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Physico-Chemical Properties and Sensory Evaluation of Toast Bread Fortified with Different Levels of White Grapefruit (*Citrus paradise* L.) Albedo Layer Flour

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Abstract: The current study aimed to utilize the white grapefruit albedo layer flour in wheat toast bread fortification. Study included determination of gross chemical composition, caloric value and minerals (Ca, Fe, Zn, Na, K and P) content of studied toast bread likewise; physical and sensory characteristics of studied toast bread were assessed. The data revealed that incorporation of both wheat flour and defatted grapefruit albedo layer flour increased crude fat, ash and crude fiber to (1.57%, 6.41%), (0.59%, 2.20%) and (0.82%, 9.13%), respectively. However, it decreased protein and carbohydrate contents (4.24%, 12.85%) and (64.83%, 72.12%). The mean values of minerals composition of wheat flour and fortified wheat toast bread DGAF revealed that no significant differences between 5% and 10% DGAF toast bread in iron and phosphorus, while there are an increase in Ca, K contents in fortified toast bread ranged from (38.00% to 171.00%) and (90.00% to 210.00%) compared with control; respectively. The results showed that 5%, 10%, 15% and 20% (DGAF) had a different effect on all studied sensory and physical characteristics of all studied toast bread. Moreover, toast bread with 5% defatted grapefruit albedo flour was recorded the best scores of all studied sensory characteristics in fortified toast bread. Consequently, it recommended utilizing the grapefruit albedo layer flour in order to enhance the nutritional values of toast bread.

Key words: Chemical composition · Total carbohydrates · Minerals · Physical sensory characteristics · Fortified toast bread · Grapefruit albedo flour

INTRODUCTION

Citrus (*Citrus* L. from Rutaceae) is one of the most important world fruit crops and is consumed mostly as fresh produce or juice because of its nutritional value and special flavour. Most popular within European and North American consumers are grapefruits (*Citrus paradisi*), lemons (*Citrus limon*), limes (*Citrus aurantiifolia*) and sweet oranges (*Citrus sinensis*) [1, 2]. Consumption of citrus fruit or juice is found to be inversely associated with several diseases [3]. The health benefits of citrus fruit have mainly been attributed to the presence of bioactive compounds, such as phenolics (e.g. flavanone glycosides, hydroxycinnamic acids) [4], vitamin C [5] and carotenoids [6]. Although, the fruits are mainly used for dessert, they are also sources of essential oils due to their aromatic compounds [7, 8]. Grapefruit (*Citrus paradisi*) has been used as a folk medicine in many countries as anti-fungal, anti inflammatory, antimicrobial, antioxidant, antiviral, astringent and preservative. It has also been used for cancer prevention, cellular regeneration, lowering cholesterol, cleansing, detoxification, heart health maintenance, arthritis and weight loss [9]. Whole peel (Fig. 1) or rind (pericarp) consists of flavedo (exterior yellow peel, epicarp) and albedo (interior whity spongy peel, mesocarp). Albedo is rich in pectin. The whole peel combined with the pulp residue (rag) and/or molasses can become a feed for animals. It is also used for production of human foods and food supplements pulp (principal edible portion, endocarp) used mainly to produce raw juice for human nutrition [8].

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Fig. 1: White grapefruit, whole peel consists of flavedo and albedo layers.

Botanists believe grapefruit was an accidental hybrid of the two primal citrus species, *Citrus maxima* (pummelo) and *Citrus sinensis* (sweet orange). Citrus is a subtropical plant and, like all citrus fruit; grapefruit grow on flowering, evergreen trees. They are distinguishable by the way in which they grow in clusters – like grapes – on trees. They are also one of the largest citrus and have an oblate shape (round with flat spheres). They are commonly grouped into three cultivars determined by the fruit's pulp color: white/yellow, pink and red. The color is a result of the fruit's genetic makeup, skin pigmentation and ripeness. The flesh is more acidic than other sweeter citrus varieties, though the pink- and red-pulped varieties have been produced with less acidity [10]. The industrial processing of grapefruit generates a large amount of wastes that can range between 49 and 69% of the total weight. These wastes include peel, segment membranes, seeds and other by-products. Although a portion of citrus waste can be used for pectin extraction or pelletized for animal feed [10], a large fraction is disposed in landfills every year.

The sensory properties of food are extremely important in addition to chemical and microbiological parameters, because these properties determine consumer acceptance and quality of foods [11]. Sensory evaluation makes possible the proper understanding of the threshold levels at which characteristics of food can be detected or the level at which it can be differentiated. Sensory analysis relies upon evaluation through the use of human senses such as sight (colour), taste and touch (tactile, properties, temperature and pain). The application of well controlled sensory testing procedures is nevertheless crucial in order to obtain reproducible results that can be analyzed statistically [12]. Optimal information can be obtained by the coordination of instrumental and human sensory analysis. Instruments will only analyze single components, whereas human senses give a total impression of aroma, taste, temperature and tactile properties [13]. This is because human sense organs can perceive sensitivity even at the limit of instrumental measurements. Therefore, the use of humans in sensory evaluation of aroma, flavour and texture is necessary since no mechanical device can replicate the perception formulated by the human mouth, nose and brain [14]. According to Lawless and Heyman [15], the objective sensory quality of bread is described by its sensory profile which is constituted by sensory attributes. These attributes tend to be perceived in the following order: appearance, aroma, texture and flavor [16].

The aim of our investigation was done to evaluate the physico-chemical attributes of defatted grapefruit albedo flour (DGAF) as well as to evaluate the physico-chemical, nutritional and sensory properties of toast bread prepared with different levels of DGAF.

MATERIALS AND METHODS

Materials: 5 kg wheat flour 72% extraction hard red winter was obtained from El-Haram Milling Company. Feisal, Giza, Egypt. Sodium chloride and yeast were purchased from Assiut local market. 20 kg white grapefruit variety (*Citrus paradise* L.) was procured from botanical Farm Faculty of Agriculture, Assiut University, Egypt in December 2013.

Sample Preparation: 20 kg grapefruit were chosen on the basis of established criteria: The fruits were ripe and had no signs of injury or infection. The fruits were washed in tap water and the albedo layers peeled of carefully then dried from the solvent (ice cold acetone), thus the obtained powder defatted grapefruit albedo flour (DGAF). Stored in glass containers at 4°C in the refrigerator until analysis.

Table 1: Toast bread formula*

Ingredients	Types of toast bread				
	Control	5%	10%	15%	20%
Wheat flour (72% extraction)	100	95	90	85	80
Defatted grapefruit albedo flour (g)	--	5	10	15	20
Water (ml)	60	60	60	60	60
Sodium chloride (g)	1	1	1	1	1
Yeast (g)	0.5	0.5	0.5	0.5	0.5

* Mostafa and Othman [17]

- Control= 100% wheat flour 72% extraction toast bread
- 5% = defatted grape fruit albedo flour
- 10% =% defatted grape fruit albedo flour
- 15%= defatted grape fruit albedo flour
- 20% = defatted grape fruit albedo flour

Technological Process

Toast Bread Formula and Ingredients: Toast bread dough was prepared according to Mostafa and Othman [17], the formula presented in Table 1. The toast bread was supplemented with 5%, 10%, 15% and 20% defatted grapefruit albedo flour (DGAF).

Preparation of Toast Bread: Wheat flour, water, salt, (sodium chloride) and yeast were mixed in the kneader dough for 10 minutes. Fermentation was performed at 30°C±2 for 135 minutes and relative humidity 80-85%. The dough pressed to release CO_2 and moulded with corn oil (about 1.5 g oil) in pans with dimensions: length 12 cm, width 6 cm and height 8 cm. Baking was carried out in an electric oven at 230-240°C for 20-25 minutes. The bread top was subjected to wet brush in order to enhance crust appearance immediately after removing from the oven.

Methods

Physical Evaluation of Toast Bread: Loaves were weighed in grams after two hours from baking and the volume in (ml) of each loaf was determined using the seed displacement method using clover seeds the specific loaf volume (S.L.V) and loaf weight were calculated according to Mostafa and Othman [17] using the following equation:

$$S.L.V = \frac{\text{Volume (ml)}}{\text{Weight (g)}}$$

Sensory Evaluation of Toast Bread: Sensory for the color, texture, taste, odor and overall acceptability were done by using scoring system according to Mostafa and Othman [17] in order to determine consumer acceptability. A numerical hedonic scale ranging from 1 to 10 (1 is very bad and 10 for excellent). Then experienced judges from the staff of Food and science Technology Department, Faculty of Agriculture, Assiut University, Egypt.

Determination of Gross Chemical Composition and Caloric Value: Moisture, crude protein, crude oil, crude fiber and ash were determined as described in the AOAC methods [18]. The total carbohydrates were calculated by difference according to Pellet and Sossy [19].The caloric value (energy) determined according to Wilson *et al*. [20] and Seleet [21] as follow:

$$\text{Energy (Kcal/100g)} = (\text{protein content x } 4) + (\text{fat content x } 9) + (\text{carbohydrate content x } 4)$$

Determination of Minerals: Minerales (Ca, Fe and Zn) were analyzed by GBC Atomic Absorption 906 A.A. Na, K were determined by a flame photometer corning 400 and P was determined by spectrophotometer [22] after wet ashing by method described in AOAC [18].

Statistical Analysis: The data collected were analyzed with analysis of variance (ANOVA) Procedures using the MSTAT-C Statistical Software Package [23]. Differences between means were compared by LSD at 5% level of significant [24].

RESULTS AND DISCUSSION

Gross Chemical Composition of Toast Bread Fortified with Defatted Grapefruit Albedo Flour: The chemical analysis of wheat flour 72% extraction and defatted grapefruit albedo flour (DGAF) are shown in Table 2. Results indicated that DGAF was lower in protein (4.24%), higher in crude fat (6.41), ash (2.20) and crude fiber (9.13) as compared with wheat flour 72% extraction.

The moisture content of toast bread samples was ranged from 22.65 to 33.50% (Fig. 2). Addition of DGAF caused a significant increase in moisture content for the fortified toast bread samples as compared with control bread.

The gross chemical composition of toast bread with different levels of fortification of wheat flour with DGAF is presented in Table 3. There were no significant ($P>0.05$) differences in ash content between the control which contained 100% wheat flour and the other fortified toast bread. The protein content in the control (15.68%) was significantly ($P<0.05$) higher than all other DGAF toast bread, this results could be due to higher content of protein in wheat flour compared to DGAF so the addition of DGAF to toast bread led to reduction of protein content, while the crude fiber content in DGAF toast bread was significantly different ($P<0.05$) higher when compared with control. The data revealed that all fortified

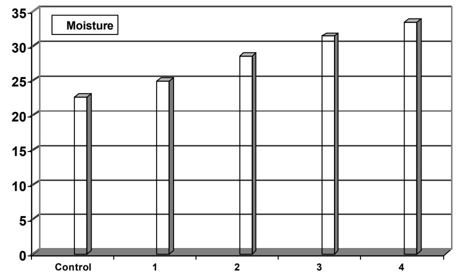

Fig. 2: Moisture content of toast bread made from wheat flour and its mixtures with defatted grapefruit albedo flour.

- Control= 100% wheat flour 72% extraction toast bread
- 5% = defatted grape fruit albedo flour
- 10% =% defatted grape fruit albedo flour
- 15%= defatted grape fruit albedo flour
- 20% = defatted grape fruit albedo flour

Table 2: Gross chemical composition of wheat flour and defatted grape fruit albedo flour (g /100 g) on dry weight basis*.

	Flour samples	
Parameters	Fine wheat flour	Defatted grapefruit albedo flour
Moisture	12.05	13.19
Ash	0.59	2.20
Protein	12.85	4.24
Crude fat	1.57	6.41
Crude fiber	0.82	9.13
Carbohydrates**	72.12	64.83

* Mean of three replicates

** Calculated by difference

Table 3: Gross chemical composition of toast bread fortified with defatted grapefruit albedo flour (g/100g dry weight)

Parameters	Control	5%	10%	15%	20%
Ash	2.26^{NS}	2.42^{NS}	2.56^{NS}	2.68^{NS}	2.81^{NS}
Protein	15.68^{A}	14.72^{B}	14.68^{C}	14.50^{D}	14.08^{E}
Crude fat	2.48^{E}	2.97^{D}	3.23^{C}	4.21^{B}	4.22^{A}
Crude fiber	8.51^{E}	10.40^{D}	11.99^{C}	12.79^{B}	13.17^{A}
Total carbohydrates	71.07^{A}	69.49^{B}	67.54^{C}	65.82^{D}	64.72^{E}
Energy (Kcal/100 g)	369.32^{A}	363.57^{B}	357.95^{D}	359.17^{C}	353.18^{E}

*Means having different superscripts within the rows are significantly different at p<0.05.

Table 4: Minerals composition of wheat flour and toast bread fortified with defatted grapefruit albedo flour (µg/100g on dry weight basis)*

	Minerals contents					
Parameters	Ca	Fe	Zn	Na	K	P
DGAF	830.00	12.00	1.90	50.00	520.00	90.00
Control	38.00^{E}	10.00^{A}	1.20^{NS}	600.00^{A}	90.00^{E}	120.00^{B}
5%	72.00^{D}	8.00^{C}	1.60^{NS}	590.00^{B}	120.00^{D}	130.00^{A}
10%	91.00^{C}	8.00^{C}	1.40^{NS}	520.00^{D}	150.00^{C}	130.00^{A}
15%	121.00^{B}	10.00^{A}	1.20^{NS}	510.00^{E}	180.00^{B}	110.00^{C}
20%	171.00^{A}	9.00^{B}	1.90^{NS}	540.00^{C}	210.00^{A}	100.00^{D}

*Means having different superscripts within the column are significantly different at p < 0.05.

- Control= 100% wheat flour 72% extraction toast bread
- 5% = defatted grape fruit albedo flour
- 10% =% defatted grape fruit albedo flour
- 15%= defatted grape fruit albedo flour
- 20% = defatted grape fruit albedo flour

Table 5: Physical evaluation of toast bread fortified defatted grapefruit albedo flour

	Types of toast bread				
Physical characteristics	Control	5%	10%	15%	20%
Volume (ml)	340	320	300	275	255
Weight (g|)	132.44	135.20	143.50	148.42	150.13
Specific volume (ml/g)	2.57	2.37	2.09	1.85	1.70

with defatted grapefruit albedo flour were decreased in total carbohydrates and energy (Kcal/100 g) compared with the control.

Mineral Composition of Toast Bread Fortified with Defatted Grapefruit Albedo Flour: Minerals content in toast bread at different levels of wheat flour fortification with DGAF (µg/100g) are shown in Table 4. More significantly was observed in the mineral contents between control treatment and all treatments which contained DGAF. But no significant differences were found between 5% and 10% DGAF toast breads in their content of iron and phosphorus.

Analysis of variance indicated that there was a significant varietal effect on Ca, Fe, Na, K and P contents. The abundant minerals in the studied samples were sodium and potassium with values ranging from (510.00 – 600.00) and (90.00 – 210.00 µg/100 g); respectively followed by calcium (38.00 – 171.00 µg/100 g). The increase in Ca, K contents in fortified breads may be a result of addition DGAF which have higher contents of Ca, K with values 830.00 and 520.00 µg/100 g, respectively as shown in Table 4. Phosphorus varied from 100.00 to 130.00 and iron from 8.00 to 10.00 µg/100 g. According to the data in Table (4) that there was no significant effect on zinc content in all toast bread samples ranged from 1.20 to 1.90 µg/100 g.

Fig. 3: 100% wheat flour -72% extraction

Fig. 5: 10% grapefruit albedo layer flour

Fig. 4: 5% grapefruit albedo layer toast bread flour fortified toast bread

Fig. 6: 15% grapefruit albedo layer flour fortified toast bread fortified toast bread

Fig. 7: 20% grapefruit albedo layer flour fortified toast bread

Table 6: Sensory characteristics of toast bread (control) and toast bread fortified with defatted grapefruit albedo flour (g/100g dry weight).*

	Crust	Crumb					
Sample	Color	Color	Graining	Texture	Taste	Odor	Over all acceptability
No	(10)	(10)	(10)	(10)	(10)	(10)	(60)
Control	9.03	8.22	8.12	8.02	9.14	9.10	51.63
5%	8.03	7.68	7.01	7.85	8.02	8.03	46.62
10%	7.53	7.06	6.94	6.76	7.89	7.07	43.25
15%	7.45	7.03	6.73	6.43	7.16	6.93	41.73
20%	7.18	6.95	6.68	6.22	6.98	6.81	40.82

* Mean of ten replicates

Physical Evaluation of Toast Bread: Baking tests were carried out to evaluate the differences in the characteristic of bread made from wheat flour and mixed with 5, 10, 15 and 20 percent of DGAF. The results of the baking showed in Table 5. It was found from Table 5 that with the replacement ratios of DGAF the loaf weight increased in all blends. The increased of bread weight was correlated to the amount of DGAF present in the flour mixture. As shown in Table 5 it was found that the 100% wheat flour toast bread had larger volume and specific volume than that made from fortified toast bread but loaf volume and specific volume decreased in fortified toast bread at these ratios of fortification. These results were in agreement with those obtained by Mettler and Seibel [25], who mentioned that the increase in bread weight was caused by high water retention whereas the reduction of loaf volume was due to the dilution of gluten.

Sensory Characteristics of Toast Bread Fortified with Defatted Grapefruit Albedo Flour: Sensory evaluation of toast bread at different levels of wheat flour fortification with DGAF is presented in Table 6. The crust color, crumb properties, texture, taste, odor, over all acceptability scores of control treatment and 5%, 10%, 15%, 20% DGAF treatments were different. Incorporation of DGAF recorded lowest scores for all quality attributes of fortification 5%, 10%, 15% and 20% lower than that control treatment. Moreover, color appeared to be a very important criterion for initial acceptability of the baked product by the consumer. The color of the toast bread was affected by the addition of DGAF (Fig. 3–7). The data revealed that both fortified toast bread improved all studied sensory characteristics. However, the best scores of all studied sensory characteristics were recorded for 5% fortified toast bread with defatted grape fruit albedo flour.

CONCLUSION

The grapefruit abledo layer flour may actually be regarded as functional food and healthful foods. Moreover, they could be recommended for caloric reduced diets for obese and overweight.

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