Egypt. J. Chem. **Vol. 63** No. 11 pp. 4547 - 4563 (2020)

Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

Chemical Composition, Rheological, Organoleptical and Quality Attributes of Gluten-Free Fino Bread

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Abstract

Preparation and evaluation of acceptable gluten-free Fino bread (pearl millet, rice and corn flours) were targeted. Rheological properties of six blends were determined by Mixolab and Alveograph. Sensory evaluation of bread samples was done by ten mothers. The most acceptable samples were selected for chemical, antioxidant, texture, physical, microbial analysis and sensorial evaluation by 20 celiacs from Abu-Rish children's hospital. Pearl millet flour has high protein and fiber (12.11 and 2.92 %, respectively), low carbohydrate (77.88 %), high minerals content, high antioxidant activity (55.31 %), high phenols and flavonoids (474.29 mg Gallic/100 g and 80.43 mg Quercetin/100g, respectively) compared to corn or rice flours. High dough stability was in the M.R.RS blend (34 g millet, 34 g rice and 32 g rice starch). The highest P (resistance to extension), and the lowest L values (dough extensibility) were found in the M.R.C.RS blend (23 g millet, 23 g rice, 23 g corn and 31 g rice starch). Mothers preferred M.R.RS.E bread (M.R.RS+18g Egg), while their children preferred the same formula without egg (M.R.RS). The M.R.RS.E sample had the highest protein, fiber and mineral (Ca, Zn) contents. It was the largest specific volume (3.41 cm^3/g) and high freshness (404.89). This work achieved the goal by making acceptable gluten-free Fino bread using local materials with appropriate nutritional value for celiac patients.

Keywords: Pearl millet; Fino bread making; Gluten free; Celiac disease; Mixolab; Alveograph.

Introduction

Celiac disease (CD) becomes a global health problem and one of the most lifelong food-related disorders worldwide [1]. It defines as small intestine inability to tolerate prolamin of some cereal with definite sequence of oligopeptide, which causes atrophy of intestinal villi [2], lesions of the mucosa and malabsorption for children or adults, results from interaction between genetic, immunologic and environmental factors [3].

Celiac disease prevalence rates differ according to geographic regions. It is frequent in North Africa (Egypt), South-West Asia, North and South America, Australia, and Europe for high consumption of wheat. In contrast, it is very rare in sub-Saharan Africa and Far East Asia, where wheat and other gluten cereals are not staple foods [4]. Its prevalence in the world was 1.4%, including 0.5% in Africa [1]. In pediatric, it is estimated to be around 1% in the general population worldwide [4]. Therefore, the demand for gluten-free products has increased [5]. An imperative need to develop and produce gluten-free bakery products, especially bread has grown [6].

In Egypt, bread is a staple food, 50% of the daily energy is taken from bread [7]. There are three main types of bread made from wheat flour: Baladi (a rough brown flat loaf, 82% extraction), Shami (a white flat loaf, 76% extraction), and Fino (a longe loaf like french bread or hot dog buns, 72% extraction) [8]. Gluten is the protein which plays an important role in bread acceptance. It is responsible for bread structure of and helps to keep the gas

*Corresponding author e-mail: shimma55@yahoo.com
Receive Date: 19 April 2020, Revise Date: 03 May 2020, Accept Date: 06 May 2020
DOI: 10.21608/EJCHEM.2020.28290.2597

bubbles that give their volume, texture and taste [9]. The Egyptian children with celiac disease have a scarcity of Fino bread suitable to their condition for making sandwiches, as school classmates.

Therefore, the selection of raw materials plays the main role in quality of bread and consumer acceptance. Millet is widely grown in the semiarid tropics of Africa and Asia[10]. Pearl millet is an alkaline forming grain that is gluten-free [11]. They grains are good sources of energy, fatty acids, minerals, vitamins, dietary fibre and polyphenols. So, pearl millet foods are characterized as a prebiotic and they can enhance the viability of probiotics with significant health benefits for human [12].

Rice has several advantage (a gluten-free cereal, neutral flavor, white color, easy to digest and low sodium content). It is available worldwide to be a desired ingredient for gluten-free bakery products [5]. Corn flour is a very useful for its lack in gluten, high amounts of easily digested carbohydrates & protein and desirable in celiac diets [13]. Using starches, gums, and hydrocolloids are the most methods to imitate gluten structure, which affect the specific volume of gluten-free bread [14].

Due to high price and scarcity of gluten-free (GF) products, the development of new GF food with high quality and suitable for celiac disease patients are obviously necessary [15].

It is noticeable that there is no gluten-free Fino bread in the Egyptian markets. Therefore, the current study was designed to prepare acceptable gluten-free Fino bread and evaluate it by different methods. This product is depending on pearl millet, as a main constituent, rice and corn flour.

Materials and Methods

Materials

Pearl millet grain (Pennisetum americanum), var. Shandawel-1 was obtained from the Feed Crop Department, Crop Research Institute, Agricultural Research Center, Giza, Egypt. Corn and rice flours, potato and rice starch, sugar, salt, fresh eggs, dry yeast (Saccharomyces cerevisiae) (Saf-Instant, France), and corn oil were purchased from the local market, Giza, Egypt. Lecithin (emulsifier) and Xanthan gum were supplied by Cornell laboratory, Cairo, Egypt. All chemicals (analytical grade) were obtained from Sigma-Aldrich Chemical Co., Egypt.

Methods

Preparation of blends and Fino bread

Pearl millet grain was cleaned and milled into flour, then stored at 4°C in polyethylene bags until used. Several preliminary trials were conducted to select the optimum formula of gluten-free bread using millet, rice, corn, starch of rice and potato with different ratios. Five blends of bread and two controls were prepared as described in the AACC [16], they are stated in Table 1. All ingredients were mixed for 10 min to obtain uniform dough, divided into pieces of 55g each then manually formed. Fermentation was carried out at 45°C, 75-80% relative humidity for 45 min., and then baked in an oven at 230°C for 10 min. The Fino loaves were cooled at room temperature (25±1°C), then packed and stored for 0, 24, 48, and 72hrs at room temperature.

Rheological properties of dough

Thermo-mechanical properties of blends were carried out by Mixolab (Chopin, Tripette et Renaud, Paris, France), which determines characteristics of protein and starch during the mixing process at a stable temperature (heating and cooling period). Chopin+ protocol is used to determine mixing properties of the dough. Each blend was mixed with distilled water to form dough. It mixed at 30°C for 8 min., heated to 90°C at a speed of 4°C min^{-1}, maintained at 90°C for 7 min, then decreased the temperature to 30°C at a speed of 4°C min^{-1} [17]. Parameters like water absorption (WA, %), dough development time (DT, min), dough stability time (ST, min), and different torque (C1, C2, C3, C4, C5) during different periods (Nm) were obtained from the recorded curve. Dough strength weakening (C1-C2, Nm) and retrogradation of starch (C5-C4, Nm) were calculated.

Resistance to extension was measured using Alveograph machine and were automatically recorded by the Alveolink-NG software (Chopin Technologies., Villeneuve La Garenne, France), according to modified method [17]. Each sample was taken (250 g) to test, then sodium chloride solution (2.5%) was added to hydrate and mixed for 7 min. The dough was forced through the extrusion gate in the form of a thin strip on to a small oiled

TABLE 1. Ingredients of gluten-free Fino bread formulas

Ingredients* (g)	Bread formulas						
	Control C	Control M	M.R.RS	M.R.PS	M.RS.PS	M.R.C.RS	M.R.RS.E
Corn flour	100	-	-	-	-	23	-
Millet flour	-	100	34	34	67	23	34
Rice flour	-	-	34	34	-	23	34
Rice Starch	-	-	32	-	17	31	32
Potato Starch	-	-	-	32	16	-	-
Egg	-	-	-	-	-	-	18

* Bread formulas contain the same ingredients (6 g sugar, 4 g xanthan, 4 g dry yeast, 2 g lecithin, 1 g salt, 8 ml oil and 80 ml water).

steel plate. Five dough pieces were produced and allowed to rest for 20 min at 25°C, then inserted into the alveograph. A bubble was blown and the resulting air pressure profile was recorded on a recording manometer. The measured parameters were: maximum over pressure (P index of resistance to extension), average abscissa at rupture (L index of dough extensibility), P/L, configuration ratio and energy of dough (W index of dough strength). These parameters are used to predict performance of dough during the baking process.

Organoleptic evaluation

Sensory evaluation of gluten-free bread samples was done according to the procedure of Khorshid et al. [18]. The five samples and two control samples were presented to ten mothers (25-43 years) in the outpatient clinic Abu Rish Hospital, Cairo, Egypt. Two slices of every sample (3 cm^3 for each) were coded and served to each mother. Water was offered to them after tasting every sample. They were asked to evaluate the quality attributes [appearance (15), crust color (15), crumb color (15), texture (15), odor (20), taste (20), and overall acceptability (100)]. After statistical analysis, the most acceptable four bread samples by mothers were chosen for offering to 20 children with CD (9-11 years). Sensory evaluation was carried out for children by using a hedonic scale questionnaire (satisfied, neutral and unsatisfied), with watching face feature and asking every child about his preference for certain type of bread.

Chemical analysis

Proximate analysis: Moisture, protein, fat, fiber and ash of raw materials and the most acceptable bread samples were determined according to the AOAC [19]. Carbohydrates were calculated by difference. The mineral contents were determined according to the method described in the AOAC [19] using atomic absorption spectrophotometer (model 3300, Perkin-Elimer, Beaconsfield, UK). Vitamins B1, B2, B3, B6 and folic acid were determined according to the method of Batifoulier et al. [20] using HPLC. Vitamins A and E were investigated by the method described by Plozza et al. [21].

Biological activity

Antioxidant activity: The DPPH (2, 2-diphenyl-1- picrylhydrazyl) radical scavenging activity of methanolic extracts was determined following the method reported by Oms-Oliu et al. [22]. Two milliliter of DPPH solution (0.004%) was mixed with 1 ml of methanolic extracts. The samples were incubated for 30 min in the dark at room temperature. It absorbance was recorded (517 nm) using spectrophotometr.

$$\% \text{ Antioxidant activity} = [(A_{control} - A_{treatment} / A_{control})] \times 100.$$

Total phenolic content: Determination of total phenolic content was measured according to Sahu and Saxena [23]. One ml of methanolic extracts was mixed with 2.5 ml of Folin-Ciocalteu's phenol reagent. After 3 min, was added 2 ml of 7.5 % sodium carbonate solution and adjusted to 10 ml with distilled water. The reaction was kept in dark place for 90 min, absorbance was recorded at 760 nm spectrometrically. The results were expressed as mg Gallic acid equivalents per 100 g of the sample (mg GAE / 100 g).

Total flavonoids: Total flavonoids were measured as quercetin equivalent according to Sahu and Saxena [23]. One ml of extract solution, 4 ml of distill water and 0.3ml of (5%) $NaNO_2$ added to the flask. After 5 min, 0.3 ml (10%) $AlCl_3$ was added to the mixture. At the sixth minutes two ml of (1M) NaOH were added and completed to 10 ml with distills water. The absorbance was noted at 510 nm using spectrophotometer. The results were expressed as mg quercetin equivalents per 100 g of the sample (mg Quercetin /100 g).

Bread staling and texture profile analysis

Bread staling: Staling of each packed samples was measured at room temperature during storage at 0, 24, 48 and 72 hrs by alkaline water retention capacity (AWRC) according to Kitterman and Rubenthaler [24].

Texture Profile Analysis (TPA): The bread texture was determined by a universal testing machine (Conetech, B type, Taiwan) provided with software according to Bourne [25]. Bread samples were tested, using an aluminium 25 mm diameter cylindrical probe, double compression test to penetrate to 50% depth, at 1mm/s speed test, then the hardness, cohesiveness and chewiness of the samples were calculated from the TPA curve. The analyses were performed after 0, 24, 48 and 72 hours of baking.

Physical properties

Baking quality: The weight (g) of samples was estimated after cooling for 1hr, and the volume (cm^3) was determined using rapeseed displacement method, according to the AACC [16]. The specific volume (cm^3 /g) and density (g/cm^3) were calculated.

Water activity (a_w) was measured by using HygroLab3 (Rotronic Switzerland) according to the method of Chirife and Buera [26]. All bread samples were cutting into small pieces immediately before measuring. Bread was measured at room temperature during storage at 0, 24, 48 and 72 hrs.

Microbiological analysis

The total plate count of bread samples were determined at 0, 24, 48 and 72 hrs using the standard plate count agar method as described by Swanson et al. [27], while yeast and mold count were measured using potato-dextrose agar medium by the method of Mislivec et al. [28]. Ten grams of each bread sample were taken aseptically and homogenized with 90 ml sterile distilled water. Serial dilutions were made in 9 ml sterile distilled water and 3 dispensed in test tubes. One ml of each dilution was pouring plated in sterile Petri dishes, using the plate count agar for bacteria and potato dextrose agar for fungi. Incubation was at 30°C for 3 days. After incubation, the plates were examined for bacterial and fungal growth and counts of visible colonies are to be made.

Statistical analysis

The collected data were analyzed and presented as mean, standard deviations, analysis of variance (ANOVA) and least significant differences (LSD) at $p < 0.05$.

Results and discussion

Chemical composition of raw materials

Data reported in Table (2), showed that pearl millet flour rich in protein, fiber and fat (12.11, 2.92 and 5.20%, respectively), however it had the lower value in total carbohydrate (77.88%) than rice (89.89%) and corn (82.96%). It was possible to observe a significant difference ($P < 0.05$) among raw materials. The previous mentioned values are nearly similar to those found by Sayed et al. [29]. Furthermore, Vila-Real et al. [30] reported that carbohydrates of millet ranged from 70 to 78%. The same Table significant differences ($P < 0.05$) were obtained among samples in all minerals. The results revealed that the pearl millet contained a higher level of minerals content (Ca, P, K, Mg, Fe, Zn and Cu) than those in either corn or rice flours. The abovementioned results are nearly similar to those found by Mehra and Singh [31].

High level of vitamins were found in pearl millet in comparison to those of rice or corn flours except folic acid (15.26±0.04 mg/100g), while was lower than corn flour (17.86±0.02 mg/100g), as well as it had high content of fat-soluble vitamins. This might be ascribed to its high oil content. The presence of vit. A and E adds important value of pearl millet as antioxidant grains that may be curb triglyceride deterioration. The Jaybhaye et al. [32], who found

TABLE 2. Chemical composition and antioxidant profile of raw materials (on dry weight)

Items	Raw materials			LSD
	Pearl millet flour	Rice flour	Corn flour	
Protein (%)	12.11±0.01[a]	8.03±0.01 [c]	9.38±0.01[b]	0.039
Fat (%)	1.89±0.09 [a]	0.60±0.14 [b]	1.78±0.06 [a]	0.338
Ash (%)	5.20±0.02 [a]	0.72±0.01[c]	2.90±0.28 [b]	0.523
Crude Fiber (%)	2.92±0.03 [a]	0.76±0.02 [b]	2.98±0.02 [a]	0.067
Carbohydrate(%)	77.88±0.06 [c]	89.89±0.03 [a]	82.96±0.01[b]	0.134
Moisture (%)	8.43±0.02 [c]	10.53±0.02 [b]	12.04±0.28 [a]	0.176
Minerals (mg/100g)				
Ca	47.55±0.03 [a]	28.85±0.04[b]	22.35±0.14 [c]	1.279
P	330.0±0.35 [a]	160.0±0.28 [c]	290.0±0.05[b]	2.838
K	305.9±0.28 [a]	111.0±0.05 [c]	287.0±0.02[b]	4.533
Mg	176.6±0.33 [a]	25.50±0.28 [c]	49.10±0.03[b]	1.418
Na	6.10±0.28 [c]	7.11±0.38 [b]	39.00±0.02 [a]	0.939
Fe	10.50±0.05[a]	4.21±0.01 [c]	6.20±0.02 [b]	1.117
Zn	5.45±0.02 [a]	2.10±0.28 [c]	3.13±0.03 [b]	0.925
Cu	0.80±0.03 [a]	0.69±0.06 [b]	0.31±0.01[c]	0.093
Mn	4.64±0.02 [c]	20.15±0.03 [a]	4.90±0.01[b]	0.075
Vitamins (mg/100g)				
Vit. A	0.37±0. 04 [a]	0.01±0.02 [b]	ND	0.087
Vit. E	0.85±0.05 [a]	0.11±0.04 [c]	0.49±0.07 [b]	0.091
Thiamine (B_1)	0.38 ±.04 [a]	0.06±0.03 [c]	0.29±0.04 [b]	0.081
Riboflavin (B_2)	0.27±0.02 [a]	0.02±0.03 [c]	0.19±0.04[b]	0.075
Niacin (B_3)	6.37±0.05 [a]	1.6±0.05 [b]	1.63±0.02 [b]	0.934
Pyridoxine (B_6)	2.68±0.01 [a]	0.03±0.02[b]	0.06±0.03 [b]	0.811
Folic acid (B_9)	15.26±0.04[b]	0.8±0.04 [c]	17.86±0.02 [a]	1.053
Antioxidant profile				
Radical scavenging activity (DPPH , %)	55.31±0.37 [a]	11.24±0.24 [c]	20.23±0.44 [b]	1.157
Total phenolic content (mg Gallic/100 g)	474.29±0.20 [a]	6.53±0.31 [c]	167.25±0.42[b]	5.037
Total flavonoid content (mg quercetin/100g)	80.43±0.31 [a]	4.23±0.01 [c]	30.05±0.01[b]	6.572

Means in the same row with different letters are significant ($p<0.05$); ND: not detected;
LSD: least significant difference.

that it is rich in lipids, with high levels of vitamins A and E. Also, pearl millet had a high content of B-vitamins (B_1, B_2, B_3 and B_6).

Biological activity

Data pertaining the antioxidants content (Table 2) showed the same trend that the pearl millet had high level values of total phenols and flavonoids compared to rice and corn. The highest DPPH radical scavenging activity was found in millet (55.31%), total phenolic content (TPC) was expressed as 474.29 ± 0.2 mg GAE /100 g and total flavonoid content (TFC) was 80.43 ± 0.31 mg Quercetin /100g and significantly different ($P < 0.05$) from the others. In this respect, a study was done by Revankar et al. [33] indicated that pearl millet is characterized by high total phenol (106.86±2.57 mg GAE/100g flour), high flavonoid (40.22±2.41 mg Quercetin/100 g flour) and high DPPH activity (70.39±2.57%). While Berwal et al. [34] stated that the pearl millet contained polyphenols from 221 to 345 mg/100g, those findings were lower than our. This may be ascribed to the genetic or the environmental effects.

Rheological properties of bread blends

The rheological properties are critical in food manufacturing. Dough behavior during mixing process is related to many parameters as starch and protein contents and quality. Mixolab and Alveograph are essential tools to evaluate quality of bread processing. Mixolab measures development behaviour of dough during mixing and heating [35]. The first part of the Mixolab curve refers to the protein characteristics and it is characterized by the following parameters: WA, DT, ST, C2 and C2-C1 are used to evaluate the quality of gluten. The second part of the Mixolab curve reveals the properties of starch. C3 is the measure of starch gelatinization and C5 - C4 value which illustrate the degree of starch retrogradation [36].

Figure 1 shows the Mixolab indices of the gluten-free doughs. The absorption index depends on the flour components (protein, starch, fiber and additives). All samples could be considered to have high absorption values between 8 and 9. Mixing index displays the behavior of dough during mixing process. A high value is consistent with high dough stability in mixing process. It ranged from 2 for control M to 5 for M.R.RS and M.R.PS dough samples. This declares that 100% of pearl millet dough is the least stability. Gluten index expresses the gluten behavior during heating, the high value points out the high resistance of gluten to heat. All the gluten-free samples had the highest value (9), it could be referred to presence xanthan gum in flour formulas. Viscosity index displays the upper value of viscosity during heating and depends on amylase and starch quality. High value links to increase viscosity of dough during heating. M.R.RS was the least index while, M.R.PS and M.R.C.RS had the highest value (9). Amylase activity index ranged from 2 to 7 with M.RS.PS having the least and control C the highest. The amylase activity index expresses the starch ability to resist breakdown. A high value relates to low amylase activity and vice versa. The retrogradation index is higher the less shelf life. Index of M.RS.PS sample is 4, which is a great shelf life, compared to others. Control C has a lower shelf life.

The obtained results in Table (3) indicated that water absorption (WA) was aligned between 65.6 and 71.5%, corresponding to the flour control M and control C, respectively. The mixing time as an indication of protein quality and stronger flours need a longer time to mix than do the weaker flours. It could be noticed that the WA of five blends contained pearl millet was less than control C. These results are in agreement with those findings of Sharma et al. [37] who stated that the increasing amount of the millet flour reduced water absorption. The dough development time (DT) is the time of the dough have optimum viscoelastic properties for gas retention [38]. The highest value of DT (5.37min) was found in M.R.RS blend. This blend was the most stable dough by 10.13 min, followed by M.R.C.RS blend (9.98 min), then M.R.PS blend (9.73 min) and M.RS.PS blend (9.30 min). However, control C and control M recorded least dough stability (8.88 and 8.18 min, consecutively).

The torque at C1 is a indicator of flour water absorption and maximum dough consistency [39]. The value of C1 varies between 1.07 to 1.14 Nm corresponding to the flour control M and M.R.RS blend, respectively. After reaching the maximum consistency (C1), the temperature starts to increase, the dough viscosity decreases and dilution of protein takes place till C2 torque is reached. C2 is a measure of dough weakening as a result of reduction of protein. Minimum values of torque produced as the dough was subjected to mechanical and thermal stress were 0.71 Nm for control M. While the maximum value was noticed in M.R.PS blend (0.85 Nm). Meanwhile the other values were in between. Protein weakening% (C1-C2%) of the samples ranged between 0.26 Nm for M.R.C.RS blend and 0.37 Nm for control M.

C3 is an indicator for starch gelatinization during the heating. It is torque (maximum) obtained during the heating stage be caused by bursting of starch granules [40]. The value at C3 point was highest in M.R.PS blend (2.92Nm) however, the lowest in the M.R.RS blend (2.41Nm). This may be attributed to the protein and lipid contents [41]. When dough was held at 90°C/7 min. the torque constantly decreases till C4 was reached [42]. The torque at C4 is an indicator of enzymatic hydrolysis and hot gel stability. The lower value of C4 is less stable starch gel. Control C had the highest value of 2.49 Nm, indicating the most stable hot gel. The last stage (C5) indicates to the starch retrogradation during cooling phase and involves how shelf-life of product will be stable. The M.RS.PS blend had the least value (1.82). The setback torque were ranged from 0.32 to 0.84 Nm while the remaining were in between.

The alveograph is suitable to measure the characteristics of weak gluten dough. Strong gluten

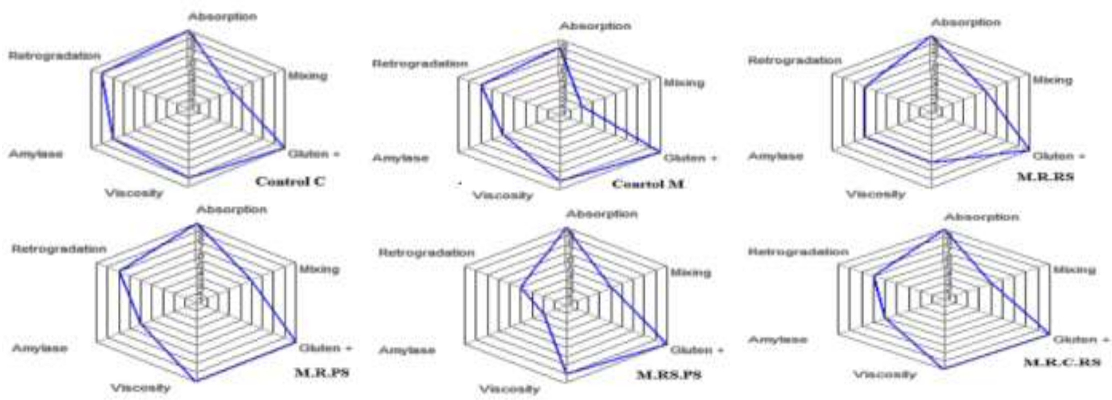

Fig.1 Mixolab Profiler values of gluten-free flour blends for preparing Fino bread

TABLE 3. Mixolab and Alveograph parameters of tested flour blends

Parameters	Flour blends					
	Control C	**Control M**	**M.R.RS**	**M.R.PS**	**M.RS.PS**	**M.R.C.RS**
Mixolab parameters						
Water absorption (%)	71.5	65.6	66.5	67.5	68.8	66.7
Development time (min)	5.00	2.13	5.37	4.83	4.42	2.30
Stability (min)	8.88	8.18	10.13	9.73	9.30	9.98
C1 (Nm)	1.13	1.07	1.14	1.12	1.11	1.07
C2 (Nm)	0.83	0.71	0.78	0.85	0.83	0.82
C1- C2 (Nm)	0.30	0.37	0.36	0.27	0.28	0.26
C3 (Nm)	2.79	2.78	2.41	2.92	2.80	2.91
C4 (Nm)	2.49	2.08	2.13	2.22	1.50	2.10
C5 (Nm)	3.33	2.70	2.64	2.89	1.82	2.67
C5-C4 (Nm)	0.84	0.62	0.52	0.67	0.32	0.57
Alveograph parameters						
P (mm H_2O)	48	40	84	75	46	101
L (mm)	91	151	78	90	169	43
G (mm)	21.2	27.3	19.6	21.1	28.9	14.6
W (J)	148	165	210	227	179	176
P/L	0.53	0.26	1.08	0.83	0.27	2.35
Ie (%)	55.2	55.1	48.3	55.3	47.7	47.2

Control C: (100g Corn Flour); Control M: (100 g Millet Flour); M.R.RS Sample: (34 g Millet Flour + 34 g Rice Flour + 32 g Rice Starch); M.R.PS Sample: (34 g Millet Flour+ 34 g Rice Flour+ 32 g Potato Starch); M.RS.PS Sample: (67g Millet Flour+ 17 g Rice Starch + 16 g Potato Starch); M.R.C.RS Sample: (23 g Millet Flour+ 23 g Rice Flour+ 23 g Corn Flour+ 31 g Rice Starch).

flour will have high P values and is preferred for bread. Data in Table (3) showed that the highest P-value was found in the M.R.C.RS blend (101 mm), while control M recorded the lowest value (40 mm). However, the remaining samples were in between. The M.RS.PS blend had a highest extensibility (L value 169 mm). The P/L ratio ranged from 0.26 to 2.35. However, control M had the lowest value while M.R.C.RS blend was the highest. The required energy (W) for deformation, is an indication of the dough strength. It ranged from 148 J in the control C to 227 J in the M.R.PS blend. In this respect, our results are compatible with Codina et al. [43] who

TABLE 4. Sensory evaluation of gluten-free Fino bread samples by mothers and hedonic scale (%) (%) of more acceptable (four samples) by children with celiac disease

Samples	Appearance (15)	Crust color (15)	Crumb color (15)	Texture (15)	Odor (20)	Taste (20)	Overall acceptability (100)	Cost (L.E)
Control C	13.7±0.41 ^{a}	13.5±0.51 ^{a}	13.2±0.71 ^{a}	13.3±0.67 ^{ab}	18.5±0.84 ^{a}	18.1±0.59 ^{b}	96.3±0.65 ^{b}	1.63
Control M	12.0±0.24 ^{c}	13.0±0.68 ^{ab}	12.9± 0.73^{b}	13.1±0.57 ^{ab}	17.3±0.69 ^{cd}	14.2±0.63 ^{d}	92.2±0.68 ^{cd}	1.43
M.R.RS	13.4±0.61 ^{ab}	13.4±0.67 ^{a}	13.0±0.61 ^{ab}	13.5±0.49 ^{a}	17.8±0.71^{b}	16.1±0.49 ^{c}	95.0±0.78^{bc}	1.34
M.R.PS	12.8±0.35 ^{b}	12.9±0.81 ^{ab}	12.8±0.53 ^{b}	13.1±0.51 ^{ab}	16.9±0.95 ^{c}	12.4±0.51 ^{e}	93.6±0.69 ^{c}	2.43
M.RS.PS	12.6±0.39^{bc}	12.9±0.72 ^{ab}	12.6±0.17 ^{b}	12.9±0.67 ^{b}	15.7±0.83 ^{d}	11.9±0.58 ^{f}	90.1±0.73 ^{d}	2.03
M.R.C.RS	13.4±0.64 ^{ab}	13.5±0.59 ^{a}	13.0±0.25 ^{ab}	13.4±0.59 ^{a}	18.1±0.87 ^{ab}	18.0±0.61 ^{b}	97.8±0.81 ^{ab}	1.44
M.R.RS.E	13.8±0.48 ^{a}	13.5±0.53 ^{a}	13.2±0.34 ^{a}	13.5±0.61 ^{a}	18.6±0.69 ^{a}	19.0±0.68 ^{a}	98.3±0.72 ^{a}	2.34
LSD	0.800	0.741	0.731	0.782	0.906	0.427	1.530	

Samples	Hedonic scale (%, of children)		
	Satisfied	**Neutral**	**Unsatisfied**
			
Control C	40	60	0
M.R.RS	75	25	0
M.R.C.RS	15	50	35
M.R.RS.E	20	30	50

Means±SD in the same column with different letters are significant ($p<0.05$).
LSD: least significant difference.
Control C: (100g Corn); Control M: (100 g Millet); M.R.RS Sample: (34 g Millet + 34 g Rice + 32 g Rice Starch); M.R.PS Sample: (34 g Millet + 34 g Rice + 32 g Potato Starch); M.RS.PS Sample: (67g Millet + 17 g Rice Starch + 16 g Potato Starch); M.R.C.RS Sample: (23 g Millet + 23 g Rice + 23 g Corn + 31 g Rice Starch); M.R.RS.E Sample: (34 g Millet + 34 g Rice + 32 g Rice Starch + 18 g Egg).

showed that the improving of wheat flour gluten might correlate with Alveograph P and W and decrease in L values in different tested crop blends.

Organoleptic evaluation of gluten-free Fino bread

The sensory evaluation of gluten-free Fino bread samples was carried out in two steps, the first step was done by the mothers of children with celiac disease because they are good judges for the quality attributes of the usual types of wheat bread.

Table (4) revealed that all tested gluten-free breads got over than 90% as overall acceptability. The most acceptable samples was M.R.RS.E (98.3 %) (mix of 34g millet, 34 g rice, 32 g rice starch and 18 g egg) which was significantly highest scores for all their attributes followed by M.R.C.RS sample (97.8 %), control C (96.3 %) then M.R.RS sample (95%). This may be ascribed to the addition of egg. On the contrary, acceptable of M.RS.PS sample (mix of 67 g millet, 17 g rice starch and 16 g potato starch) was lower than the others. In a study of Al Shehry [13] found an increase in sensory characteristics value of 100% corn flour pan bread. Significant differences were noticed between control M, M.R.PS and M.RS.PS samples for appearance, crumb color and taste. Meanwhile, no significant differences in crust color between all samples. However, the texture of M.RS.PS sample was the lowest value (12.9 ± 0.67). Significant differences were found between the odor values of control M, M.R.RS, M.R.PS and M.RS.PS sample, while no significant differences between control C, M.R.C.RS and M.R.RS.E samples which recorded high values in the same character.

The second step started after statistical analysis of bread samples which illustrated that the most acceptable bread by the mothers were four samples [Control C (100% corn), M.R.RS (34 g millet, 34 g rice and 32 g rice starch), M.R.C.RS (23 g millet, 23 g rice, 23 g corn and 31 g rice starch) and M.R.RS.E (34 g millet, 34 g rice, 32 g rice starch and 18 g egg)]. These samples were offered to children suffered from celiac disease in the out-patient clinic, Abu-Rish hospital to choose the most acceptable and favorite taste by using a hedonic scale questionnaire (satisfied, neutral and unsatisfied). It could be noticed (Table,4) that the higher satisfied sample by 75% of kids was M.R.RS sample. On the contrary, 50% of children were unsatisfied about M.R.RS.E sample versus their mothers.

Concerning the prices of gluten-free samples, these prices were within available limits as their bread which they children with celiac disease consumed. M.R.RS sample (34 g millet, 34 g rice and 32 g rice starch), which was more acceptable by celiac disease children recorded the lowest price (1.34 L.E) compared with M.R.RS.E sample (34 g millet, 34 g rice, 32 g rice starch and 18 g egg)(2.34 L.E). However, the price of commercial flat corn bread (two layers) was 1.25 L.E.

Chemical composition of gluten-free Fino bread samples

Data in Table (5) showed that the protein content of bread was ranged from 10.01% to 14.86%. The high fiber content (2.03%) was in M.R.C.RS sample (mix of 23g millet, 23g rice, 23g corn and 31g rice starch). While, fat content ranged from 10.92% to 15.40 %, where M.R.RS.E sample recorded the highest amount of fat (15.40 ± 0.03), followed by M.R.C.RS sample (13.05 ± 0.02), while the values of the other samples were in between. Control C (100% corn) had the highest carbohydrates, while M.R.RS.E bread had the lowest content of carbohydrates.

With respect to the mineral content of bread samples, Table (5) showed that M.R.RS.E sample (mix of 34g millet, 34g rice, 32g rice starch and 18g egg) had higher calcium than the others. While, the highest values of P, K, Na and Fe were found in control C (100% corn) in comparison with the other bread samples.

Regarding the vitamin contents, it could be noticed that bread samples had a reasonable amount of folic acid, especially control C (100% corn). The M.R.RS.E bread (mix of 34g millet, 34g rice, 32g rice starch, and 18g egg) had the highest content of A, E and B-complex vitamins (A: 0.69, E: 0.60, B_1: 0.25, B_2: 0.31 and B_3: 2.21 mg/100g) than the other samples. Only M.R.RS sample (mix of 34g millet, 34g rice and 32g rice starch) had the highest value of vitamin B_6 (Table, 5).

With regard to antioxidant profile, the higher values of antioxidant activity (30.42%), total phenolic (169.42 mg GAE/100g) and total flavonoid (43.87 mg quercetin/100g) were found in M.R.RS.E sample than the other samples. It could be noticed that the high content of pearl millet bread samples in polyphenols in comparison with the control sample to the pearl millet was rich in phenolic compounds and heating effect as a release of bound phenolics or polyphenols depolymerization [44]. There was a significant difference in antioxidant profile between all samples.

Bread staling and textural profile analysis of gluten-free Fino bread samples

Bread staling could be considered as freshness indicator. So, we estimated it for each sample at zero time, 24, 48 and 72hrs at room temperature. Data in Table (6) revealed that the baking freshness values increased in all samples compared to the control. This may be ascribed to an increase starch ratio in samples. On the contrary, bread freshness decreased with increasing storage period. The results illustrated that M.R.RS.E sample had the highest freshness values 404.89, 393.37, 388.28 and 380.41, respectively at 0, 24, 48

TABLE 5. Chemical composition and antioxidant profile of gluten-free bread samples (on dry weight)

Items	Bread samples				LSD
	Control C	M.R.RS	M.R.C.RS	M.R.RS.E	
Protein (%)	10.01±0.01 d	12.45±0.03 c	13.60±0.04b	14.86±0.01a	0.980
Fat (%)	10.92±0.01 d	11.16±0.04c	13.05±0.02b	15.40±0.03 a	0.088
Ash (%)	1.17±0.01b	1.61±0.04b	2.27±0.04 a	2.27±0.01 a	0.095
Crude Fiber (%)	1.99±0.02b	1.14±0.01 d	2.03±0.02 a	1.86 ±0.04 c	0.029
Carbohydrate (%)	75.91±0.01 a	73.65±0.06 b	68.34±0.01 c	65.62±0.01 d	0.903
Moisture (%)	10.08±0.02 d	11.17±0.02 c	12.25±0.03b	14.51±0.02 a	0.074
Minerals (mg/100g)					
Ca	25.76±0.05 d	44.19±0.27 b	43.03±0.12 c	69.81±0.26 a	0.936
P	294.5±0.28 a	170.5±0.49 d	183.4±0.35 c	250.7±0.42 b	2.254
K	289.3±0.35 a	143.7±0.35 d	162.9±0.35 c	207.9±0.54 b	4.125
Mg	35.20±0.06 d	76.68±0.04 a	59.18±0.22 c	74.67±0.29 b	1.926
Na	35.98±0.52 a	7.37±0.28 c	14.88±0.44b	7.36±0.33 c	4.082
Fe	6.60±0.05 a	5 .15±0.21 c	4.81±0.16 d	5.85±0.43 b	0.231
Zn	3.20±0.18 b	2.95±0.49 c	2.66±0.22 d	3.50±0.33 a	0.105
Cu	0.20±0.04 d	0.55±0.02 a	0.43±0.01 c	0.53±0.02 b	0.010
Mn	3.97±0.04 c	8.99±0.06 a	6.82±0.01 b	8.97±0.05 a	1.059
Vitamins (mg/100g)					
Vit. A	ND	0.11±0.01 b	0.09±0.03 c	0.69±0.04 a	0.014
Vit. E	0.39±0.03b	0.32±0.01 c	0.32±0.03 c	0.60±0.02 a	0.055
Thiamine (B_1)	0.25±0.03 a	0.14±0.02 c	0.17±0.02 b	0.25±0.01 a	0.050
Riboflavin (B_2)	0.23±0.01b	0.10±0.03 c	0.11±0.02 c	0.31±0.03 a	0.085
Niacin (B_3)	1.13±0.02 d	2.71±0.02 b	2.15±0.03 c	2.92±0.01 a	0.160
Pyridoxine (B_6)	0.03±0.01 d	0.82±0.02 b	0.64±0.02 c	0.95±0.04 a	0.099
Folic acid (B_9)	15.66±0.05 a	5.34±0.06 d	7.70±0.04 c	8.04±0.07 b	0.233
Antioxidant profile					
Radical scavenging activity (DPPH, %)	17.34±0.45 d	27.12±0.32 b	20.33±0.17 c	30.42±0.36 a	2.169
Total phenolics content (mg Gallic/100 g)	150.26±0.21 d	164.47±0.35 b	153.56±0.16 c	169.42±0.17 a	2.713
Total flavonoid content (mg quercetin/100 g)	28.02±0.01 c	30.48±0.23 b	26.38±0.25 d	43.87±0.45 a	1.941

Means in the same row with different letters are significant ($p<0.05$); ND: not detected;
LSD: least significant difference.
Control C: (100g Corn); M.R.RS Sample: (34 g Millet + 34 g Rice + 32 g Rice Starch); M.R.C.RS Sample: (23 g Millet + 23 g Rice + 23 g Corn + 31 g Rice Starch); M.R.RS.E Sample: (34 g Millet + 34 g Rice + 32 g Rice Starch + 18 g Egg).

TABLE 6. Bread staling and texture profile analysis of gluten-free Fino bread samples at 0, 24, 48 and 72 hrs

Items	Bread samples				LSD
	Control C	M.R.RS	M.R.C.RS	M.R.RS.E	
Bread staling					
Zero Time	333.34 ± 0.76 ^{d}	389.61 ± 3.19 ^{c}	400.23 ± 0.31 ^{b}	404.89 ± 1.07 ^{a}	4.178
24 hrs	323.56 ± 0.36 ^{d}	380.38 ± 0.35 ^{c}	398.47 ± 0.48 ^{a}	393.37 ± 0.45 ^{b}	4.211
48 hrs	300.91 ± 0.04 ^{c}	373.31 ± 0.30 ^{b}	388.20 ± 0.11 ^{a}	388.28 ± 0.72 ^{a}	5.228
72 hrs	291.42 ± 0.54 ^{d}	365.78 ± 1.10 ^{c}	382.41 ± 0.44 ^{a}	380.41 ± 0.35 ^{b}	1.904
Texture profile analysis (TPA)					
Hardness (N)					
Zero Time	18.02±0.04 ^{a}	17.09±0.05 ^{c}	17.62±0.03 ^{b}	1٦.٧٧±0.02 ^{d}	0.290
24 hrs	19.56±0.04 ^{a}	18.00±0.01 ^{c}	19.02±0.49 ^{b}	17.85±0.03 ^{d}	0.181
48 hrs	21.٥٩±0.07 ^{a}	20.65±0.04 ^{c}	21.04±0.02 ^{b}	20.04±0.03 ^{d}	0.298
72 hrs	24.62±0.02 ^{a}	23.81±0.03 ^{c}	24.26±0.04 ^{b}	23.21±0.01 ^{d}	0.286
Cohesiveness					
Zero Time	0.59±0.05 ^{c}	0.78±0.04 ^{a}	0.75±0.03 ^{a}	0.76±0.01 ^{a}	0.086
24 hrs	0.51±0.04 ^{c}	0.74±0.03 ^{a}	0.70±0.04 ^{a}	0.71±0.02 ^{a}	0.084
48 hrs	0.46±0.03 ^{c}	0.70±0.03 ^{a}	0.68±0.03 ^{a}	0.69±0.04 ^{a}	0.078
72 hrs	0.44±0.03 ^{c}	0.69±0.03 ^{a}	0.63±0.05 ^{a}	0.65±0.01 ^{a}	0.089
Chewiness(N)					
Zero Time	3.16±0.04 ^{a}	2.83±0.04 ^{c}	3.05±0.03 ^{b}	2.13±0.04 ^{d}	0.094
24 hrs	3.43±0.06 ^{a}	2.95±0.04 ^{c}	3.15±0.05 ^{b}	2.32±0.02 ^{d}	0.195
48 hrs	3.71±0.01 ^{a}	3.01±0.05 ^{c}	3.45±0.02 ^{b}	2.59±0.05 ^{d}	0.188
72 hrs	3.94±0.06 ^{a}	3.07±0.02 ^{c}	3.51±0.03 ^{b}	2.87±0.04 ^{d}	0.095
Gumminess(N)					
Zero Time	10.63±0.03 ^{d}	13.33±0.04 ^{a}	13.22±0.02 ^{b}	12.75±0.01 ^{c}	0.086
24 hrs	9.98±0.04 ^{d}	13.35±0.01 ^{a}	13.27±0.03 ^{b}	12.76±0.04 ^{c}	0.070
48 hrs	9.93±0.04 ^{d}	14.46±0.03 ^{a}	14.31±0.05 ^{b}	13.83±0.04 ^{c}	0.094
72 hrs	10.83±0.02 ^{d}	16.43±0.03 ^{a}	15.28±0.01 ^{b}	15.09±0.04 ^{c}	0.089
Springiness (mm)					
Zero Time	0.78±0.02 ^{d}	0.87±0.01 ^{b}	0.85±0.03 ^{c}	0.89±0.05 ^{a}	0.015
24 hrs	0.73±0.03 ^{d}	0.84±0.05 ^{b}	0.82±0.02 ^{c}	0.86±0.03 ^{a}	0.012
48 hrs	0.70±0.04 ^{d}	0.79±0.03 ^{b}	0.77±0.05 ^{c}	0.82±0.03 ^{a}	0.014
72 hrs	0.66±0.03 ^{d}	0.76±0.04 ^{b}	0.74±0.02 ^{c}	0.79±0.05 ^{a}	0.011

Means in the same row with different letters are significant ($p<0.05$);
LSD: least significant difference.
Control C: (100g Corn); M.R.RS Sample: (34 g Millet + 34 g Rice + 32 g Rice Starch); M.R.C.RS Sample: (23 g Millet + 23 g Rice + 23 g Corn + 31 g Rice Starch); M.R.RS.E Sample: (34 g Millet + 34 g Rice + 32 g Rice Starch + 18 g Egg).

and 72hrs. These results are in agreement with those with those reported by Han et al. [15], who found that egg proteins showed a strong cohesive, foaming capacity and stability might develop quality and nutritional value of gluten-free bread.

The textural profile analysis (TPA) test are presented in Table 6. The hardness of crumb is a main quality factor in bakery products, as it is associated with bread freshness [29]. The results concluded that the softer samples (less hardness) at zero time were M.R.RS.E, M.R.RS and M.R.C.RS (16.77 N, 17.09 N and 17.62 N, respectively) than the control C (18.02 N). However, all bread samples increased in hardness during storage. It worth to mention that M.R.RS.E sample revealed the lowest hardness (16.77 N), while in the same time it showed a highest specific volume (3.41 cm^3/g) as shown in the next Table (7), which indicated that the M.R.RS.E sample was the softer and larger loaf volume. This result is in agreement with that of Feizollahi et al. [45] who reported that hardness had a adverse correlation with specific volume.

Cohesiveness the internal resistance of bakery structure. It is material ability to stick to itself. The highest cohesiveness in M.R.RS sample (0.78), followed by M.R.RS.E sample (0.76) then, M.R.C.RS sample (0.75). There is no significant different between bread samples (M.R.RS, M.R.C.RS and M.R.RS.E) in cohesiveness. While, the control was the lowest (0.59). Liu et al. [46] confirmed that bread with low cohesiveness are more liable to fracture or crumbling, which makes it less acceptability of consumers.

Chewiness parameter decreased in (M.R.RS.E) sample in comparison with corn bread control. Chewiness values were increased in all bread samples during the storage periods. The highest value of gumminess was observed in M.R.RS sample and the lowest in control C. Regarding springiness, M.R.RS.E sample has the highest value. High values of springiness are preferred to its relation with freshness and elasticity of bread [47].

Physical Properties of gluten-free Fino bread samples

Baking quality of bread samples (Table, 7) revealed that M.R.RS.E sample had the highest loaf volume (135 cm^3) compared with the control (C) (120 cm^3). Volume of loaf is important character of baking performance. Specific volume is one of the bread features and it is a key for evaluating quality of bread [45]. Maximum specific volume was in the M.R.RS.E sample followed by M.R.RS sample then M.R.C.RS sample (3.41, 3.33 and 3.16 cm^3/g, in succession). Gluten-free (GF) bread with egg had larger specific volumes and texture properties improvement [15]. While, the control recorded 3.07 cm^3/g as specific volume. These results are in agreement with those reported by Al Shehry [13] who found that the specific volume of corn flour in pan bread was 3.46 cm^3/g. On the contrary, control C showed the highest density (0.33g/cm^3), where the density is inversely proportional to the specific volume. Lowest density was found in bread M.R.RS.E sample, reached to 0.29 g/cm^3. Significant differences were found between all bread samples.

Water activity (a_w) is a key characteristic of the shelf-life of bread. The level of water activity can be used as an indicator for potential growth of molds. Bread containing high water activity spoils faster. The water activity of bread ranges from 0.80 to 0. 98 [48].

It could be noticed from Table (7) that the water activity (a_w) of all bread samples increased during 3 days of storage periods. This may be ascribed to the addition of gums to the blends. Water activity ranged from 0.898 to 0.917 at zero time. The obtained results are in agreement with those findings of Yang [48] who stated that the aw increased in gluten-free bread due to the addition of gums. No significant differences were noticed between all samples.

Microbiological analysis of gluten-free Fino bread

Microbial spoilage is the main factor affecting the shelf-life of bread. Sixty percent of spoilage of bakery products was attributed to the

TABLE 7. Physical, water activity and microbiological properties of gluten-free Fino bread samples

Parameters	Bread samples				LSD
	Control C	M.R.RS	M.R.C.RS	M.R.RS.E	
Physical properties					
Loaf weight (g)	39.10±0.02 [c]	39.00±0.01 [d]	39.58 ±0.01[b]	39.61±0.02 [a]	0.029
Loaf volume (cm³)	120 ±0.57 [d]	130±0.58 [b]	125±0.53 [c]	135 ±0.57 [a]	4.198
Specific volume (cm³/g)	3.07±0.04 [d]	3.33±0.03 [b]	3.16±0.04 [c]	3.41±0.03 [a]	0.071
Density (g/ cm³)	0.33±0.05 [a]	0.30±0.05 [c]	0.31±0.03[b]	0.29±0.04 [d]	0.818
Water activity					
Zero Time	0.904 ± 0.007 [a]	0.898 ± 0.004 [a]	0.906 ± 0.009 [a]	0.917 ± 0.004 [a]	0.030
24 hrs	0.906± 0.005 [a]	0.899 ± 0.006 [a]	0.905 ± 0.007 [a]	0.919 ± 0.002 [a]	0.036
48 hrs	0.908 ± 0.004 [a]	0.902 ± 0.006 [a]	0.909 ± 0.006 [a]	0.920 ± 0.013 [a]	0.028
72 hrs	0.910 ± 0.007 [a]	0.905 ± 0.004 [a]	0.911 ± 0.003 [a]	0.922 ± 0.006 [a]	0.024
Microbiological properties					
Total plate count (TPC) CFU/g					
Zero Time	ND	ND	ND	ND	ND
24 hrs	ND	ND	ND	ND	ND
48 hrs	6×10 [c]	5×10 [d]	7×10[b]	9×10 [a]	0.016
72 hrs	9×10^2 [b]	8×10^2 [c]	8×10^2 [c]	14×10^2 [a]	0.039
Yeast and mold count CFU/g					
Zero Time	ND	ND	ND	ND	ND
24 hrs	ND	ND	ND	ND	ND
48 hrs	3×10 [c]	2×10 [d]	4×10 [b]	5×10 [a]	0.041
72 hrs	3×10^2 [d]	5×10^2 [c]	6×10^2 [b]	9×10^2 [a]	0.052

Means in the same row with different letters are significant ($p<0.05$); ND: not detected;
LSD: least significant difference.
Control C: (100g Corn); M.R.RS Sample: (34 g Millet + 34 g Rice + 32 g Rice Starch); M.R.C.RS Sample: (23 g Millet + 23 g Rice + 23 g Corn + 31 g Rice Starch); M.R.RS.E Sample: (34 g Millet + 34 g Rice + 32 g Rice Starch + 18 g Egg).

growth of fungi, while, mold growth also negativity affect the shelf-life of bread [48].

Data in Table (7) displays the total plate count (TPC) of bread during storage at room temperature for 3 days to monitor the shelf life of the products. No detected cells were found at zero time and 24hrs, due to the lethal effect of the baking temperature on micro-organisms [49]. Meanwhile, the results showed an increase in log bacterial count by increasing the storage period of all samples at 48hrs and 72hrs. The initial count of fungi (molds and yeasts) of M.R.RS.E sample at 48 hrs and 72 hrs were 5x10 and 9×10^2 CFU/g, consecutively. This is in agreement with the findings of Ezeocha et al. [49] which states that the total aerobic count and total fungal count increased progressively with a storage period of bread. Generally, data showed that the total counts were increased by increasing the storage period until 3 days in all samples, meanwhile these results are lower than the permissible limits of WHO standard (1994) of baked products for total plate count (TPC) is 2.0×105 cfu g^{-1}, and for yeast and mold is <1.0×104 cfu g^{-1}.

Conclusion

In this study, the presence of gluten-free Fino bread is very important, especially for school children with celiac disease (CD) to emulate their colleagues. So, evaluated the effect of gluten-free raw materials such as pearl millet, corn and rice on bread for celiac patients. Seven blend formulas were evaluated by mixolab and alveograph. The highest stability doughs was M.R.RS sample. Mothers preferred the M.R.RS.E sample, while their children preferred the M.R.RS. The M.R.RS.E sample had the highest protein, fiber, Ca, Zn and antioxidant contents. It was less hardness, the least sample in staling and larger loaf volume due to effect of egg proteins. Total plate count increases by increasing the storage period of all samples at 48 hrs and 72 hrs, they were still below the permissible limits of WHO standards for baked products. Therefore, this work satisfied children needs in existence acceptable gluten-free Fino bread using available raw materials with appropriate nutritional value for CD patients.

Compliance with the ethical statement

All authors of this paper have no conflict of interest with one or organization.

Acknowledgement

The authors want to thank Dr. Maha Abou Zekri, Consultant Pediatrician in Children Hospital, Cairo University, for her support in sample providing, either mothers or children with celiac disease for implementation of sensory evaluation.

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التركيب الكيميائى و الريولوجى و الحسى وخصائص الجوده لخبز الفينو الخالى من الجلوتين

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استهدفت الدراسه إعداد خبز فينو خالي من الجلوتين (دقيق الدخن اللؤلؤي و الأرز و الذرة) و تقيمه. حيث تم تقدير الخصائص الريولوجية لسته خلطات بواسطة Mixolab و Alveograph. أجرى تقييما حسيا لعينات الخبزبواسطه عشر أمهات. و قد تم اختيار العينات الأكثر قبولاً لاجراء التحليل الكيميائي والفيزيائي والميكروبي والنشاط المضاد للأكسدة و القوام و التقيم الحسى بواسطه ٢٠ مصاب من مستشفى أبو ريش للأطفال. حيث وجد ان دقيق الدخن اللؤلؤي عالى فى محتواه من البروتين و الالياف (١٢.١١ و٢.٩٢%) و منخفض الكربوهيدرات (٧٧.٨٨%) وعالى فى محتواها من المعادن وذو نشاط مضاد للأكسدة مرتفع (٥٥.٣١ %) و عالى فى الفينولات والفلافونويدات (٤٧٤.٢٩ ملجم جاليك /١٠٠جم و ٨٠.٤٣ ماجم كورستين/١٠٠جم) مقارنة بدقيق الذره و الارز. خليط العجين M.R.RS (٣٤ جم دخن ، ٣٤ جم أرز و ٣٢ جم نشا الأرز) كان اكثر ثباتا. وجد أعلى قيم P (مقاومه التمدد) وأقل قيم L (تمدد العجين) في خليط العجين M.R.C.RS (٢٣ جم دخن و ٢٣ جم أرز و ٢٣ جم ذره و ٣١ جم نشا الأرز). و لقد فضلت الأمهات خبز الفينو M.R.RS.E الذى يحتوى على (M.R.RS +١٨ جم بيض) ، بينما فضل الاطفال نفس العينة بدون اضافه البيض (M.R.RS). و اظهرت عينة M.R.RS.E أعلى محتوى من البروتين والألياف و المعادن (الكالسيوم و الزنك). و نفس العينه كانت اكبر حجما نوعيا (٣.٤١ سم^{٣}/جم) و أكثرها طراوه (٤٠٤.٨٩). لذلك ، فان هذا العمل قد حقق الهدف منه من خلال صنع خبز فينو مقبول خالٍ من الجلوتين لدى الاطفال باستخدام المواد المحلية ذات القيمة الغذائية المناسبة لمرضى حساسيه الجلوتين.