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Physicochemical, Sensory and Cooking Qualities of Gluten-free Functional Noodles as a Result of Addition of Date Press Cake

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ABSTRACT

The search for healthier or functional foods that promote wellness and healthy has generated a new market in the food sector. Nowadays, gluten-free products have become a trend as a healthy food. Because consuming wheat noodle, which contains gluten, may cause an allergenic response, especially in celiac disease. Date press cake is one of the agro-industrial wastes and underutilization by it is mainly due to the lack of information about its chemical composition, So, this work aims to explore the benefits and effects of the potential use of date press cake as a fiber-enriching ingredient on the physiochemical properties, cooking qualities and organoleptic indices of gluten-free or gluten noodles. The obtained results indicated that flour type and date press cake ratio had a significant effect on physical properties (elongation, adhesiveness, cohesiveness, and springiness), chemical components (moisture, protein, lipids, total carbohydrates, total dietary fiber, and ash%), minerals composition, (Ca, Mg, K, and Fe mg/100g, except Na element), cooking qualities, (optimum cooking time, cooking loss and cooking yield), and organoleptic indices, (smoothness, appearance, taste, chewiness and overall acceptability) of prepared noodles. Generally, it can be concluded that noodles substituted with 10% date press cake are recommended as an alternative food choice for health-conscious consumers. This was involved in the development of such functional noodles not only to improve the nutritional value of the general population but also to help those suffering from degenerative diseases associated by people with celiac and those who wish to exclude gluten-based products from their diet for health reasons.

Keywords: Noodles, gluten-free products, Celiac, date press cake.

INTRODUCTION

Noodles appeared in China since 5000 BC and then they moved to other countries of Asia. Worldwide, Noodle is an instant staple food available in different ingredients composition. The main ingredient or flour that can be used in the making of noodles is gluten flour or gluten-free flour (Lee et al., 2008). Noodle quality made from wheat flour (semolina) is the best and flour is low in fiber. Consumption of gluten noodles causes three main clinical states: 1- Sensitivity of nonceliac gluten, 2-Celiac disease (CD), and 3- Allergy to wheat. The optimal treatment for these states is a diet of gluten-free (GFD). The demand for a diet of gluten-free is large and quickly increasing nowadays because of the increase in the number of humans who suffer from CD as studied by Foschia et al., (2016) and Romero et al., (2017). Recently, food processors have responded to the demands of consumers for diets with larger dietary fiber by improving food products in which ingredients containing high fiber are used.

Date press cake (DPC) as a agro-manufacture residues contributes to a large loss of raw agricultural materials and causes disposal issues and environmental problems due to containing their high fibers and bulky nature (Al-Farsi and Lee, 2008; Ashraf and Hamidi-Esfahani,2011). Heidarinejad et al., (2018) concluded that sugar extraction of low-quality dates resulted in nearly17- 28% DPC, which is used in either animal feed or dumped into drains or open soils. This action leads to great environmental and economic problems. The lack of available information on the chemical composition of DPC, as well as its benefits for food, and health is the cause of the underutilization of its and other food applications. From fiber-rich ingredients is DPC which will potentially it's used in food processing led to improve not only the value of nutritional but also indices of functional and benefits of immense therapeutic like cholesterol reduction, diseases of coronary heart, loss of weight, diabetes, etc. (Pakhare, et al. 2018; and Adejuwon, et al.2019). Majzoobi et al. (2019) and Sutheeves et al. (2020) reported that DPC contained 13.4% moisture, 6.3% protein, 4.9% fat, fiber, 79.1% carbohydrate and11.7% crude.

The main work aims were to determine the chemical composition of raw materials, i.e., gluten flour (GF), gluten-free flour (GFF), egg and date press cake (DPC) produced from Egyptian Saidy cultivar used in preparation and develop a functional noodle with low carbohydrate digestibility. The other objective of this work was to study the use of date press cake as a fiber-rich ingredient in the preparation of gluten-free noodles or gluten noodles. So, the effects of supplementation by different ratios of DPC (0.00, 5.00, and 10.00% of the flour weight) on physiochemical composition, qualities of cooking, and organoleptic indices of GF and GFF functional noodles were investigated.

MATERIALS and METHODS

Raw materials

Commercial gluten flour (GF), sunflower oil food, and egg samples were collected and randomly purchased from different markets and stores during the November 2021 season in closed plastic containers, El. Kharga Oasis, New Valley Governorate, Egypt. Gluten-free flour (GFF) was purchased from a local Supermarket, in Assiut district, Assiut Governorate, Egypt.

Date press cake (DPC) is the remained part of Saidy cultivar dates flesh after the sugar extraction from its Tamer stage produced from one of the largest date processing factories, El-Gharga Oasis, New Valley Governorate, Egypt. The press cake was provided as a dry powder packed in polyethylene bags and stored at -18 °C for analysis tests. EL-Gomhouria Trading Chemicals and Drugs Co. in Assiut, Egypt, supplied the chemicals used in this work to estimate the physiochemical analysis of the studied noodles products

Preparation of functional noodles

Functional Noodles were prepared by blending the used ingredients for each treatment as in Table 1, for 15 minutes using a commercial laboratory mixer and steamed for 30 minutes. The resulting dough was fed in the small-scale single-screw extruder at a temperature setting of 60 o C and speed of 50 rpm. Noodles were to be taken to dry in an oven with air circulation at 60 °C for 40 min. The treatments of blending are as follows:

Table 1. Noodles formulations supplemented with different ratios of date press cake

Formulations	Ingredients						
	Gluten flour (g)	Gluten-free flour (g)	DPC* (g)	Egg (g)	Salt (g)	Oil	Water
T1 (Control)	100	-	-	50	0.5	4 mL	30 ml
T2	95	-	5	50	0.5	4 mL	30 ml
T3	90	-	10	50	0.5	4 mL	30 ml
T4 (Control)	-	100	-	50	0.5	4 mL	30 ml
T5	-	95	5	50	0.5	4 mL	30 ml
T6	-	90	10	50	0.5	4 mL	30 ml

DPC*= Date press cake

Analytical determinations

The proximate composition

The proximate composition (moisture, protein, lipids (Soxhlet method), dietary fiber, and ash) of functional noodles was analyzed according to Rekas& Marciniak- Lukasiak (2015). The total carbohydrate content was calculated by the following equation:

Total carbohydrate%= (100 - [protein% + fat% + ash%]) (on dry solid).

Calcium (Ca), phosphorous (P), and iron (Fe) contents (mg/100g) of the studied samples were determined using Perkin Elmer 2380, atomic absorption spectrophotometer according to the methods of AACC (2000).

The physical properties

The physical properties of studied noodles samples, i.e., cohesiveness elongation, adhesiveness, and springiness. The physical properties were determined using a Texture Analyzer (Micro Systems, Surrey, UK) according to the methods described in AACC (2000).

Cooking qualities

The optimum cooking time, cooking loss and cooking yield (or water absorption) of functional noodles were determined according to Wójtowicz & Mościcki (2014); Bouasla et al. (2017) and Romero, et al. (2017).

Cooking loss value was calculated as follow:

Cooking loss (%) = Dry matter loss during cooking x 100 / Weight of noodles before cooking

The cooking yield value was calculated as follow:

Cooking yield (%) = Weight of noodles after cooking x 100 / Weight of noodles before cooking

Sensory evaluation

The noodle samples were boiled using tap water for the optimum cooking time. The samples were then stored for not more than 30 min in tightly covered plastic food containers before testing. The noodles were evaluated by thirty untrained panelists who like eating noodles. The six optimally cooked noodles with the soup were evaluated for smoothness, Appearance, taste, chewiness, and overall acceptability parameters using a ten-point structured hedonic scale, where 1 = very much dislike and 10 = very much like according to ÇELİK, et al. (2010) and Dutcosky (2011).

Statistical analysis

Statistical analysis was conducted on the experimental data using a one-way analysis of variance (ANOVA), and a comparison of the means was completed by LSD test with a significance level of $p<0.05$ according to Montgomery, (2017).

RESULTS AND DISSUSSION

Raw materials composition

Chemical composition of gluten flour, gluten-free flour, and egg and DPC were analyzed and compared (Table 2). It could be from data in Table that there were significant differences in chemical composition parameters, i.e. moisture, protein, lipids, total carbohydrates, total dietary fiber, and ash contents of the studied raw materials samples used for the functional noodles preparation. Gluten flour (GF) and egg had the highest value (12.55%) of protein content. Also, eggs contained the highest value (9.92%) of lipids content and the lowest values (0.74, 0.95, and 0.00%) of total carbohydrates, ash, and total dietary fiber contents. However, date press cake (DPC) had the highest values (85.76 and 53.41%) of total carbohydrates and total dietary fiber contents, as well as the lowest values (2.25 and 0.96%) of protein and lipids contents, respectively. Gluten-free flour (GFF) contained the highest value (1.68%) of ash content. These results were found to be in good agreement with those secured by Chillo et al., (2009) and Sozer, (2009). They revealed that the date press cake had interesting characteristics from a nutritional and functional standpoint, as it is a source of fiber and a substitute for flour in the processing of GF food. Also, they indicated that an improvement in noodle texture when the egg was used. In addition, the gliadin and glutenin in gluten flour form a “network” structure when water is added to the wheat dough, which traps the water in the dough and prevents the dissolution of the noodle during cooking. The absence of gluten makes it difficult to achieve a cohesive dough structure, and consequently, noodle made of gluten-free flour has a different and undesired textural quality.

Table 2. Chemical raw materials composition used in noodles preparation.

Raw material	Moisture%	Protein%	Lipids%	Carbo.	Fiber%	Ash%
GF	12.55	12.55	1.22	72.70	2.11	0.98
GFF	10.93	10.99	1.69	74.74	2.92	1.68
Egg	75.84	12.55	9.92	0.74	0.00	0.95
DPC	9.51	2.25	0.96	85.76	53.41	1.52
Mean	27.21	9.59	3.45	58.48	14.61	1.28
F value	**	**	**	**	**	**
LSD at 5%	0.12	0.13	0.11	0.17	0.12	0.12

DWB*=Dry weight basis. Carbo.=Total carbohydrates Fiber%= Total dietary fiber%, GF= Gluten flour, GFF= Gluten-free flour, and DPC= Date press cake.

Mineral composition of raw materials

The results recorded in Table 3 clarified that there were significant differences in mineral composition, i.e. Ca, K, Mg, Na, and Fe of the studied raw materials samples used for noodles preparation. The data indicated that GFF had the highest value (164.17 mg/100 g DWB) of Ca content. While the egg scored the lowest values of Ca, Mg, K, and Fe contents (53.00, 12.00, 128.00, and 1.81 mg/100 g) as well as the highest value (40.00 mg/100) of Na content. However, date press cake (DPC) had the highest values (159.00 and 18.00 mg/100 g) of Mg and Fe contents, as well as the lowest value (2.22 mg/100g) of Na content, respectively. Gluten flour (GF) contained the highest value (312.24 mg/100g) of K content. The differences in mineral composition were because of the differences in total solids and ash% of the studied raw materials samples. These results were found to be in accordance with Chillo et al., (2009) and Sozer, (2009).

Effect of supplementation by date press cake on physical properties of Noodles

The results in Table 4 clarified that there were significant differences in the physical properties (elongation, adhesiveness, cohesiveness, and springiness) of noodles prepared from gluten flour (GF) at different ratios of DPC compared to gluten-free flour (GFF). Elongation is one of the parameters to determine the quality of noodles.

Table 3. Minerals composition (mg/100g DWB*) of raw materials used in functional noodles preparation.

Raw material	Ca	Mg	K	Na	Fe
GF	41.00	98.11	312.24	4.00	3.20
GFF	164.17	52.00	231.00	2.22	2.41
Egg	53.00	12.00	128.00	40.00	1.81
DPC	122.33	159.00	355.00	15.33	18.00
Mean	95.13	80.28	256.56	15.39	6.36
F value	**	**	**	**	**
LSD at 5%	2.67	8.48	5.75	3.77	1.00

DWB*=Dry weight basis. GF= Gluten flour, GFF= Gluten-free flour, and DPC= Date press cake.

Noodles prepared from gluten flour or wheat flour had higher values (154.00%, 0.74, and 0.81) of elongation, cohesiveness, and springiness as well as a lower value (-50.80 g.sec) of adhesiveness. However, functional noodles prepared from gluten-free flour (GFF) had lower values (146.22%, 0.65, and 0.77) of elongation, cohesiveness, and springiness as well as a higher value (-45.90 g.sec) of adhesiveness, respectively. This result was mainly attributed to the lack of gluten in gluten-free and the differences in chemical components of flour type. As expected, gluten or wheat noodles again presented the highest cohesiveness and had a stronger elastic structure network than gluten-free wheat noodles before and after cooking. Such findings are in the same line with Romero et al. (2017) and Sholichah, et al. (2021). They showed that good quality noodles have a high elongation value, and people prefer noodles with elasticity when served.

Table 4. Physical properties of gluten and gluten-free noodles at different DPC levels.

Type of flour (A)	DPC % (B)	Physical properties of gluten and gluten-free noodles			
		Elongation %	**Adhesiveness (g.sec)**	**Cohesiveness**	**Springiness**
Gluten flour	**0.0**	165.00	-55.50	0.76	0.82
	5.0	153.00	-51.70	0.74	0.81
	10.0	145.00	-45.20	0.71	0.80
Mean		154.33	-50.80	0.74	0.81
Gluten-free flour	**0.0**	154.67	-49.60	0.68	0.78
	5.0	146.00	-46.40	0.66	0.76
	10.0	138.00	-41.70	0.62	0.76
Mean		146.22	-45.90	0.65	0.77
Means of DPC % (B)	**0.0**	159.83	-52.45	0.72	0.80
	5.0	149.50	-49.05	0.70	0.78
	10.0	141.50	-43.45	0.67	0.78
Overall mean		150.28	-48.35	0.70	0.79
F value A		**	**	**	**
B		*	**	**	**
AB		Ns	**	Ns	Ns
LSD at 5% A		1.26	0.44	0.01	0.01
B		1.57	0.32	0.02	0.01
AB		-	0.45	-	-

NS= non-significant.

Results in Table 4 clarified the physical properties (elongation, adhesiveness, cohesiveness, and springiness) of noodles supplemented by different ratios of date press cake (DPC). Data illustrated that as the concentration of date press cake (DPC) incorporated in noodles increased from 0.00% to 5.00 and 10.00% led to a significantly decreased in the elongation from 159.83 to 149.50 and 141.50 %, the cohesiveness from 0.72 to 0.70 and 0.67, the springiness from 0.80 to 0.78 and 0.78, and a significant increase in the adhesiveness from -52.45 to -49.05 and -43.45, respectively. The negative correlation between DPC concentration and elongation, cohesiveness, and springiness of functional noodles indicated the negative effect of DPC on the interactions among gelatinized granules (Abdulmola et al., 1996). These results are in agreement with those obtained by Sudha et al. (2007); O'Shea et al., (2015); Kosmala et al., (2017). They mentioned that the underutilization of the DPC is mainly due to the lack of information about its chemical composition. Similar findings are obtained by Heidarinejad et al., (2018) and Sholichah, et al. (2021) who showed that the addition of date press cake causes a significant decrease in GF pasta elongation. This might be due to the addition of date press cake causing a significant decrease in the gluten content of GF noodles.

The adhesiveness of functional noodles was significantly influenced by the interaction between the type of flour and supplementation with DPC as shown in Table 4. The lowest value (-55.60 g. sec) of adhesiveness was recorded with noodles prepared from gluten flour and supplementation with 0.00% DPC, while, the highest value (-43.45 g. sec) was found with noodles prepared from gluten-free flour and supplementation with 10.00% DPC. Although the noodle supplemented with date press cake (DPC) was lower in elongation, cohesiveness, and springiness than those of wheat, there was no doubt that adding DPC improved the network of starch in functional noodles substantially, since the pure noodles disintegrated during cooking. It was observed that both DPC promoted starch granule association at high temperatures, which may be the mechanism involved in the improvement of noodle texture (Chaisawang and Suphantharika, 2005). These results are in agreement with Adejuwon, et al. (2019). They revealed that dietary fiber is a substance that can reduce the risk of many human disorders. 25-35 grams per day is the ideal amount of daily requirement. Diseases have led to an increasing awareness among consumers about the health benefits of dietary fiber.

Effect of supplementation by date press cake on chemical composition of Noodles

Noodle is criticized to be poor in protein, fiber, and micronutrient. As seen from the results in Table 5 that there were significant differences the chemical components (moisture, protein, lipids, total carbohydrates, total dietary fiber and ash%) of noodles prepared from GF and GFF at different ratios of DPC. Moisture content (11.31%) was significantly lower in the gluten-free flour noodles (GFF noodles) than gluten flour noodles, GF noodles, (13.63%), probably due to its low water-retaining capacity. Here too, GF noodles exhibited higher values of protein and ash contents (13.63 and 1.36%) and lower values of lipids, total carbohydrates, and dietary fiber contents (1.42, 71.23, and 3.03%) compared with GFF noodles (11.31 and 0.89,1.63, 75.03 and 3.40%), respectively. The highest protein content was observed for products prepared with gluten or wheat flour (Table 2). Consuming wheat noodle, which contains gluten, may cause an allergenic response, especially in CD (Houben, et al 2012 and Bouasla, et al., 2017; Fitzmaurice, et al 2018). They revealed that this disease is a chronic entheropathy caused by gluten proteins intolerance, which causes atrophy of intestinal villi, malabsorption and clinical symptoms that can appear in both childhood and adulthood. In this subject, food consumption is directly related to a person's health. Because foods eaten are causes of life-threatening diseases such as cancer, diabetes, heart disease, hypertension, etc. (Kaur, and Das, 2011). They indicated that gluten gives negative impacts of human health, particularly in the coeliac disease patients who are intolerance to this protein fraction (Rosell, et al., 2014). These results are in line with those studied by Bilgiçli, (2013) and Bouasla, et al., (2017). They indicated that consumers give importance to consideration of nutritional value and benefits of foods before they consume to gain maximum benefits.

Table 5. Chemical composition of gluten and gluten-free noodles at different DPC levels.

Type of flour (A)	DPC % (B)	Moisture%	Protein %	Lipids %	Carb.*	Total dietary fiber%	Ash %
Gluten flour	**0.0**	12.55	14.35	1.58	70.67	1.86	1.32
	5.0	12.86	13.61	1.38	71.27	3.08	1.37
	10.0	13.12	12.92	1.31	71.76	4.15	1.40
Mean		12.84	13.63	1.42	71.23	3.03	1.36
Gluten-free flour	**0.0**	10.17	11.91	1.81	74.79	2.26	0.84
	5.0	10.83	11.31	1.66	74.84	3.35	0.88
	10.0	11.04	10.72	1.42	75.45	4.58	0.93
Mean		10.68	11.31	1.63	75.03	3.40	0.89
Means of DPC % (B)	**0.0**	11.36	13.13	1.70	73.60	2.06	1.08
	5.0	11.84	12.46	1.52	73.06	3.22	1.13
	10.0	12.08	11.82	1.36	72.73	4.37	1.17
Overall mean		11.76	12.47	1.52	73.13	3.21	1.13
F value A		**	**	*	**	**	**
B		**	**	**	**	**	*
AB		**	Ns	Ns	**	*	NS
LSD at 5% A		0.09	0.20	0.16	0.16	0.04	0.05
B		0.08	0.10	0.08	0.13	0.06	0.12
AB		0.11	-	-	0.18	0.09	-

***Carb.** = Total carbohydrates NS= non-significant.

The significant differences among chemical components of GF or GFF noodles supplemented with different ratios of date press cake (DPC) were tabulated in Table (5). Supplementation of GF or GFF functional noodles with DPC from control (0.00%) to 5.00 and 10.00% led to an increasing in moisture content by 4.23 and 6.34%, total dietary fiber content by 56.31 and 112.14%, ash content by 4.63 and 8.33%, as well as decreasing in protein content by 5.38 and 11.08%, lipids content by 11.84 and 25.00%, total carbohydrates content by 0.74 and 1.20% of the control value, respectively. The addition of DPC from control (0.00%) to 5.00 and 10.00% for GF or GFF noodles resulted in the highest increase for total dietary fiber content of GF or GFF noodles compare to the other components. This may be related to the high content of total carbohydrates, dietary fiber, and ash content in DPC (Wójtowicz & Mościcki, 2014; Singh, et al., 2007). The results highlight two interesting parts of the utilization of the addition of DPC in developing GF or GFF noodles. First, the high total dietary fiber of DPC can be considered an important aspect to develop GF or GFF noodles with improved nutrition values. Secondly, the utilization of DPC in GF or GFF noodle-making would not necessarily have a significant effect on predictive glycaemic loading. However, incorporating a higher proportion of DPC in the noodles formulation leads to lower glycaemic loading properties. Thus, these findings can be used to develop GF or GFF functional noodles from DPC with some further improvement to achieve better nutritional value with desirable quality to conventional noodles made from GF or GFF. Celiac people have a low intake of dietary fiber (Stojceska, et al., 2010). This study's result is in line with the previous studies conducted by Bilgiçli, (2013) who demonstrated that the DPC substitution increases total dietary fiber by almost 70% and has been successfully used as a replacement or base material in noodles-making. This may be related to the high content of total carbohydrates, dietary fiber, and ash content in DPC (Wójtowicz & Mościcki, 2014; Singh, et al., 2007). Kosmala et al., (2017) demonstrated that DPC offers an available, natural component and low cost suitable for the production of many types of foods including allergy-free (e.g. gluten and lactose-free) products. In this respect, Majzoobi et al. (2019) showed that date press cake is a waste of date fruit juicing that has remained underutilized in the food industry.

Total carbohydrates and dietary fiber contents of noodles were significantly influenced by the interaction between type of flour and supplementation with DPC as shown in Table 5. The highest values (75.45 and 4.58%) of total carbohydrates and dietary fiber contents were recorded with noodles prepared from gluten-free flour and supplemented with 10.00% DPC, while, the highest value (14.35%) of protein content was found with noodles prepared from gluten or wheat flour and supplementation with 0.00% DPC. Increasing levels of supplementation with DPC resulted in a decreased protein content which altered the chemical composition of GF or GFF noodles. These results are in agreement with Adejuwon, et al. (2019) who clarified that diets had low glycemic which are rich in dietary fiber, reduce the insulinemic responses to food and exert hypocholesterolemic action.

Effect of supplementation by DPC on minerals composition of Noodles

There were significant differences in the minerals composition, i.e. Ca, Mg, K, Na, and Fe mg/100g, of functional noodles prepared from GF and GFF at different ratios of DPC, except Na element was non-significant (Table 6). The lower values of Ca, Mg, K, and Fe (39.33, 46.33, 186.89, and 3.37 mg/100g) were observed for GFF noodles, while GF noodles contained the higher values (106.67, 84.67, 261.67, and 3.99 mg/100g), respectively. This might be attributed to the ash content being higher in GF noodles than in GFF noodles.

Table 6. Minerals composition (mg/100g) of gluten and gluten-free noodles at different DPC levels.

Type of flour (A)	DPC % (B)	Minerals composition of gluten and gluten-free noodles				
		Ca	Mg	K	Na	Fe
Gluten flour	0.0	100.00	82.33	253.00	388.67	3.20
	5.0	109.00	84.67	262.00	398.67	4.03
	10.0	111.00	87.00	270.00	410.33	4.73
Mean		106.67	84.67	261.67	399.22	3.99
Gluten-free flour	0.0	36.00	43.00	180.00	391.00	2.60
	5.0	40.00	47.00	186.67	400.00	3.30
	10.0	42.00	49.00	194.00	409.00	4.20
Mean		39.33	46.33	186.89	400.00	3.37
Means of DPC % (B)	0.0	68.00	62.67	216.50	409.67	2.90
	5.0	74.50	65.83	224.33	399.33	3.67
	10.0	76.50	68.00	232.00	389.83	4.47
Overall mean		73.00	65.50	224.28	399.61	3.68
F value A		**	*	*	Ns	*
B		*	*	*	*	*
AB		Ns	Ns	Ns	Ns	Ns
LSD at 5% A		0.83	8.72	11.63	-	0.13
B		5.04	3.05	3.74	11.57	0.14
AB		-	-	-	-	-

***Carb.** = Total carbohydrates NS= non-significant.

Bilgiçli, (2013) reported that the absence of cereals in a diet can led to nutrient deficiencies in iron, calcium, folate, and select fat-soluble vitamins. These findings are in accordance with those scored by Wójtowicz & Mościcki, (2014) and Singh, et al., (2007) who concluded that the highest Ca, Cu, Fe, K, Mn, P, and Zn contents were in gluten-free noodles than gluten noodles. Bilgiçli, (2013) stated that a good choice for celiac patients is gluten-free noodle with the advantages of having a long shelf-life and ease of transportation. Farrand, et al. (2017) noted that extremely wide variation in sodium content in noodles products from 10 countries had, both between and within countries, according to product ranges and brands. Adejuwon, et al. (2019) and Wang, et al. (2023) revealed that noodle is poor in fiber, micronutrient, and protein, while it's high in sodium.

Significant differences among minerals composition of GF or GFF functional noodles supplemented with different ratios of date press cake (DPC) were tabulated in Table (6). Supplementation of GF or GFF functional noodles with DPC from control (0.00%) to 5.00 and 10.00% led to an increase in Ca content by 9.56 and 12.50%, Mg content by 5.04 and 8.50%, K content by 3.62 and 7.16%, Fe content by 26.55 and 54.14%, as well as decreasing in Na content by 2.59 and 5.09% of the control value, respectively. The addition of DPC from control (0.00%) to 5.00 and 10.00% for GF or GFF noodles resulted in the highest increase for Fe content of GF or GFF functional noodles compare to the other minerals. This may be related to the high content of Fe content in DPC (Table,2). The results highlight Fe content of the utilization of the addition of DPC in developing with some further improvement to achieve better nutritional value with desirable quality to conventional noodles made from GF or GFF. This study's result is in line with the previous studies conducted by Bilgiçli, (2013) who demonstrated that the DPC substitution increases Fe content by almost 50% and has been successfully used as a replacement or base material in functional noodles-making. This may be related to the high content of total carbohydrates, dietary fiber, and ash content in DPC. These findings are in the same line with those scored by Wójtowicz & Mościcki, (2014); Singh, et al., (2007).

Minerals contents of functional noodles were non-significantly influenced by the interaction between type of flour and supplementation with DPC as shown in Table 6.

Effect of supplementation with DPC on cooking qualities of noodles

As demonstrated from the results in Table 7 that there were significant differences in the cooking qualities, i.e., optimum cooking time, cooking loss, and cooking yield, of functional noodles prepared from GF and GFF at different ratios of DPC. The optimum cooking time was defined as the time at which the white center and core color of ungelatinized starch in the noodles strands disappeared. The optimum cooking time was lower in GFF noodles (10.89) than in GF noodles, (17.74 min.). While the higher values of cooking loss and cooking yield% (7.68 and 308.65%) were observed for GFF noodles than GF noodles (5.09 and 280.74%) prepared with gluten or wheat flour, respectively. In noodles, solid loss during cooking is mostly due to the solubilization of loosely bound gelatinized starch from the surface of the product (Resmini & Pagani, 1983). Additionally, because of the lack of a gluten network, starch polymers are less efficaciously entrapped in the matrix, resulting in a product with a high cook loss, up to three-four times greater than that of the semolina sample (Marti et al., 2013). Similar results are recorded by Bilgiçli, (2013) who demonstrated that cooking loss was related to the structural strength of the noodles, and a higher value indicated a lower structural strength. Longer cooking in GF noodles might be due to a strong protein network formed by cross-linking of glutenin and gliadin which surrounds starch granules and restricts their swelling and gelatinization during cooking. Since the major storage proteins from wheat, glutenins, and gliadins, are rich in cysteine residues. In addition, starch components of flour also play an important role in the water uptake of cooked noodles. These interactions might allow GFF noodles to develop stronger structures. A negative correlation was observed between the optimum cooking time and cooking loss values. These results are in the same trend as those reported by Sudha et al. (2007); O'Shea et al., (2015); Kosmala et al., (2017). They clarified that DPC as a functional ingredient has an immense scope in the improving of value-added products and healthy foods.

Table 7. Cooking parameters of gluten and gluten-free noodles incorporated with different DPC amounts.

Type of flour (A)	Date press cake % (B)	Cooking parameters of gluten and gluten-free noodles		
		Optimum cooking time(min)	Cooking loss%	Cooking yield%
Gluten flour	0.0	15.07	6.66	271.17
	5.0	17.97	4.72	281.71
	10.0	20.19	3.88	289.33
Mean		17.74	5.09	280.74
Gluten-free flour	0.0	6.50	8.47	299.91
	5.0	10.59	7.75	309.26
	10.0	15.57	6.81	316.77
Mean		10.89	7.68	308.65
Means of DPC % (B)		10.78	7.57	285.54
		14.28	6.23	295.49
		17.88	5.35	303.05
Overall mean		14.31	6.38	294.69
F value A		**	**	**
B		*	**	**
AB		**	**	Ns
LSD at 5% A		0.48	0.15	1.20
B		0.41	0.13	1.39
AB		0.59	0.19	-

NS= non-significant.

Significant differences in cooking parameters i.e., optimum cooking time, cooking loss, and cooking yield of GF or GFF functional noodles supplemented with different ratios of date press cake (DPC) were tabulated in Table (6). Supplementation of GF or GFF functional noodles with DPC from control (0.00%) to 5.00 and 10.00% led to an increase in optimum cooking time by 32.47 and 65.86%, cooking yield by 3.48 and 6.13%, as well as decreasing in cooking loss by 21.51 and 41.50% of the control value, respectively. The addition of DPC from control (0.00%) to 5.00 and 10.00% for GF or GFF functional noodles resulted in the highest increase for optimum cooking time of GF or GFF functional noodles compare to the other cooking parameters. This behavior explained to suggest that DPC could act as a texture modifier. Sajilata, et al. (2006) and Sozer et al. (2007 & 2008) demonstrated that the substitution of durum wheat semolina with dietary fiber caused an increase in optimum cooking time compared to control noodles as a result of the greater ability of "exposed" hydrophilic groups to bind water molecules and form a gel (Lai & Cheng, 2004). Conversely, Vernaza et al. (2012) and Aravind, et al. (2013) in other studies showed that replacing durum wheat semolina with dietary fiber caused a slight decrease in optimum cooking time values. The disagreement between the studies could be due to the different noodle formulation (type and content of dietary fiber and flour) and the different process conditions for noodle production. The cooking loss of DPC-enriched samples was lower than control, suggesting the formation of a structure that is more resistant to disintegration on boiling. Bilgiçli, (2013) demonstrated that the cooking loss of noodles was because the soluble starch and other soluble components, including non-starch polysaccharides, leached out into the water during cooking. In this subject, Gull et al., (2016) indicated that the cooking loss for a good quality noodle should be lower than 12%. This study's result is in line with the previous studies conducted by Foschia, et al. (2017). The positive effect of DPC on noodles quality was confirmed by the cohesiveness parameter (Table, 4). The cooking yield explains the ability of the noodles to absorb water during the cooking process (Tan et al., 2016). An increase in the cooking yield of noodles prepared from a blend of DPC had higher cooking weight than the control might be due to absorbing more water and the lower cooking loss. The highest cooking yield was observed in the samples in which DPC was added. This result may be due to the ability of the DPC to absorb water in its interrelated network and interact with starch granules (Rodge, et al., 2012). This result is in the same line as previous studies by Sozer, et al. (2007) and Aravind, et al. (2013) in which noodles replaced with 20% of commercial fiber and spaghetti enriched with 10% fiber had higher cooking weight than the control. In this respect, Al-Farsi and Lee, (2008); Ashraf and Hamidi-Esfahani, (2011) clarified that date press cake as one the agro-industrial waste contributes to a great loss of raw materials and causes disposal problems and environmental issues due to their bulky nature and high carbohydrate.

Optimum cooking time and cooking loss of functional noodles were significantly influenced by the interaction between type of flour and supplementation with DPC as shown in Table 7. The highest value (20.19 min.) and lowest value (3.88%) of optimum cooking time and cooking loss were recorded with noodles prepared from gluten flour and supplemented with 10.00% DPC, while, the lowest value (6.50 min.) and the highest value (8.47%) of protein content were found with noodles prepared from gluten or wheat flour and supplementation with 0.00% DPC. Increasing levels of supplementation by DPC resulted in a decreased cooking loss which increased the cooking yield of GF or GFF noodles. These results are in agreement with Sozer, et al. (2007) and Aravind, et al. (2013). Conversely, these results are in disagreement with Ovando-Martinez et al. (2009) who concluded that partial or complete substitution of durum wheat semolina with fiber material can result in negative changes to pasta quality, including increased cooking loss. The industry standard of cooking loss for pasta is no greater than 8 % (Foschia et al., 2015). Increasing the level of protein inclusion resulted in a decrease of cooking loss, this happened due to poor structure in the absence of a gluten network resulting in faster water penetration into the noodle structure (Mertz and Wang 2011). They concluded that the shorter optimum cooking time appears to be related to lower water absorption (81.13%- 97.92%). They also observed a positive correlation between optimum cooking time and water absorption index or cooking yield. In this respect, Adejuwon, et al. (2019) stated that the cooking qualities of noodles could be influenced by flour quality, other ingredients formulation, and processing.

Effect of supplementation by DPC on Organoleptic indices of noodles

Significant differences in organoleptic indices, i.e., smoothness, appearance, taste, chewiness, and overall acceptability of noodles made from GF or GFF flour and supplemented by different ratios of DPC, except appearance were summarized in Table 8. The higher values of smoothness, appearance, taste, chewiness, and overall acceptability (8.06, 7.67, 7.98, 7.64, and 7.82) were scored in noodles made from GF, while, noodles made from GFF contained the lower values (7.59, 7.72, 7.86, 7.49 and 7.71), respectively. However, it is worth noting that the use of raw materials with higher fiber content in the noodles promotes a general reduction in sensory characteristics (Aravind, et al., 2012). Similar results occurred by Bilgiçli, (2013) who mentioned that gluten-free noodles showed lower values of lightness compared to gluten noodles. However, these types of noodles or products have a place in the consumer market because they meet the needs of a specific target audience. Adejuwon, et al. (2019) demonstrated that noodles color remains an important characteristic of quality because it indicates the product's first apparent properties. Consumer color preference is the major parameter used in assessing noodle quality. They indicated that another parameter consideration was flour extraction rate as the presence of bran particles in flour is a function of flour extraction rate. Flour extraction rate has been shown to significantly influence the color and texture of noodles.

Table 8. Organoleptic indices of gluten and gluten-free noodles at different DPC levels.

Type of flour (A)	DPC % (B)	Organoleptic indices of gluten and gluten-free noodles				
		Smoothness	Appearance	taste	Chewiness	Overall acceptability
Gluten flour	**0.0**	8.30	7.97	7.50	7.17	7.53
	5.0	7.97	7.60	7.97	7.70	7.87
	10.0	7.90	7.43	8.47	8.07	8.07
Mean		8.06	7.67	7.98	7.64	7.82
Gluten-free flour	**0.0**	7.83	7.97	7.33	7.07	7.43
	5.0	7.53	7.67	7.90	7.53	7.77
	10.0	7.40	7.53	8.33	7.87	7.93
Mean		7.59	7.72	7.86	7.49	7.71
Means of DPC % (B)	**0.0**	8.07	7.97	7.42	7.12	7.48
	5.0	7.75	7.63	7.93	7.62	7.82
	10.0	7.65	7.48	8.40	7.97	8.00
Overall mean		7.82	7.69	7.92	7.57	7.77
F value A		**	Ns	**	**	*
B		**	**	**	**	**
AB		Ns	Ns	Ns	Ns	NS
LSD at 5% A		0.17	-	0.10	0.05	0.10
B		0.07	0.08	0.07	0.12	0.07
AB		-	-	-	-	-

NS= non-significant.

Significant differences in organoleptic indices, i.e., smoothness, appearance, taste, chewiness, and overall acceptability of GF or GFF functional noodles supplemented with different ratios of date press cake (DPC) were tabulated in Table (8). Supplementation of GF or GFF functional noodles with DPC from control (0.00%) to 5.00 and 10.00% led to a decreasing in smoothness by 4.13 and 5.49%, appearance by 4.46 and 6.55%, as well as increasing in taste by 6.87 and 13.21%, chewiness by 7.02 and 11.94% and overall acceptance by 4.55 and 6.95% of the control value, respectively. Similar findings are recorded by Baliga, et al. (2011) who demonstrated that the light brown color of date press cake is due to the natural pigments from date flesh and seeds, mainly carotenoids and anthocyanins. However, it is worth noting that the use of raw materials with higher fiber content from DPC in the noodles promotes a general reduction in sensory characteristics (Aravind, et al., 2012). However, these types of products have a place in the consumer market because they meet the needs of a specific target audience. Adejuwon, et al. (2019) mentioned that noodles are consumed by large numbers of people around the world because of their taste, low cost, and ease of preparation which make them appeal to busy people and the economic class. Also, they concluded that the addition of dietary fiber will contribute to increasing the functional properties of noodles and can give texture, and stabilizing properties to the supplemented noodles. The fiber-rich noodles are currently in high demand.

CONCLUSION

Consuming wheat noodle, which contains gluten, may cause an allergenic response, especially in CD. This disease is a chronic enteropathy caused by gluten protein intolerance, which causes atrophy of intestinal villi, malabsorption, and clinical symptoms that can appear in both childhood and adulthood. From a nutritional point of view, the use of DPC is considered an important gain, especially for consumers suffering from CD. The extrusion-cooking process caused strong interactions among the noodle components. Substitution of wheat semolina or gluten-free flour with dietary fiber caused an increase in optimum cooking time compared to control consequently, supplementation of flour in noodle processing by 10.00%DPC, showed low cooking losses and produced better taste, chewiness, and overall acceptability. This behavior seemed to suggest that DPC could act as a texture modifier. GFF noodles substituted with 10% DPC are recommended as an alternative food choice for health-conscious consumers.

Conflicts of Interest/ Competing interest

All authors declare that they have no conflicts of interest.

Data availability statement

All data sets collected and analyzed during the current study are available from the corresponding author on reasonable request.

List of Abbreviations

GFF Gluten-free Flour
GF Gluten Flour
DPC Date press cake
BC Before Christmas
CD Celiac Disease
GFD Gluten-free diet
Co. Company
NS Non-significant
AACC American Association of Cereal Chemists
Carb Total Carbohydrates
DWB Dry Weight Basis

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