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QUALITY CHARACTERISTICS OF CORN TORTILLA PREPARED WITH DIFFERENT LEVELS OF RICE BRAN PROTEIN CONCENTRATE

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ABSTRACT: ***This study was conducted to evaluate the possibility of partial replacement of yellow corn flour with rice bran protein concentrate (RBPC) to prepare highly nutritive and acceptable tortilla. The crude protein and total ash contents of tortilla were increased (p ≤ 0.05) by increasing the level of RBPC in a tortilla. However, total carbohydrates, crude fat and crude fiber had an opposite trend. The caloric values of tortilla were not affected (p > 0.05) by RBPC. Alkaline water retention capacity of the tortilla was increased (p ≤ 0.05) by increasing RBPC levels in the tortilla. However, it was decreased (p ≤ 0.05) by increasing the storage period from 24 to 72 hours. Tortilla prepared with RBPC had darker color than control tortilla. Tortilla prepared with 7.5% RBPC had higher lysine (27.31%) and tryptophan (33.33%) than control tortilla. In-vitro protein digestibility of tortilla was increased (p ≤ 0.05) by increasing the RBPC up to 7.5%. Control tortilla had sensory rating scores ranged from 4.35 (neither like nor dislike) to 6.75 (like very much) for all sensory properties. However, tortilla prepared with 7.5% RBPC had rating scores ranged from 5.35 (like moderately) to 6.95 (like very much) for all sensory properties. The results showed that partial replacement of corn flour with 7.5% of RBPC resulted in an improvement in the nutritive value and overall acceptability of the tortilla.***

Key words: ***Corn flour, rice bran protein concentrate, tortilla, lysine, overall acceptability***

INTRODUCCTION

Rice bran protein concentrate is a good source of lysine and methionine and can be used as an effective tool to supplement the lysine and methionine deficient foods such as wheat, maize and sorghum (Sohail *et al.,* 2017). Rice bran is a rich source of B-vitamins and minerals such as potassium, calcium, magnesium and iron (Michael *et al.,* 2013). Rice bran protein is a good source of well-balanced amino acid and bioactive phytochemicals such as γ-oryzanol, tocopherols, tocotrienols, phytosterols and phenolic compounds that have antioxidant activities, as well as other reported health-beneficial properties (Rohrer and Siebenmorgen, 2004 and Sohail *et al.,* 2017). Flours with 11.0–11.5% protein content yielded more shelf-stable tortillas (Waniska *et al.,* 2004). Addition of commercial wheat protein fractions to the tortilla formulation improves tortilla shelf-stability (Pascut *et al.,* 2004 and Alviola *et al.,* 2008). Supplementation of corn flour with different levels of chia flour improved the nutritive value of tortilla (Rendon-Villalobos *et al.,* 2012). Montemayor-Mora *et al.* (2018) reported that enrichment wheat flour with 5 or 10%

of soybean residue improved lysine and dietary fiber contents of a wheat flour tortilla.

Due to the nutritional deficiency in corn tortilla the current study was designed to incorporate different levels of RBPC in preparation of corn tortilla. The proximate composition, physical properties, color, alkaline water retention capacity, in-vitro protein digestibility, textural profile and sensory properties of tortilla were evaluated.

MATERIALS AND METHODS

Materials

Yellow corn flour was obtained from Zamzam for Food Industries Co., El-Mokatm, Cairo Governorate, Egypt. Rice bran (*Oryza sativa* L.) was obtained from the Rice Research and Training Center, Sakha, Kafr El-Sheikh Governorate, Egypt.

Methods

Preparation of rice bran protein concentrate

Fresh rice bran was defatted twice using hexane according to Wang *et al.* (1999). The rice bran and solvent ratio was 1:3 (w/v). The mixture was shacked at room temperature (~25°C) for 30 min. The defatted rice bran was dried at room temperature (~25°C) overnight, then ground to sieve through a 60 mesh screen.

The defatted rice bran was added to distilled water at 1:4 w/v ratios. The pH of the mixture was adjusted to pH 10.0 (sodium hydroxide 0.1N). The mixture was shacked at room temperature (~25°C) for 30 min then centrifuged (Beckman J2-MC, USA centrifuge) at 3000 rpm for 30 min. The pH of the supernatant was adjusted to pH 4.0 (HCl 0.1N) then centrifuged at 3000 rpm for 30 min. The pH of the precipitate was adjusted to pH 7.0 (HCl 0.5N) then washed three times using distilled water and centrifuged at 3000 rpm for 30 min after each washing time. The precipitate was frozen at -10ºC overnight then dried using freeze-dryer (Freeze dryer, Flexi-Dry µP FTS ™system). The RBPC was packed in polyethylene bags and kept at -5ºC until use.

Preparation of tortilla

Corn tortilla was prepared as described by Rendón-Villalobos *et al.* (2009). One hundred gram of yellow corn flour and 2 ml of corn oil were mixed for 2 min on the hot plate. Boiled water (120 ml) was added to corn flour-corn oil mixture with mixing until forming the dough. The dough was cut into pieces each piece weighed 35g. Each piece is formed into a round thin layer with 1 mm thick. The formed dough was baked on a hot plate at 250°C for 30s on the first side and 40s for the second side. The baked tortilla was cooled at room temperature (~25°C) for 3 min then frozen at –18°C until use.

To prepare yellow corn flour-rice bran protein concentrate composite flour tortillas, the yellow corn flour in the control tortilla formula was replaced with different levels of rice bran protein concentrate (2.5, 5, 7.5 and 10%). The same procedure described above for the control tortilla was followed.

Analytical methods

Proximate composition

Moisture, crude protein, crude fat, total ash, and crude fiber contents were determined in rice bran protein concentrate, corn flour and tortilla according to the method described by AOAC (2010). The total carbohydrate was calculated by difference.

Amino acid profiles

Amino acids profiles of tortilla were carried out according to the AOAC (2010) using an Amino Acid Analyzer (Biochrom 30).

Tryptophan was determined according to the methods of Hernandes and Bates (1969) as follows:
Lysine = tryptophan × (3.04 + 0.5)

In-vitro protein digestibility

In-vitro protein digestibility was determined according to method described by Aksson and Stammann (1983).

Alkaline water retention capacity

Alkaline water retention capacity of tortilla was determined according to the method of Kitterman and Rubentholar (1971). Alkaline water retention capacity was determined at zero, 24, 48 and 72 h of storage at room temperature (~25°C).

Color

Color of tortilla was measured using reflectance colorimeter (model CR-400, Konica Minolta, Japan). The color profile system of lightness (L*, 100 lightness to zero darkness), redness (a*, (−) green to (+) red) and yellowness (b*, (−) blue to (+) yellow) was used.

The total color difference from the control (ΔE) was calculated as follows:

$$\Delta E = \sqrt{(L_o^* - L^*)^2 + (a_o^* - a^*)^2 + (b_o^* - b^*)^2}$$

0 = color reading for control

Sensory properties

Ten trained panelists were used for evaluating the sensory properties of tortilla. The coded samples were served to each panelist. The color, odor, taste, texture and overall acceptability were measured for the tortilla. Seven points hedonic scale was used for each trait where 7 = like extremely, 6 = like very much, 5 = like moderately, 4 = neither like nor dislike, 3 = dislike moderately, 2 = dislike very much and 1 = dislike extremely.

Statistical analysis

Data were presented as the mean ± standard deviations. Data of sensory properties were the mean of ten replicates. However, other data were the mean of three replicates except for amino acids. Alkaline water retention capacity was analyzed by two-way analysis of variance using Costat version 6.311 (Copyright 1998-2005, CoHort software). The other data were analyzed by one-way analysis of variance. The LSD test was used for comparing among means. The difference among samples was considered significant at the 5% level.

RESULTS AND DISCUSSION

Proximate composition of tortilla

The proximate composition of rice bran protein concentrate, corn flour and tortilla prepared by replacing corn flour with different levels of rice bran protein concentrate was presented in Table (1). The rice bran protein concentrate had higher ($p \leq 0.05$) crude protein and total ash and lower ($p \leq 0.05$) moisture, crude fat, crude fiber, total carbohydrates contents and caloric value than corn flour. Chandi and Sogi (2007) reported that the crude protein content of rice bran protein concentrate was in the range of 47.69–73.14%. The moisture and crude protein contents of corn flour were comparable with the values reported by Argüello-García *et al.* (2017).

The crude protein and total ash contents of tortilla were significantly ($p \leq 0.05$) increased by increasing the level of rice bran protein concentrate in the tortilla. However, total carbohydrates, crude fat and crude fiber had an opposite trend. The increase in crude protein and total ash as well as the decrease in total carbohydrates, crude fat and crude fiber contents might be attributed to the increase in rice bran protein concentrate in tortilla which had higher crude protein and total ash contents and lower total carbohydrates, crude fat and crude fiber contents than corn flour. The similar increase in ash and decrease in fiber were reported by Argüello-García *et al.*

(2017) for the tortillas fortified with nontoxic *Jatropha curcas* flour. Also, the similar increase in crude protein and decrease in the nitrogen-free extract were reported by Acevedo-Pacheco and Serna-Saldı´var (2016) for maize tortilla fortified with 6% defatted soybean.

The caloric values of tortilla were not affected ($p > 0.05$) by replacing corn flour with different levels of rice bran protein concentrate in a tortilla. The increase in protein is compensated by the decreasing in total carbohydrates, where both protein and carbohydrates are given 4 Kcal when calculating the total caloric values. On the other hand, moisture contents were increased ($p \leq 0.05$) by replacing corn flour with rice bran protein concentrate in a tortilla. The increase in moisture content might be attributed to the increase in protein content, which retained more water (Salinas *et al.,* 2011). The moisture contents were within the range 35–50% reported by Agama *et al.* (2004) for tortillas and lower than the values (44.07-47.83%) reported by Argüello-García *et al.* (2017) for the tortillas fortified with nontoxic *Jatropha curcas* flour.

Table (1): Proximate composition and caloric values of rice bran protein concentrate, corn flour and tortilla prepared by replacing corn flour with different levels of rice bran protein concentrate (on the dry weight basis)

	Moisture	Crude protein	Total ash	Crude fat	Crude fiber	Total carbo-hydrates	Caloric values
	(%)						Kcal/100g
[1]RBPC	3.21[b]	72.38[a]	1.96[a]	1.30[b]	0.15[b]	24.21[b]	398.10[b]
	±0.25	±0.26	±0.04	±0.02	±0.04	±0.23	±0.19
Corn flour	8.69[a]	9.17[b]	1.43[b]	2.85[a]	1.17[a]	85.38[a]	403.85[a]
	±0.18	±0.22	±0.07	±0.08	±0.06	±0.21	±0.65
LSD	0.23	0.35	0.10	0.13	0.21	0.42	1.52
Tortilla with different levels of RBPC (%)							
0	36.22[e]	8.08[e]	1.99[e]	2.87[a]	0.99[a]	86.07[a]	402.43[a]
	±0.03	±0.01	±0.05	±0.18	±0.01	±0.21	±2.04
2.5	37.13[d]	9.96[d]	2.21[d]	2.77[b]	0.94[b]	84.12[b]	401.02[a]
	±0.06	±0.05	±0.01	±0.36	±0.06	±0.16	±0.53
5	37.97[c]	11.63[c]	2.26[c]	2.71[c]	0.90[c]	82.50[c]	400.92[a]
	±0.03	±0.04	±0.01	±0.06	±0.05	±0.01	±0.66
7.5	38.34[b]	13.60[b]	2.30[b]	2.60[d]	0.85[d]	80.75[d]	400.66[a]
	±0.06	±0.01	±0.04	±0.02	±0.02	±0.41	±0.38
10	39.08[a]	15.61[a]	2.36[a]	2.54[e]	0.80[e]	78.69[e]	399.66[a]
	±0.05	±0.04	±0.01	±0.01	±0.06	±0.01	±0.46

Means in the same column with different letters are significantly different ($p \leq 0.05$)

In-vitro protein digestibility of tortilla

In-vitro protein digestibility of tortilla prepared by replacing corn flour with different levels of rice bran protein concentrate was presented in Table (2). In-vitro protein digestibility of control tortilla was 41.79%. This value was much lower than the value (72.5%) reported by Acevedo-Pacheco and Serna-Saldı´var (2016) for maize tortilla fortified with 6% defatted soybean and the value (84.9%) reported by Lecuona-Villanueva *et al.* (2012) for tortilla fortified with protein concentrate from *Phaseolus lunatus*. This difference might be due to the corn interspecies variation, growing conditions, storage conditions and the methods of tortilla.

Control tortilla had lower ($p \leq 0.05$) in-vitro protein digestibility than tortilla prepared with rice bran protein concentrate. In-vitro protein digestibility of tortilla was significantly ($p \leq 0.05$) increased by increasing the level of rice bran protein concentrate up to 7.5%. Similar improvement in in-vitro digestibility was reported by Lecuona-Villanueva *et al.* (2012) for tortilla fortified with protein concentrate from *Phaseolus lunatus.* These results have differed from those reported by Serna-Saldivar *et al.* (1988) for maize-decorticated sorghum tortillas fortified with 8% soybean. A non-significant ($p > 0.05$) difference in in-vitro protein digestibility was observed between tortilla prepared with 7.5 and 10% rice bran protein concentrate.

Alkaline water retention capacity of tortilla

Alkaline water retention capacity of tortilla prepared by replacing corn flour with different levels of rice bran protein concentrate was presented in Table (3). Alkaline water retention capacity of the tortilla was significantly ($p \leq 0.05$) increased by increasing rice bran protein concentrate levels. This might be attributed to the retention of water which absorbed by rice bran protein concentrate during the processing of tortilla. However, alkaline water retention capacity of the tortilla was significantly ($p \leq 0.05$) decreased by increasing the storage period from 24 to 72 hours. Kim and D'Appolonia (1977) reported that high protein content often resulted in a lower staling rate. Protein influences the crystallization process of starch directly and the distribution of water.

Table (2): In-vitro protein digestibility of tortilla prepared by replacing corn flour with different levels of rice bran protein concentrate

Replacer levels (%)	In-vitro protein digestibility (%)
0	$41.79^{d} \pm 0.21$
2.5	$56.76^{c} \pm 0.24$
5	$57.87^{b} \pm 0.18$
7.5	$59.06^{a} \pm 0.56$
10	$58.95^{a} \pm 0.43$
LSD	0.63

Means in the same column with different letters are significantly different ($p \leq 0.05$)

Table (3): Alkaline water retention capacity of tortilla prepared by replacing yellow corn flour with different levels of rice bran protein concentrate

Replacer levels (%)	Storage period (Hours)				[1]Means
	0	24	48	72	
0	400.15	383.18	354.19	310.18	$361.93^{e}\pm0.40$
2.5	413.58	399.47	374.44	341.44	$382.23^{d}\pm0.54$
5	423.83	410.72	388.54	366.13	$397.26^{c}\pm0.57$
7.5	421.65	411.64	399.51	387.43	$405.06^{b}\pm0.62$
10	430.22	416.34	404.06	393.54	$411.04^{a}\pm0.55$
[2]Means	$417.89^{a}\pm0.74$	$404.27^{b}\pm0.54$	$384.15^{c}\pm0.41$	$359.74^{d}\pm0.51$	

[1]Means in the same column with different letters are significantly different ($p \leq 0.05$), LSD = 5.413
[2]Means in the same row with different letters are significantly different ($p \leq 0.05$), LSD = 3.842

Similar alkaline water retention results were reported by Saleh *et al.* (2019) for wheat flour pan bread substituted with different levels of pumpkin peeled, El-Gammal and El kewawy (2014) for pan bread fortified with stabilized rice bran (20-40%) and Assem (2013) for corn tortilla substituted with 10-30% millet flour. This result has differed from that reported by Abd El-Kader and Hendawy (2013) as respect to rice bran concentration and it is in good agreement as respect to storage period. The alkaline water retention capacity of tortilla prepared with corn flour at 10% RBPC was increased by 13.67% as compared with control tortilla. However, it reduced after 72 hours of storage period by 13.92%.

Color of tortilla

Tortilla prepared with rice bran protein concentrate had lower ($P \leq 0.05$) lightness (L* = 69.58-80.13) and yellowness (b* = 21.93-30.07) and higher ($P \leq 0.05$) redness (a* = 1.84-4.11) than control tortilla (Table 4). The dark color (lower L* values) of tortilla prepared with different levels of rice bran protein concentrate is attributed to the dark color of rice bran protein concentrate itself compared with corn flour. Increasing the level of rice bran protein concentrate in the tortilla resulted in significant ($P \leq 0.05$) decrease in lightness (L*) and yellowness (b*) values of the tortilla. However, Redness (a*) value was increased. These results are in good agreement with L* and b* values reported by Lecuona-Villanueva *et al.* (2012) for the native maize tortilla fortified with protein concentrate from *Phaseolus lunatus*. Anil (2012) Indicated that Turkish bread supplemented with rice bran had lower L* values and higher a* and b* values as compared to control bread. However, these results have differed from those reported by Argüello-García *et al.* (2017) for fortified corn tortilla dough with nontoxic *Jatropha curcas.*

The total color (the difference from the control, ΔE) of tortilla (3.48-16.84) prepared with rice bran protein concentrate was increased by increasing the level of rice bran protein concentrate in the tortilla formula. These results have differed from those reported by Lecuona-Villanueva *et al.* (2012) who reported that the ΔE values of the native maize tortilla fortified with protein concentrate from *Phaseolus lunatus* were decreased with the of levels protein concentrate.

Sensory properties of tortilla

Non-significant ($p > 0.05$) differences in odor and taste were observed between control tortilla and tortilla prepared by replacing corn flour with rice bran protein concentrate up to 7.5% replacement level

(Table 5). At 10% replacement level, odor and taste of tortilla had lower ($p \leq 0.05$) rating scores than other tortilla samples. The texture (5.06-6.88) and overall acceptability (5.55-6.95) scores of tortilla were improved by replacing corn flour with different replacement levels of rice bran protein concentrate as compared to control (4.45 and 5.10, respectively). The highest ($p \leq 0.05$) texture and overall acceptability scores were observed in tortilla prepared with 7.5% rice bran protein concentrate. The control tortilla had higher ($p \leq 0.05$) color score than tortilla prepared with rice bran protein concentrate.

The color of the tortilla was significantly ($p \leq 0.05$) decreased by increasing the level of rice bran protein concentrate. These results were supported by the results reported in Table 4. Ameh *et al.* (2013) reported that bread supplemented with stabilized rice bran had dark crust and crumb colors. Control tortilla had rating scores ranged from 4.35 (neither like nor dislike) to 6.75 (like very much) for all sensory properties. However, tortilla prepared with 7.5% RBPC had rating scores ranged from 5.35 (like moderately) to 6.95 (like very much) for all sensory properties. Therefore, tortilla prepared with 7.5% rice bran protein concentrate was selected for evaluating essential amino acids as compared with control tortilla. Lecuona-Villanueva *et al.* (2012) reported that fortification of corn tortilla with protein concentrate from *Phaseolus lunatus* improved the nutritive value of tortilla with accepted sensory properties.

Table (4): Color of tortilla prepared by replacing yellow corn flour with different levels of rice bran protein concentrate

Replacer levels (%)	L*	a*	b*	ΔE
0	$83.33^{a} \pm 0.24$	$0.98^{e} \pm 0.01$	$31.13^{a} \pm 0.17$	-
2.5	$80.13^{b} \pm 0.27$	$1.84^{d} \pm 0.09$	$30.07^{b} \pm 0.01$	$3.48^{d} \pm 0.24$
5	$78.79^{c} \pm 0.09$	$2.18^{c} \pm 0.05$	$29.47^{c} \pm 0.11$	$4.98^{c} \pm 0.17$
7.5	$72.32^{d} \pm 0.25$	$2.52^{b} \pm 0.01$	$23.37^{d} \pm 0.10$	$13.56^{b} \pm 0.21$
10	$69.58^{e} \pm 0.18$	$4.11^{a} \pm 0.01$	$21.93^{e} \pm 0.01$	$16.84^{a} \pm 0.18$
LSD	1.16	0.12	0.21	0.34

Means in the same column with different letters are significantly different ($p \leq 0.05$)

Table (5): Sensory properties of tortilla prepared by replacing corn flour with different levels of rice bran protein concentrate

Replacer levels (%)	Color	Odor	Taste	Texture	Overall acceptability
0	$6.65^{a} \pm 0.24$	$6.75^{a} \pm 0.26$	$6.49^{a} \pm 0.31$	$4.35^{e} \pm 0.24$	$5.10^{e} \pm 0.55$
2.5	$6.15^{b} \pm 0.24$	$6.65^{a} \pm 0.36$	$6.33^{a} \pm 0.32$	$5.06^{d} \pm 0.33$	$6.10^{c} \pm 0.41$
5	$5.90^{c} \pm 0.43$	$6.54^{a} \pm 0.27$	$6.23^{a} \pm 0.40$	$5.81^{c} \pm 0.21$	$6.45^{b} \pm 0.15$
7.5	$5.35^{d} \pm 0.33$	$6.48^{a} \pm 0.22$	$6.26^{a} \pm 0.42$	$6.88^{a} \pm 0.11$	$6.95^{a} \pm 0.05$
10	$4.65^{e} \pm 1.47$	$5.35^{b} \pm 0.41$	$5.30^{b} \pm 0.34$	$6.30^{b} \pm 0.25$	$5.55^{d} \pm 0.34$
LSD	0.21	0.29	0.33	0.22	0.32

Means in the same column with different letters are significantly different ($p \leq 0.05$)

Amino acid profile of tortilla

Essential amino acid compositions of tortilla prepared by replacing corn flour with 7.5% of rice bran protein concentrate as compared with control tortilla and FAO/WHO/UNU (1985) amino acid pattern were presented in Table (6). Leucine and aromatic amino acids were the major essential amino acids in control tortilla and tortilla prepared by replacing corn flour with 7.5% of rice bran protein concentrate. However, the lowest amino acids were lysine and tryptophan in control tortilla and lysine in a tortilla with 7.5% rice bran protein concentrate. Tortilla prepared with 7.5% rice bran protein concentrate had higher lysine (27.31%) and tryptophan (33.33%) than control tortilla. The increase in lysine and tryptophan is attributed to rice bran protein concentrate content in a tortilla which had higher lysine and tryptophan contents than those in corn flour. Acevedo-Pacheco and Serna-Saldı´var (2016) reported that fortification of maize tortilla with 6% defatted soybean flour improved the lysine and tryptophan contents. Lecuona-Villanueva *et al.* (2012) reported that fortification of corn tortilla with protein concentrate from *Phaseolus lunatus* resulted in an increase in available lysine and tryptophan.

On the basis of FAO/WHO/UNU (1985) requirements, control tortilla and tortilla prepared with 7.5% of rice bran protein concentrate had higher total and individual essential amino acids than the standard pattern for the adults. Also, control tortilla and tortilla prepared with 7.5% of rice bran protein concentrate had higher total and individual essential amino acids than the standard pattern for the child (10-12 years) except for lysine and tryptophan for control tortilla and lysine for tortilla prepared with 7.5% rice bran protein concentrate. The standard pattern for the child (10-12 years) had higher Lysine (40.91%) and tryptophan (25%) than control tortilla and higher lysine (24. 77%) than tortilla prepared with 7.5% rice bran protein concentrate.

Table (6): Essential amino acids of control tortilla and tortilla prepared by replacing corn flour with 7.5% of rice bran protein concentrate as compared with FAO/WHO/UNU (1985) amino acid pattern

Amino acids (g/100g)	Tortilla		FAO/WHO/UNU (1985)	
	control	[1]RBPC 7.5%	Child 10-12 years	Adult
Isoleucine	3.09	3.31	2.8	1.3
Leucine	9.04	8.02	4.4	1.9
Lysine	2.60	3.31	4.4	1.6
Aromatic amino acids	7.75	7.35	2.2	1.9
Therionine	3.09	3.38	2.8	0.9
Valine	4.33	4.63	2.5	1.3
Histidine	2.48	2.50	1.9	1.6
Sulfur amino acids	4.83	4.04	2.2	1.7
Tryptophan	0.69	0.92	0.9	0.5
Total essential amino acid	37.9	37.46	24.1	12.7

[1] Rice bran protein concentrate

CONCLUSION

It could be concluded that replacing corn flour with 7.5% rice bran protein concentrate resulted in an improvement of nutritive value without negative effects on its sensory properties.

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خصائص جودة تورتيلا الذرة المعدة مع نسب مختلفة من بروتين نخالة الأرز المركز

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الملخص العربى

أجريت هذه الدراسة لتقييم إمكانية الاستبدال الجزئي لدقيق الذرة الصفراء مع بروتين نخالة الأرز المركز (RBPC) لإعداد تورتيلا ذات القيمة الغذائية العالية. زادت قيم البروتين الخام والرماد الكلي للتورتيلا معنوياً بزيادة نسب RBPC في خلطات التورتيلا، في حين سلكت الكربوهيدرات الكلية والدهن الخام والألياف الخام اتجاهاً معاكساً، ولم تتأثر قيم السعرات الحرارية للتورتيلا معنوياً بزيادة نسب RBPC. كما زادت طزاجة التورتيلا معنوياً بزيادة نسب RBPC، فى حين انخفضت معنوياً بزيادة فترة التخزين من ٢٤ إلى ٧٢ ساعة. وكان لون التورتيلا المعدة بنسب مختلفة من RBPC أكثر داكنة بالمقارنة مع كنترول التورتيلا. وتحتوي التورتيلا المعدة بنسبة ٧,٥٪ من RBPC على محتوى أعلى من الليسين (٢٧,٣١٪) والتربتوفان (٣٣,٣٣٪) مقارنة بكنترول التورتيلا. وزاد البروتين المهضوم معنوياً بزيادة نسب RBPC حتى ٧,٥٪. وتراوحت درجات تقييم كنترول التورتيلا ما بين ٤,٣٥ (محايد) إلى ٦,٧٥ (جيد جداً) لجميع الخصائص الحسية، فى حين تراوحت درجات تقييم التورتيلا المعدة بإضافة ٧,٥٪ RBPC ما بين ٥,٣٥ (متوسط) إلى ٦,٩٥ (جيد جداً) لجميع الخصائص الحسية. وهذا الدراسة تبين أن استبدال دقيق الذرة مع ٧,٥٪ RBPC أدى إلى تحسن في القيمة الغذائية ودرجة القبول العام للتورتيلا.

الكلمات الدالة: دقيق الذرة، بروتين نخالة الأرز المركز، تورتيلا، الليسين، القبول العام

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