of fullness and makes people gain fewer calories ***(Leszczyñski, 2004)***. Hydrothermal treatments to which starches have been subjected such as heat-moisture treatment (HMT) is physical modification, without destroying its granule structure. HMT is a related process in which the starch to moisture ratio, the temperature and heating time are critical parameters that need to be controlled ***(Chung et al., 2009).***

Autoclaving treatment promotes hydration of the amorphous zone in starch granules under the action of a pressure field. The amorphous layer of the starch granule crystallization zone swells in water with increasing pressure, which causes rearrangement of the amylopectin double helices ***(Bravo et al., 1998).*** Microwave treatment affects starch through dielectric heating and electromagnetic polarization effects ***(Bilbao-Sáinz et al., 2007).*** Therefore, modification alters the starch physicochemical properties and can improve the functionality of native starch ***(Bemiller and Huber, 2015).***

Muffins are one of the most popular and common bakery products, which are highly appreciated by consumers due to their taste and soft texture. Muffins are high in volume, spongy in texture, which is characterized by typical porous structure. To obtain such a final structure, a stable batter lodging incorporated with many tiny air bubbles is required ***Martínez-Cervera et al. (2012).***

There fore, this study was carried out to prepare resistant starch from native corn starch physically modified by several methods such as heat-moisture treatment (HMT), microwave and autoclaving. Application of the obtained muffins was evaluated by examining the physical attributes (color, texture characteristics) and sensory evaluation as affected by the used formula and applied baking process.

Material and Methods

Materials

Corn starch was obtained from Egyptian Starch & Glucose Company. Commercial wheat flour 72% extraction, sugar, shortening, milk, baking powder, eggs and salt were purchased from the local markets for muffins making. All other reagents used in this work were of analytical grade.

Preparation of resistant starch

Corn starch samples were physically modified by different methods

Heat-moisture treatment (HMT)

Treated starch was prepared according to ***zheng et al, (2016)*** with modification. Corn starch (100g) was mixed with distilled water (350ml). The starch slurry was pregelatinized in a boiling water bath (95 ºC ± 2 for 40 min). The sample was cooled to room temperature and stored at 4 ºC for 24 h under refrigeration, then the sample was dried at 60 ºC for 24h and milled to pass through 20 mesh sieve for analysis.

Autoclaving method

Corn starch (100g) was dispersed in 350ml distilled water and the mixture was then pressure cooked in an autoclave at 121 ºC for 20 min according to ***zhao and lin, (2009).*** The autoclaved starch paste was allowed to cool to room temperature and then stored at 4 ºC for 24 h. The sample was dried at 60 °C for 24 h and milled to produce fine particles (20 mesh).

Microwave method

Corn starch (100g) was mixed with distilled water (350ml). The starch slurry was microwaved for 2.5 min. using a household microwave oven (model Microchef 1235 Molinex, France) capable of generating 1200 watts power by 220 volt. Each sample was placed in beaker and heated by microwave for the required period. The sample was cooled to room temp., and stored at 4 ºC for 24 h, then the sample was dried at 60ºC for 24 h and milled to pass a 20 mesh sieve according to ***Staroszczyk, (2009).***

Determination of resistant starch in vitro

Current resistant starch content of the raw materials and treated samples was determined using Resistant starch kit obtained from Porcine Pancreas, (Sigma chemical Co. product No. P1625) according to the method described by ***Eerlingen et al., (1994).***

Preparation of muffins

A standard muffin formulation was used to prepare the products according to the method described by ***AACC, (2012)*** with some modifications. Muffins were prepared without RS (conventional muffin as control with corn starch), and with three different treatments of RS. Five formulations were prepared using the same quantity of all the ingredients except the flour, corn starch and RS. The batter formulation consisted of ingredients for making muffin formulas as shown in **Table (1)**.

The mixing procedure was carried out by placing the wet ingredients in the bowl of a Kitchen Aid type electrical mixer and whipping at speed 4 for 1 min., the sifted dry ingredients were added

and blended using the flat paddle at speed 1 for 4 sec before scraping the bowl and paddle. Batter samples (40 g) were weighed into each muffin cup and were baked at 204 ºC for 22 min. Following a 5 min setting period, the muffins were removed from the cups and allowed to cool for 1 h before being used in various physical and sensory evaluation.

Evaluation of muffins

Physical characteristics

Volume, specific volume, final weight and baking loss during backing of muffin samples were determined using the rapeseed displacement method for volume. Weights after baking were obtained to allow the computation of water loss during baking and specific volume was calculated from the ratio between weight and volume of the muffin according to ***AACC, (2012).***

Softness value was measured by penetration depth reading using a probe of 10 g, (cones 45°) by an automatic Penetrometer A4, No 1; Dresden, Germany). At three different location at the top surface of the muffin. Penetration time was set for 30 seconds and the penetration depth was taken as average of the three test readings from each muffin sample to give the compressibility measured by penetrometer units (mm).

Color of muffins crust samples was determined according to the tristimulus color system using spectrophotometer (MOM, 100D, Hungary). Color coordinates X, Y & Z were converted to corresponding Hunter L^*, a^* & b^* color parameters according to formula given by manufacturer. The Chroma (C) represents color

saturation or purity was calculated from $C = (a^2+b^2)^{1/2}$ and total color intensity $(a^2+b^2+L^2)^{1/2}$ as described by ***Francis (1983).***

Sensory evaluation of muffins

Muffins with resistant starch were coded with different numbers and submitted to sensory evaluation by ten semi trained member panels staff at Food Science Department. The panelists were asked to rate each sensory attribute using the control muffins as the basic for evaluation. Muffins were evaluated for appearance, texture, flavor and overall quality on a 9-point hedonic scale using a report sheet according to ***ISO, (1988).*** .

Statistical analysis

All data were expressed as mean values ± SE. Statistical analysis was performed using one way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test with $P \leq 0.05$ being considered statistically significant using SAS program ***(SAS, 1996).***

Results and Discussion

Resistant starch content of the raw materials and treated samples

Results illustrated in **Table (2)** show resistant starch content of wheat flour; corn starch and three different treatments for RS. Obtained results indicate that resistant starch content increased gradually by physical treatment from 19.18 to 30.97 % which indicate that microwave treatment had the highest resistant starch content compared with wheat flour and corn starch. These results are in accordance with ***Zheng et al., (2020),*** who recorded that resistant starch contents were increased by autoclave and microwave treatment, but only slightly by Heat moisture treatment.

Physical characteristics of muffins

Physical characteristics of muffins made from native and modified corn starches by different methods are shown in **Table (3)**. Measurements of softness (penetrometer) indicated that the microwave resistant starch (RS) had a higher significant ($p< 0.05$) effect on the tenderness of the produced muffins then corn starch, control and autoclave modified starch incorporated muffin samples. Meanwhile, the heat moisture (RS1) recorded lowest tenderness than the other physical treatment.

From the same table, results of volume value of muffin made from all types of modified starch were decreased slightly compared with that made from control and corn starch. On other side, muffins with autoclave modified starch were recorded highest weight loss value compared to others muffin sample. However, lowest values of specific volume were observed in muffin made from microwave and autoclave treated starch. These results are in agreement with ***Nadir et al., (2015).***

Color parameters of muffins

Color as a matter of visual perception is an important consideration in food product development because food color and appearance are usually the first impressions to register in the consumer's mind. Analysis of muffins for (L*) lightness, (a*) redness and (b*) yellowness as well as Chroma and total intensity characteristics is shown in Table (4).

The lighter (whiter) samples were recorded for muffin samples containing RS3 modified starch comparison with other samples.

Muffins with RS2 showed significantly higher a* values than all the other muffins, which revealed its higher red color component. On the other hand, control and RS3 muffin samples showed the highest value of parameter b*, compared to other muffin. Meanwhile, muffins with RS3 recorded significantly higher Chroma and intensity value. These findings are in harmony with those obtained by ***Baixauli et al., (2008).***

Sensory evaluation of muffins

The mean sensory acceptance scores for the appearance, texture, flavor and overall acceptance of the control muffin and the muffins with the different modified method of RS are presented in **Table (5)**. Statistical analysis showed that all muffin treatments did not differ significantly ($P \leq 0.05$) in appearance, texture and flavor. On the other hand, Overall acceptability also showed the RS2-containing muffins showed significantly the lowest overall acceptability in comparison to the other muffin treatments. This observation agree with those reported by ***Nadir et al., (2015).***

Table 1: Ingredients (g) for type of produced Muffin

Ingredients	Control	Corn starch	RS1	RS2	RS3
Wheat Flour	312	180	180	180	180
Corn starch	-	132	-	-	-
Resistant Starch	-	-	132	132	132
Egg White	168	168	168	168	168
Sugar	312	312	312	312	312
Egg Yolk	84	84	84	84	84
Vanilla	7.44	7.44	7.44	7.44	7.44
Fresh Milk	156	156	156	156	156
Sodium bicarbonate	12.36	12.36	12.36	12.36	12.36
Citric acid	4.2	4.2	4.2	4.2	4.2

Where: RS1: Heat-moisture resistant starch, RS2: Autoclave resistant starch, RS3: Microwave resistant starch

Table 2: Resistant starch content %

Treatment	Resistant starch content %
Wheat Flour (72%)	$12.15^{e} \pm 0.33$
Corn starch	$17.38^{d} \pm 0.22$
Heat moisture treated starch	$19.18^{c} \pm 0.16$
Autoclave treated starch	$23.26^{b} \pm 0.13$
Microwave treated starch	$30.97^{a} \pm 0.05$

Data are the mean ± SE, n = 3, Mean values in the same column bearing the same superscript do not differ significantly ($P \leq 0.05$)

Table 3: Effect of different RS on some physical characteristics of muffins

Treatment	Penetrometer (mm)	Final weight (g)	Baking loss (g)	Volume (cm^3)	Specific volume (cm^3/g)
Control	30.17^{b} ±	35.56^{b} ±	4.88^{b} ±	50.0^{a} ±	1.41^{a} ±
Corn	34.23^{a} ±	35.97^{b} ±	4.46^{b} ±	50.0^{a} ±	1.39^{ab} ±
RS1	29.07^{b} ±	35.47^{b} ±	4.96^{b} ±	49.0^{b} ±	1.38^{b} ±
RS2	30.07^{b} ±	34.76^{c} ±	5.68^{a} ±	47.0^{c} ±	1.35^{c} ±
RS3	34.57^{a} ±	36.60^{a} ±	3.84^{c} ±	49.0^{b} ±	1.34^{c} ±

Data are the mean ± SE, n = 3, Mean values in the same column bearing the same superscript do not differ significantly (P ≤ 0.05); Control: wheat flour; RS1: heat moisture treated starch; RS2: autoclave treated starch; RS3: microwave treated starch

Table 4: Effect of different RS on Color parameters of Muffins

Treatment	L^*	a^*	b^*	Chroma	Intensity
Control	60.35^{b}	2.77^{d}	35.46^{a}	35.57^{a}	70.05^{b}
Corn	56.49^{c}	4.68^{b}	31.05^{c}	31.40^{b}	64.63^{c}
RS1	56.09^{d}	3.74^{c}	29.79^{e}	30.02^{d}	63.62^{d}
RS2	52.99^{e}	7.12^{a}	30.25^{d}	31.09^{c}	61.44^{e}
RS3	63.50^{a}	4.12^{e}	35.29^{b}	35.53^{a}	72.76^{a}

Data are the mean ± SD, n = 3, Mean values in the same column bearing the same superscript do not differ significantly (P ≤ 0.05). L*, lightness; a*, redness; b*, yellowness; Control: wheat flour; RS1: heat moisture treated starch; RS2: autoclave treated starch; RS3: microwave treated starch

Table 5: Effect of different RS on Sensory attributes of Muffins

Treatment	Appearance	Texture	Flavor	Over all
Control	8.50^{a} ± 0.34	8.83^{a} ± 0.16	8.33^{a} ± 0.49	8.83^{a} ± 0.16
Corn starch	8.33^{a} ± 0.42	8.66^{a} ± 0.33	7.83^{a} ± 0.47	8.33^{ab} ± 0.49
RS1	7.66^{a} ± 0.49	7.83^{a} ± 0.60	7.33^{a} ± 0.21	7.50^{bc} ± 0.50
RS2	8.16^{a} ± 0.65	7.66^{a} ± 0.61	7.00^{a} ± 0.51	6.83^{c} ± 0.47
RS3	7.50^{a} ± 0.42	8.16^{a} ± 0.47	7.50^{a} ± 0.34	8.0^{abc} ± 0.36

Data are the mean ± SD, n = 10, Mean values in the same raw bearing the same superscript do not differ significantly (P ≤ 0.05); Control: wheat flour; RS1: heat moisture treated starch; RS2: autoclave treated starch; RS3: microwave treated starch.

Conclusion

Based on the abovementioned results, it could be concluded that the resistant starch content increased by modified method especially microwave. Also, the addition of resistant starch in muffins produced a softer texture except those prepared from heat moisture treated starch, Results of physical characteristics, color parameters and sensory evaluation of muffin samples made from corn starch modified by heat moisture, autoclave and microwave methods indicated that, resistant starches are suitable as a supplemented materials for producing and improving bakery products like muffins**.**

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تحضير النشا المقاوم بواسطة بعض الطرق الفيزيائية المختلفة والاستفادة منها في إنتاج المافن

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الملخص العربى

قيمت هذه الدراسة نشا الذرة المعدل إلى النشا المقاوم عن طريق المعالجة الحرارية والرطوبة (RS1)، المعالجة بالأتوكلاف (RS2) والمعالجة بالميكروويف (RS3). تمت دراسة تأثير هذه المعالجات على محتوى النشا المقاوم ، وكذلك المافن المحتوى على النشا المقاوم وخصائصه الفيزيائية (بما في ذلك الحجم والحجم النوعي وفقدان الوزن وعمق الاختراق) ودلائل اللون والصفات الحسية. تمت زيادة محتوي النشا المقاوم بكل طرق المعالجات مقارنة بالعينة الضابطة (دقيق القمح). أدت إضافة جميع المعالجات RS إلى زيادة قيمة القوام (مقياس الاختراق) للمافن ، ولكن أقل قيم الطراوة ظهرت بواسطة العينات المحتوية على RS1. سجل المافن المحتوي على RS2 أعلى درجة من فقدان الوزن. على العكس من ذلك ، أظهر المافن المحتوي على RS3 لونًا أفتح (L* و Chroma وقيمة كثافة للون أعلى بشكل ملحوظ) مقارنةً بالعينة الضابطة. بينما لم تختلف عينات المافن معنويا ($P \leq 0.05$) في المظهر والقوام والنكهة. من ناحية أخرى ، أظهر المافن المحتوي على RS2 أقل قبول حسي. لذلك يمكن اقتراح أن النشا المقاوم بواسطة معالجة الحرارة والرطوبة ومعالجة الميكروويف يمكن إستخدامهم في تحضير منتجات المخابز ذات الخصائص الحسية والفيزيائية الجيدة.

الكلمات المفتاحية: نشا الذرة - النشا المقاوم - المافن -القوام - اللون - القبول العام