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EFFECT OF PARTIAL REPLACEMENT OF WHEAT AND RICE FLOUR BY MODIFIED STARCH ON CAKE AND BISCUIT QUALITATIVE AND SENSORY PROPERTIES

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ABSTRACT

This study was aimed to investigate the effect of substituting different proportions (10%, 20%, 30%) of wheat flour and Amber rice with enzymatically modified starch on qualitative and sensory characteristics of biscuits and cupcakes. The results showed a decrease in the thickness of wheat biscuits with an increase in the substitution percentage . The 30% substitution showed a significant difference compared to the others. Conversely, there was an increase in the diameter of biscuit samples, ranging from (42.00-48.30 cm), as well as the spread factor. The 30% substitution treatment showed a significant difference compared to the others. As for rice biscuits, the diameter and the spread factor values increased with increasing substitution rates. Sensory evaluation for rice and wheat biscuits indicated that substitution rates of (0, 10 and 20)% achieved similarity in aroma , taste, symmetry of form, and crumb color. However, substitution rates of 30% for both products showed a darker color, more hardness, and the development of an acidic flavor . As for the cupcakes, the specific volume decreased with increasing substitution rates. The highest values for wheat cakes were recorded at substitution rates of 10% and 20%,being 3.19 and 3.00 cm^3 /g respectively. The lowest values were recorded for WC3 and RC3 (2.60 ,1.61cm^3 /g). The sensory evaluation for the cupcakes samples showed no significant differences as compared to the control sample in term of moisture, texture smoothness, crumb color, and crust color. Substitution at 10% and 20% showed similarity in terms of symmetry of form, crumb homogeneity, aroma ,taste and moisture. However, the 30% substitution rate resulted in a noticeable decline in product acceptance due to a decrease in volume , texture smoothness, reduced crumb homogeneity, as well as a darker color and an undesirable flavor

Key words: **pullulanase enzyme, pastries, resistant starch.**

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INTRODUCTION

The spread of diseases such as cardiovascular diseases, diabetes, cancer, and other non-communicable diseases is considered a major cause of global mortality. Additionally, economic transformations, unhealthy dietary habits, changing lifestyles, limited physical activity are contributing factors to the spread of non-communicable diseases. Researchers recommend reducing the consumption of high-calorie foods rich in sugars and fats. They also advocate for the consumption of high-fiber foods, as they have an impact on increasing satiety, promoting health, and preventing many diseases, making it the subject of ongoing research (Baixauli *et al.*,2008;Dipesh *et al.*,2018). Scientific studies and research have aimed to increase the fiber content in many types of food while preserving the product's characteristics. However, the reality was different, as the addition of fiber resulted in the formation of products that were less appealing, such as whole wheat bread, rye bread, pasta, and biscuits made from whole grains. This led to changes in color, flavor, texture, and overall appearance, negatively impacting consumer acceptance of familiar foods and causing hesitation towards resulting alterations.Consequently, researchers resorted to manipulating (modifying) certain food components, such as modifying starch (e.g., adding resistant starch). This positive modification reflected an increase in acceptability among consumers after the addition, providing a similar source of dietary fiber devoid of influential taste and odor. This addition has contributed to creating an acceptable product (Jefferson *et al.*,2018;

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Carlos *et al.*,2020). Resistant starch (RS) is defined as starch that resists digestion and absorption in the small intestine, undergoing fermentation in the colon. It does not break down into glucose in the small intestine within 120 minutes of consumption (Pinky *et al.*,2019). Recently, it has been considered a dietary fiber, and one method of assessing it is by using the standard method for estimating total dietary fiber. Resistant starch possesses unique properties that resemble those of dietary fiber (Baixauli *et al.*,2008). The increasing prevalence of diabetes and weight gain, in particular, has prompted a growing interest in fortifying food with fiber, which plays a role in maintaining health. Resistant starch (RS) as a nutritional and functional component stands out with unique physical effects in food. The physical and functional properties of RS, such as reduced water binding capacity, swelling, viscosity, and gel consistency, make it a valuable functional ingredient in various food applications. Its ease of handling during manufacturing, crispiness, spread, and improvement of texture and enhanced crispness of low-moisture final products, like biscuits. Biscuits, being an example of low-moisture baked goods, undergo changes in structural and sensory characteristics with any alteration in ingredients. (Jun *et al* 2023) Enzymatically modified starch is characterized by a reduction in viscosity and swelling strength, impacting the functional properties of the partially replaced flour Starch modification can be done using several techniques. These techniques may include modifying the main functional components by using low- or no-calorie sugars, forming lipid-starch complexes, or applying other processing techniques such as wet heat treatments and extrusion. This is followed by different percentages of resistant starch, which change according to the modifications. Whether chemical, physical or enzymatic, the presence of resistant starch in foods combines physical and nutritional properties in addition to stability during manufacturing, meaning that the stability of RS during manufacturing is the main factor that must be maintained to obtain nutritional properties (Pinky *et al.*,2015). Since cakes are airy baked goods, and their quality depends on raw materials, preparation and processing conditions, as well as the importance of cake properties in terms of uniformity of structure, large volume, and the softness and moistness of the crumb, researchers studied quality standards of cakes prepared from various types of flour and their substitution with non-soluble fibers, The percentages of carbohydrates an starch were lower, and the percentage of resistant starch and short-chain fatty acids was higher, in addition to lower blood sugar levels. As for cake, the viscosity of the cake batter was higher, but its density was lower and it had better stability during the storage period compared to the control sample (Tawheed *et al.*,2021). This study aimed to investigate the replacement of enzymatically modified starch that prepared from rice and wheat starch to raise the levels of resistant starch with varying substitution ratios, along with rice and wheat flour used in biscuit and cake preparation, and the effect of these ratios on the physical, qualitative and sensory characteristics of both products. The goal was to develop products with a low glycemic index suitable for consumption by individuals with diabetes and obesity or those following a specific dietary regimen.

MATERIALS AND METHODS

Amber rice flour (Jasmine Amber rice variety) and wheat flour (Alfakhir) purchased from local markets were used. Enzymatically modified starch was prepared from enzymatic treatment of Amber rice flour and wheat flour (Buhooth 22 variety) using commercial pullulanase enzyme at a ratio of 10%, following the method described by Anum Khan *et al*., 2020. with some modifications.

Biscuit production*:* Biscuits were prepared according to the method approved by the American Association of Cereal Chemists (AACC) with the code (50 B – 10) described by Al-Mehyawi, 2018. The following formula was used with some variations, including the use of xanthan gum with rice. The primary ingredients used were: 225 g of rice flour (Amber) or wheat flour (Alfakhir), 130 g of powdered sugar, 64 g of margarine butter, 2.1 g of table salt, 2.5 g of sodium bicarbonate, 33 ml of glucose solution (%6.5), 0.1% xanthan

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gum (with rice biscuits), and modified starch at ratios of 10%, 20%, and 30%.

Rice and wheat biscuit treatments

Rice biscuit: Amber rice flour and enzymatically modified resistant starch prepared from the same variety were used. The treatments included:

RB0: control treatment consisting of the basic ingredients

RB1: basic ingredients with 10% substitution of rice flour with modified starch and glucose solution volume to 30 ml.

RB2: basic ingredients with 20% substitution of rice flour with modified starch and reduction of the sugar solution volume to 28 ml.

RB3: basic ingredients with 30% substitution of rice flour with modified starch and glucose solution volume to 16 ml.

Wheat biscuit:

white all-purpose wheat flour labeled as “Alfakhir" and enzymatically prepared resistant starch from wheat starch of Buhooth 22 variety were used. The treatments included:

WB0: (Control treatment) consisting of the basic ingredients.

WB1: basic ingredients with 10% substitution of wheat flour with modified starch and glucose solution volume to 30 ml.

WB2: basic ingredients with 20% substitution of wheat flour with modified starch and glucose solution volume to 28 ml.

WB3: basic ingredients with 30% substitution of wheat flour with modified starch and glucose solution volume to 16 ml.

Cupcake Manufacturing: The method described by Jassim *et al*., 2016 was followed with some modifications, including the substitution of xanthan gum with carboxymethyl cellulose (CMC) in rice cake. Cake improver was used in wheat cake by reducing the water quantity. The mixture included the following primary ingredients: Alfakhir wheat flour or Amber rice flour 510 g, sugar 341 g, dry milk powder 28 g, margarine butter 227 g, 4 eggs, 227 ml water, vanilla 7 g, salt 7 g, lemon juice 3.5 ml, cake improver (used with wheat cake) 36 g, xanthan gum (used with rice cake) 0.1%, baking powder 21 g, and modified starch at ratios of 10%, 20%, and 30%.

Rice and wheat cake formulations:

rice cake:

RC0: (Control treatment) consisting of all basic ingredients, with 8 ml of water.

RC1: basic ingredients with the replacement of 10% of rice flour with modified starch and the addition of only 8 ml of water.

RC2: basic ingredients with the replacement of 20% of rice flour with modified starch without adding water.

RC3: consists of basic ingredients with the replacement of 30% of rice flour with modified starch without adding water.

Wheat cake:

WC0: control treatment consisting of all basic ingredients with the addition of 227 ml of water.

WC1: basic ingredients with the replacement of 10% of wheat flour with modified starch and the addition of only 188 ml of water.

WC2: basic ingredients with the replacement of 20% of wheat flour with modified starch and the addition of 120 ml of water.

WC3: consists of basic ingredients with the replacement of 30% of wheat flour with modified starch and the addition of 104 ml of water.

Physical properties of standard biscuits

measurement of thickness, diameter, and spread factor: The physical parameters, including diameter, thickness, and spread factor , of the laboratory biscuits were determined using the AACC procedure (2002) described by Al-Mehyawi.

Measurement of color degree

The color characteristics of the standard biscuit pieces were measured using a Lab colorimeter in accordance with the method described by both Mariasole *et al*. 2021 and Al-Muhayawi 2023. The Lab colorimeter utilizes the International Commission on Illumination (CIE) color scales, expressing color values as luminance (L*), red-green axis (a*), and yellow-blue axis (b*), recorded directly from the color measurement device at a calibrated rate.

Sensory evaluation of standard biscuits*:*

The questionnaire described by AL-Karkhi ,2020 was followed to analyze the sensory evaluations of laboratory biscuits by seven assessors from the Food Science department,

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relying on the established qualitative characteristics of the biscuits.

Physical characteristics of the standard cake :Specific volume measurement(s.v.): The method described by Al ali, 2018 was adopted to calculate the specific volume of baked goods. Cake pieces were weighed, and the volume was determined using the displacement method with rapeseed displacement. The specific volume was then calculated according to the following equation:

$$\mathrm{S.\ V.}\,(cm^3 g^{-1}) = \frac{\mathrm{V.\ E.R.\,(cm3)}}{\mathrm{W.Cp.\,(g)}}$$

W.CP.=weight of cake piece, V.E.R = volume of excluded rapeseed

Cake density measurement: The method described by Hedayati *et al*., 2018 was followed to calculate the density by dividing the weight of the cake piece (g) by its volume (cm^3) using the following equation:

$$\mathrm{Cake\ Density}(\mathrm{g/\ cm^3}) = \frac{\mathrm{Weight(gm)}}{\mathrm{Volume(cm^3)}}$$

Measurement of weight loss percentage after baking: The percentage of weight loss after baking was determined according to the method described by Al-Muhayawi ,2023 using the following equation:

$$\mathrm{W.\ L.\ \%} = \frac{\mathrm{W.Cp.B.B.} - \mathrm{W.Cp.A.B}}{\mathrm{W.Cp.B.B.}}\, x\ 100$$

W.L.=weight loss, W.Cp.B.B.=weight of cake piece before baking, W.Cp.A.B= weight of cake piece after baking.

Color degree measurement: The color characteristics of the surface and crumb of the standard cake were measured as described in section 2.2.3.2.

Sensory evaluation of cake: The sensory evaluation form mentioned by Jassim *et al*. ,2016 was used for the sensory evaluation of both rice and wheat cakes.

Statistical analysis: The Statistical Analysis System (SAS) program (SAS. 2018) was employed for data analysis to study the impact of different factors on the evaluated characteristics using a Completely Randomized Design (CRD). The significant differences between means were compared using the Least Significant Difference (LSD) test.

RESULTS AND DISCUSSION

The physical properties of biscuits

Table (1) illustrates the physical properties of the biscuits produced from wheat and rice flour, including thickness, diameter, and spread ratio. The results of the wheat biscuit treatments (WB0, WB1, WB2, and WB3) showed a decrease in biscuit thickness with an increase in the modified starch substitution, except for treatment WB3, which demonstrated a significant difference from the other samples. Where the results were (5.40, 5.40, 4.60, 4.00 cm) respectively. This was reflected in the diameters of the studied biscuit samples, which increased with increasing replacement rates, achieving statistical significance (P ≥ 0.05) for treatment WB3 (48.30 cm). The spread ratio also increased with the increase in rates of replacing wheat flour with modified starch. There were no significant differences between the treatments except for treatment WB3, with spread ratios of (7.78, 8.00, 9.78, 12.08) respectively. For the Rice Biscuits, it is observ from Table (1) that the biscuit thickness values increased with the substitution ratio with 10- 20% in treatments RB1 and RB2 compared to the control treatment (RB0), but without achieving statistical significance. However, it decreased significantly at the 30% replacement rate in the RB3 treatment. The respective thickness values were (4.70, 5.40, 5.00, 3.50 cm) respectively. The diameters values of the six rice biscuit samples and their spread ratios converged with the wheat biscuit treatments as the substitution ratios increased. Table 1 indicates that the overall results of the rice biscuit treatments (diameter and spread ratio) were higher compared to the wheat treatments. This is attributed to the absence of gluten and the role of xanthan gum, providing higher elasticity to the biscuits, allowing for more expansion.

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Table 1. Effect of partial replacing of wheat and rice flour by enzymatically modified starch on the characteristics (thickness, diameter, and diffusion coefficient) of biscuits manufactured from wheat and rice flour

Treatments	Thickness (cm)	Width cm	spread ratio
Biscuit treatments manufactured from replacing wheat flour by different ratio of enzymatically modified wheat starch			
WB0	5.4 a	42.0 b	7.7 b
WB1	5.4 a	43.2 b	8.0 b
WB2	4.6 ab	45.0 ab	9.7 b
WB3	4.0 b	48.3 a	.121 a
L.S.D.	.11*	.37*	.22*
Biscuit treatments manufactured from replacing rice flour by different ratio of enzymatically modified rice starch			
RB0	4.7 a	37.08 c	7.89 b
RB1	5.4 a	46.80 b	8.66 b
RB2	5.0 a	50.20 ab	10.04 b
RB3	3.5 b	54.00 a	15.42 a
L.S.D.	.12*	5.1*	2.96*
.(P≤0.05) *			

WB0: Control sample for wheat biscuit, WB1:10% substitution with modified wheat starch, WB2 : 20% substitution with modified wheat starch, WB3:30% substitution with modified wheat starch, RB0:Control sample for rice biscuit, RB1: 10% substitution with modified rice starch, RB2:20% substitution with modified rice starch, RB3:30% substitution with modified rice starch. The results of this study aligned with the findings of Cihadiye and Erbas, 2019, who reported that increasing the substitution ratios of wheat flour with ultrasound-resistant starch led to a decrease in biscuit thickness from 3.90 cm in the control treatment to 2.40 cm and 2.50 cm at substitution ratios of 25% and 50%, respectively.

The same source also indicated a noticeable increase in the diameter of biscuits with higher replacement rates, as the diameter increased from 43.20 cm for the control sample to 46.60 cm and 47.90 cm at the same replacement rates. Consequently, the spread coefficient of the biscuits increased from 11.07 for the control sample to 19.16 when using a 50% substitution ratio. This was attributed to the deformation (denaturation) of the proteins in the ultrasound- resistant starch during the treatment, as proteins play a role in supporting the structure of the biscuit (due to the role of gluten in imparting elasticity to the dough). Therefore, the loss of part of the protein present in the biscuit dough due to denaturation weakens the gluten network, allowing the starch to expand more, resulting in an increase in diameter due to reduced thickness and the proteins' reduced ability to trap gas. Kiana *et al.*, 2018 pointed out that increasing the protein content in flour may reduce the diameter and volume of biscuits after the baking process, resulting in an overall decrease in the spread ratio of the biscuits. This is attributed to the gas expansion weakening due to the tight regulation of the gluten network. Therefore, the size of biscuits manufactured from wheat flour, where partial substitution was made with various ratios of resistant corn starch, was significantly higher than the biscuits partially substituted with resistant wheat starch. They emphasized that the mitigating effect of resistant starch on wheat flour proteins tends to provide a larger volume and higher spread ratio. **Color:** Table (2) appears color values of biscuits produced from wheat and rice flour partially substituted with modified wheat and rice starch enzymatically. Increasing the substitution ratios led to the production of darker-colored biscuits compared to control treatments (WB0 and RB0), with a significant differences. For wheat biscuits, the whiteness degree of the crust ranged from (77.17, 68.29, 62.10, 60.25) for treatments (WB0, WB1, WB2, WB3) respectively. As for rice biscuits, the whiteness values for treatments (RB0, RB1, RB2, RB3) were (73.98, 67.58, 64.67, 62.31) respectively. The golden brown color of the biscuits is attributed to Maillard reactions and caramelization reactions initiated during the baking process. These reactions result from the formation of structured polymers or melanoidins through the interaction of reducing sugars and amino acids.

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Table 2. Effect of partial replacing of wheat and rice flour by enzymatically modified starch on the color of biscuits manufactured from wheat and rice flour according to the Lab colorimeter

Treatments	Crust color			
	a*	b*	L*	L/b
Biscuit treatments manufactured from replacing wheat flour by different ratio of enzymatically modified wheat starch				
WB0	3.59 c	19.26 b	77.17 a	4.00 a
WB1	4.81 bc	22.35 ab	68.29 b	3.05 ab
WB2	5.19 b	22.74 ab	62.10 c	2.73 ab
WB3	6.57 a	26.38 a	60.25 c	2.28 b
L.S.D.	1.237 *	4.722 *	5.647 *	1.294 *
Biscuit treatments manufactured from replacing rice flour by different ratio of enzymatically modified rice starch				
RB0	4.17 b	13.15 b	73.98 a	5.62 a
RB1	6.25 a	16.82 b	67.58 b	4.01 ab
RB2	6.76 a	23.09 a	64.67 bc	2.80 b
RB3	6.18 a	25.49 a	62.31 c	2.44 b
L.S.D.	1.207 *	4.968 *	5.021 *	1.863 *
.(P≤0.05) *				

WB0: Control sample for wheat biscuit, WB1:10% substitution with modified wheat starch, WB2:20% substitution with modified wheat starch, WB3:30% substitution with modified wheat starch, RB0: Control sample for rice biscuit, RB1:10% substitution with modified rice starch, RB2:20% substitution with modified rice starch, RB3: 30% substitution with modified rice starch

Although Maillard reactions occur throughout the biscuit dough, the brown color appears more intensely on the outer surface due to the high temperatures it experiences during baking process, accompanied by a decrease in moisture content (Laura *et al.*,2011; Dipesh *et al*.,2018).The published literature indicated that biscuits produced with increasing proportions of resistant starch were whiter than the control treatment. This was attributed to the increase in levels of substitution with resistant starch, leading to a reduction in the protein content in the biscuit dough, resulting in a decrease in Maillard reactions. Laura *et al*., 2011 found that when producing biscuits from wheat flour with substitution rates ranging from 0, 20, 40, to 60% of high-amylose resistant corn starch (Hi-maize 260), recorded whiteness values ranged from 66.0, 70.4, 70.8, to 71.8. On the other hand, Rafael *et al*., 2020 mentioned a decrease in the L* values of bread crust produced from wheat flour with a 20% substitution of green banana flour rich in resistant starch, dropping from 66.1 to 48.4. The redness degree for wheat biscuits ranged from 3.59 to 6.57, and for rice biscuits from 4.17 to 6.18. As for the yellowing degree b*, it varied for wheat biscuits from 19.26 to 26.38 and for rice biscuits from 13.15 to 25.49. This can be attributed to the presence of gluten proteins, in addition to rice biscuits retaining more moisture due to the use of xanthan gum (water-loving). The results of this study were lower than those reported by Cihadiye and Erbas, 2019 as the yellowing degree of wheat biscuits substituted with 25% resistant starch was 31.6.

Sensory evaluation of biscuits:

The results in table (3) indicate the sensory characteristics of biscuits manufactured from wheat and rice flour. The external properties include symmetry of form , nature of the cracks on the upper surface, spread coefficient, and crispness. The internal properties include aroma and taste, and crumb color. The results show that most of the treatments were similar in terms of external properties and did not show significant differences, except for treatment RB3. As for the cracks on the upper surface, it was similar in the treatments of wheat flour, except for treatment WB2, in which this characteristic increased without significant differences. This trait provides an idea about the quality of the soft flour used in biscuit production, reflecting the weak cohesion of the ingredients, resulting in a desired brittleness. As for rice biscuits, an increase in the surface cracks were observed with an increase in the substitution ratio, showing significant differences compared to the control treatment RB0, which had a less

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cracked surface.The results also indicates an increase in the moisture content of wheat and rice biscuits, with no significant differences up to a substitution ratio of 30% in treatment WB3 and 20-30% in treatments RB2 and RB3. They became more elastic and viscous, registering significant differences. The spread ratio increased with the rise in the substitution ratio due to a decrease in the protein content, as previously explained. Table (3) indicates that wheat flour biscuits (WB0, WB1, WB2) and rice flour biscuits (RB0, RB1, RB2) are similar in aroma and flavor characteristics (without significant differences). However, other properties in these treatments decreased, including the crumb color, with increased substitution levels.

Table 3. Effect of partial replacing of wheat and rice flour by enzymatically modified starch on Sensory Evaluation of Biscuits manufactured from wheat and rice flour

Trait	Biscuit treatments manufactured from replacing wheat flour by different ratio of enzymatically modified wheat starch						Biscuit treatments manufactured from replacing rice flour by different ratio of enzymatically modified rice starch				
	Degre	WB0	WB1	WB2	WB3	L.S.	RB0	RB1	RB2	RB3	L.S.D.
Symmetry of form	20	20 a	20 a	20 a	18 a	2.17 NS	20 a	19 a	19 a	15 b	2.76 *
Surface Cracks	10	9 a	9 a	10 a	9 a	1.55 NS	8 b	9 a	9 a	10 a	1.68 *
Crispness	10	10 a	10 a	10 a	7 b	1.82 *	10 a	10 a	8 b	7 b	1.55 *
Aroma and taste	20	20 a	20 a	19 a	16 b	2.60 *	20 a	20 a	18 a	15 b	2.79 *
Crumb color	10	9 ab	10 a	9 ab	8 b	1.42 *	9 a	10 a	9 a	7 b	1.64 *
Spread Factor	30	26 b	28 ab	29 a	30 a	2.89 *	28	29	29	30	2.30 NS
Total	100	94a	97a	97 a	88 b	5.77 *	95 a	97 a	92 a	84 b	5.82 *

.(P≤0.05) *

WB0: Control sample for wheat biscuit, WB1: 10% substitution with modified wheat starch, WB2: 20% substitution with modified wheat starch, WB3: 30% substitution with modified wheat starch, RB0 = Control sample for rice biscuit, RB1: 10% substitution with modified rice starch, RB2: 20% substitution with modified rice starch, RB3: 30% substitution with modified rice starch.

An acidic flavor developed, possibly attributed to the nature of the environment during the enzymatic treatment of modified starch, along with a darker color and increased product hardness. Reflecting on the above observations, wheat flour biscuits (WB0, WB1, WB2) achieved the highest sensory acceptance scores, as well as rice flour biscuits (RB0, RB1, RB2) with no significant differences between treatments. At the same time, the reduction observed in treatments (WB3, RB3) was not substantial despite achieving statistical differences compared to previous treatments. However, it still exceeded the acceptable limit of palatability (more than 50%), making it an acceptable product. In a study by Pinky,2019 a moderate decrease in sensory acceptability scores was noted when using concentrations of up to 30% resistant starch in biscuits. This was due to changes in sensory characteristics such as color, hardness, and appearance. Furthermore, affirmed that replacing 20% of wheat flour with resistant starch did not affect dough flowability, and consumer acceptance of the biscuits was good with insignificant differences. However, higher substitution levels, especially 60%, resulted in significant and undesirable hardness in the dough.

The physical properties of the cake

Table (4) presents the physical properties of the cupcake manufactured from wheat and rice flour, along with the substitution of wheat and rice modified starch at ratios (0, 10, 20, 30) %, , represented by weight, volume, specific volume and density. The weight provides an indication of the product's moisture retention. It is observed that the weight of the cake

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pieces decreases before baking with an increase in the substitution percentage. This indicates a decrease in the modified starch's ability to bind water in treatments WC1, WC2, WC3 compared to the control treatment WC0 by (44.01, 43.99, 43.50) respectively. This illustrates the reason for the decrease in the amount of water needed to achieve ideal dough compared to the control treatment, without recording significant differences. The variation in weight loss after baking for wheat cake increases with the rise in the substitution percentage. The highest moisture loss was recorded in treatment WC1, without significant differences between its treatments and the control sample, which showed a decrease of (12.79, 15.47, 12.52, 12.80%) respectively. This indicates the role of natural starch and vital gluten in their ability to retain water compared to the added modified starch. The weight loss percentage after baking wheat cake, there were no significant differences between treatments and the control sample.

Table 4. Effect of partial replacing of wheat and rice flour by enzymatically modified starch on the characteristics (weight, volume, specific volume, and density) of cupcake manufactured from wheat and rice flour

Treatments	Weight before baking gm	Weight after baking gm	Weight loss % after baking	Volume (cm^3)	specific volume cm^3/gm	Density gm/cm^3
Cupcake treatments manufactured from replacing wheat flour by different ratio of enzymatically modified wheat starch						
WC0	46.65	40.68	12.79	140.00 a	3.44 a	0.29
WC1	44.01	37.20	15.47	118.75 b	3.19 ab	0.31
WC2	43.99	38.48	12.52	115.62 b	3.00 ab	0.33
WC3	43.5	37.90	12.8	98.75 c	2.60 b	0.38
L.S.D.	3.22 NS	3.07 NS	0.502 NS	14.68 *	0.651 *	0.106 NS
Cupcake treatments manufactured from replacing rice flour by different ratio of enzymatically modified rice starch						
RC0	45.9	41.27	11.21	96.66 a	2.34 a	0.42 b
RC1	46.61	41.87	11.32	86.66 a	2.06 ab	0.48 ab
RC2	46.44	41.61	10.52	86.66 a	2.08 ab	0.48 ab
RC3	45.98	41.34	11.22	66.66 b	1.61 b	0.62 a
L.S.D	3.18 NS	2.95 NS	0.977 NS	12.56 *	0.547 *	0.185 *
.(P≤0.05) *						

WB0: Control sample for wheat biscuit, WB1: 10% substitution with modified wheat starch, WB2: 20% substitution with modified wheat starch, WB3: 30% substitution with modified wheat starch, RB0: Control sample for rice biscuit, RB1: 10% substitution with modified rice starch, RB2: 20% substitution with modified rice starch, RB3:30% substitution with modified rice starch.

The highest recorded value was 15.47% at a 10% substitution rate. Similarly, for rice cake, no significant differences were observed between treatments and the control sample, with the highest reading at 11.32% for a 10% substitution rate. Regarding the volume, the results indicate significant differences in the average volumes of wheat and rice cake pieces. The volume gradually decreased with the increase in the substitution percentages of flour with modified starch compared to the control treatment, showing significant differences. The volume for wheat cake treatments was (140.0, 118.75, 115.62, 98.75) cm3 respectively, while for rice cake treatments, it was (96.66, 86.66, 86.66, 66.66) cm3 respectively. Baixauli *et al.*, 2008 indicated a decrease in the height of baked muffins, along with a reduction in volume and softness. This was attributed to the reduction in gluten with an increase in the substitution percentage of flour with resistant starch, leading to insufficient development of the gluten network as required (resulting in less cohesive dough) during the mixing process. This could limit the increase in dough volume and the stability of gas cells during baking, ultimately resulting in product collapse. Tawheed *et al.*, 2023 reported a decrease in the size of the cake when using enzymatically treated wheat flour compared to the control sample, from 113.4 to 94.3 cm^3. They clarified that the protein content plays a crucial role in forming and stabilizing the foam in the cake,

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thereby achieving the desired volume. The volume reflects the amount of air that can be trapped inside the product, and several factors can affect it. An increase in the percentage of resistant starch may reduce the protein content, leading to the compression of the crumb matrix and, consequently, a decrease in volume. Additionally, resistant starch may result in the formation of large bubbles that could burst in the oven, causing another reason for the collapse of the cake. The values of weight and volume were reflected on the specific volume of the cake , where observed that the specific volume decreased, recording the lowest values for treatments (WC3 and RC3) with a significant difference from the other treatments, measuring (2.60 and 1.61) cm3/g, respectively. Indicated that the early starch gelatinization is the main factor in determining the size and quality of the cake. They also explained that one of the properties of resistant starch is its resistance to gelatinization during the baking process. Furthermore, they pointed out that the decrease in cake volume is associated with a decrease in dough density and consistency, which occurs due to the reduction in gluten concentration in the dough when replaced with resistant starch. Resistant starch cannot fully compensate for the performance of gluten (which has a higher water-binding capacity), and as a result, free water causes a decrease in dough density. The very low or very high density of the dough is related to the quality of the cake. If the density is too low, the dough cannot retain air bubbles during baking, and if it is too high, it will not allow the required expansion during baking.. The preliminary results indicate an increase in density values for wheat cake without recording significant differences between treatments. As for the rice cake, an increase in cake density is observed, ranging from 0.42 to 0.62 g/cm3, with significant differences. This increase is associated with the substitution level of rice flour with modified starch and the decrease in volume. The current findings align with those of, similar trend when substituting part of wheat flour with resistant corn starch at replacement percentages (0, 10, 20, 30%). In that study, cake density increased from 0.37 to 0.40 g/cm3, corresponding to a decrease in volume from 552.70 to 512.10 cm3 (considering the weight of each cake piece before baking as 250 g). **Color :** Results in Table (5) show the color parameters for the crust and crumb of cakes produced from wheat flour, rice flour, partially replaced with wheat and rice modified starch (enzymatically modified).

Table 5. Effect of partial replacing of wheat and rice flour by enzymatically modified starch on the color of the crust and Crumb of cupcake manufactured from wheat and rice

Treatments	Crust color				Crumb color			
	a*	b*	L*	L/b	a*	b*	L*	L/b
Cupcake treatments manufactured from replacing wheat flour by different ratio of enzymatically modified wheat starch								
WC0	3.77 c	20.04 bc	77.53 a	3.86 a	1.32 b	12.33 b	76.91 a	6.23 a
WC1	10.27 a	29.91 a	66.58 b	2.22 b	2.33 b	14.74 b	81.17 a	5.50 a
WC2	6.92 b	24.40 b	54.61 c	2.23 b	5.62 a	18.81 a	63.94 b	3.39 b
WC3	1.97 c	17.04 c	35.72 d	2.09 b	5.98 a	17.53 ab	47.72 c	2.72 b
L.S.D.	2.78 *	4.62 *	7.84 *	0.762 *	1.882 *	2.905 *	7.521 *	2.094 *
Cupcake treatments manufactured from replacing rice flour by different ratio of enzymatically modified rice starch substitution								
RC0	6.27 a	22.87 a	78.35 a	3.42 ab	1.05 b	9.13 b	82.78 a	9.06 a
RC1	4.73 ab	15.35 b	57.39 b	3.73 ab	1.60 b	14.53 a	68.69 b	4.72 b
RC2	4.04 b	11.96 bc	46.48 c	3.88 a	2.17 b	11.73 b	50.58 c	4.31 b
RC3	2.91 b	10.05 c	32.83 d	3.26 b	6.97 a	14.00 ab	37.97 d	2.71 b
L.S.D.	2.16 *	3.75 *	7.37 *	0.591 *	2.066 *	2.73 *	6.913 *	2.538 *

.(P≤0.05) *

WB0: Control sample for wheat biscuit, WB1: 10% substitution with modified wheat starch, WB2: 20% substitution with modified wheat starch, WB3: 30% substitution with modified wheat starch, RB0: Control sample for rice biscuit, RB1: 10% substitution with modified rice starch, RB2: 20% substitution with modified rice starch. RB3: 30% substitution with modified rice starch

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The table reveals color results for the crust of wheat and rice cakes, where the L* value gradually decreased with the increase in substitution percentage, showing a significant difference. The *a redness value increased for the treatment (WC1) of wheat cake, significantly differing from the control treatment, then gradually decreased until recording (1.97) in treatment (WC3). In rice cake, the Values decreased with increasing substitution percentages, ranging from (6.27 to 2.91). As for the *b yellowness value, it ranged for wheat cake from (20.04 to 17.04) and for rice cake from (22.87 to 10.05). The results of the current study, with the exception of treatments (WC3 and RC3), were higher than those reported by Hedayati *et al*., 2018. Found that the *L whiteness values for the crust color of sponge cake produced from wheat flour and replaced with corn starch high in amylose (at substitution percentages of 0, 30, 40, 50%) increased without recording significant differences at 30% and 40% concentrations compared to the control treatment. However, the 50% substitution rate showed a significant difference compared to the other treatments, measuring (40, 39.7, 41.3, and 49.3). This was attributed to the high baking temperature, exceeding 150°C, which enhances reactions between reducing sugars and amino acids in the crust, known as Maillard reactions, and caramelization of sugars, both contributing to the crust color. The results also showed that the crumb color in wheat and rice cakes had higher *L values (whiter), ranging for wheat cake (76.91 - 47.72) and for rice cake (82.78 - 37.97), both significant recording differences compared to the control sample. As for redness and yellowness readings, they increased with the increase in the substitution percentage.

Sensory evaluation of the cake

Results in Table (6) illustrate the sensory characteristics of cakes manufactured from wheat and rice flour partially replaced with enzymatically treated modified starch at percentages (0, 10, 20, 30%). The results did not show significant differences in crust color, crumb softness, texture moistness, and crumb color for wheat cake treatments. However, concerning the symmetry of form, section homogeneity, aroma and taste, and acceptbility, treatments (WC1 and WC2) did not exhibit significant differences compared to the control treatment, while treatment (WC3) showed a significant difference from the other treatments. The regularity of the crumb texture (porosity) in treatments (WC2 and WC3) showed a significant difference from the rest treatments. The overall evaluation results indicate that there are no statistically significant differences between the control sample and the samples containing modified starch, with the exception of the treatment (WC3). Some members of the judging panel expressed a preference for the cake treatment with a 20% substitution rate (WC2), as the addition did not impact the sensory properties.The sensory values for the rice cake showed no significant differences in the treatments such as crumb softness and crumb color compared to the control sample. However, properties like section homogeneity, moistness, crumb texture, aroma and taste, and l acceptability revealed that treatment (RC3) was the only treatment that exhibited a decrease in readings and recorded a significant difference compared to the other treatments. It is not able that, in terms of symmetry of form for treatment (RC3), there was a noticeable decrease in volume, leading to surface concavity. Indicated, the decrease in cake volume is associated with a reduction in density, and thus, a loss of symmetrical shape with an increase in substitution rate. They also pointed out that a decrease in protein content with an increase in substitution rate may reduce the mechanical energy associated with cake structure formation.

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Table 6. Effect of partial replacing of wheat and rice flour by enzymatically modified starch on the Sensory evaluation of cupcake manufactured from wheat and rice.

Treatments		cupcake treatments manufactured from replacing wheat flour by different ratio of enzymatically modified wheat starch					cupcake treatments manufactured from replacing rice flour by different ratio of enzymatically modified rice starch				
	Degree	WC 0	WC1	WC2	WC3	L.S.D.	RC0	RC1	RC2	RC3	L.S.D.
Symmetry of form	10	10 a	10 a	10 a	7 b	1.62 *	10 a	10 a	9 a	7 b	1.65 *
Crust Color	10	10	10	10	9	1.16 NS	9 ab	10 a	8 b	8 b	1.59 *
Crumb Softness	10	10	10	10	9	1.06 NS	9	9	8	8	1.19 NS
Section Homogeneity	10	10 a	10 a	9 a	6 b	2.18 *	10 a	10 a	9 ab	8 b	1.74 *
Moistness	10	10	10	10	9	1.06 NS	10 a	9 ab	9 ab	8 b	1.61 *
Crumb Texture (Porosity)	10	10 a	10 a	8 b	8 b	1.53 *	10 a	10 a	9 ab	8 b	1.67 *
Crumb Color	10	10	10	9	9	1.07 NS	10	10	9	9	1.07 NS
Aroma and Taste	20	20 a	20 a	19 a	15 b	2.88 *	20 a	20 a	19 a	16 b	2.85 *
Acceptbility	10	10 a	10 a	9 a	7 b	1.64 *	10 a	10 a	9 a	7 b	1.64 *
Total	100	100 a	100 a	94 a	79 b	7.42 *	98 a	98 a	89 b	79 c	6.59 *

.(P≤0.05) *

WB0: Control sample for wheat biscuit, WB1:10% substitution with modified wheat starch, WB2: 20% substitution with modified wheat starch, WB3: 30% substitution with modified wheat starch, RB0: Control sample for rice biscuit, RB1: 10% substitution with modified rice starch, RB2: 20% substitution with modified rice starch, RB3: 30% substitution with modified rice starch.

Literature suggests that incorporating RS at 10% and 20% ratios adds smoothness to the product's texture and increases consumer preference. On the other hand, there was a significant decrease in product acceptance at a 30% substitution rate due to the negative effects of resistant starch on the physical attributes of the cake, such as decreased volume, softness, structural integrity, external shape, and chewiness.

CONCLUSION

The study demonstrated that partial substitution of wheat and Amber rice flour with enzymatically modified starch affected the physical and sensory properties of biscuits and cupcakes. Moderate substitution levels maintained acceptable quality attributes comparable to the control samples. Higher substitution levels negatively influenced texture, color, volume, and flavor, leading to reduced product acceptability. Therefore, enzymatically modified starch can be used effectively at appropriate substitution levels without compromising product quality.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DECLARATION OF FUND

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AUTHOR/S DECLARATION

We confirm that all Figures and Tables in the manuscript are original to us. Additionally, any Figures and images that do not belong to us have been incorporated with the required permissions for re-publication, which are included with the manuscript.-Author/s signature on Ethical Approval Statement

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تأثير الاستبدال الجزئي لطحين الحنطة والرز بالنشا المحور على الصفات النوعية والحسية للكيك والبسكويت

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المستخلص

هدفت الدراسة الى التعرف على تأثير استبدال دقيق الحنطة ورز العنبربنسب مختلفة (10، 20, 30 %) من النشا المحور أنزيمياً في الصفات النوعية والحسية للبسكويت وكيك الاقداح .أظهرت النتائج انخفاض سمك بسكويت القمح مع زيادة نسبة الاستبدال المستحصلة مع تسجيل المعاملة بنسبة الاستبدال 30% فرقاً معنوياً بالمقارنة مع الاخريات، بالمقابل حصلت زيادة في مقياس عرض اقراص البسكويت وكانت تتراوح (42.00–48.30 سم) وكذلك معامل الانتشار،إذ حققت المعاملة بنسبة الاستبدال 30% فرقاً معنوياً عن بقية المعاملات. أما بسكويت الرز فقد ارتفعت قيم مقاييس العرض ومعامل الانتشارمع زيادة نسب الاستبدال. وأشرت نتائج التقييم الحسي تحقيق المعاملات بنسب الاستبدال (0، 10 ،20)% لعينات بسكويت الرز والقمح تماثل في جودة الطعم والنكهة وتجانس المظهر الخارجي ولون اللب. بينما المعاملات بنسب الاستبدال 30% لكلا النوعين اظهرت لوناً داكناً وزيادة بالصلابة بالاضافة الى تطورالنكهة الحامضية.أما بالنسبة لكيك الاقداح انخفضت قيم الحجم النوعي مع ارتفاع نسب الاستبدال اذ سجلت أعلى القيم لكيك القمح عند نسب الاستبدال 10و20% وكانت (3.19 و3.00 سم3/غم) على التوالي، وسجلت اقل القيم للمعاملات WC3 وRC3 وكانت (2.60 و1.61 سم3/غم)على التوالي. وبينت نتائج التقييم الحسي لصفات الطراوة ونعومة النسجة و لون اللب والقصرة عدم وجود فروقات معنوية مقارنة بعينة السيطرة، أما المعاملات بنسب الاستبدال 10 و20% فكانت متماثلة من حيث انتظام الشكل الخارجي وتجانس المقطع والطعم والطراوة، في حين شهدت نسبة الاستبدال 30% تراجع ملحوظ في تقبل المنتوج نتيجة لانخفاض الحجم والنعومة في كيك الاقداح وانخفاض في تجانس المقطع بالاضافة الى لون داكن ونكهة غيرمفضله

الكلمات المفتاحية: انزيم البولولانيز، المخبوزات، النشا المقاوم.