

## Utilization of some fruits and vegetables waste as a source of dietary fiber and its effect on the cake making and its quality attributes

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### Abstract

In this study, feasibility of using orange waste (OW), carrot pomace (CP), potato peels (PP) and green pea peels (GPP) by-products from food industry, as a starting raw material to produce dietary fiber powders and the feasibility of producing cakes intended for people suffering from obesity or over weight and diabetes. The physicochemical properties of dietary fiber powder were first evaluated. The results showed that the fiber contents, compositions and hydration properties (water and oil holding capacity and swelling capacity) of the fiber powder. Some food processing by-products {(OW), (CP), (PP) and (GPP)}, is a rich sources of fibres. The OW, CP, PP and GPP by-products were replaced with wheat flour (72%) at 5, 10, 15 and 20% levels and studied for rheological characteristics. Water absorption increased significantly with increasing by-products from 0 to 20%. Dough stability and dough development were increased. Resistance to extension values significantly increased, whereas extensibility values decreased. The produced fiber substituted cakes achieved a reduction in calories. Cakes were prepared from blends of wheat flour (72%) with 5, 10, 15 and 20% fruits and vegetables by-products. The volume of cakes decreased with increase in fruits and vegetables by-products content from 0 to 20%. Cakes prepared from 20% of by-products OW, CP, PP and GPP had a higher ratio of dietary fibres. Sensory evaluation showed that all high fiber substituted cake samples were significantly lower than control cake sample in all sensory characteristics, except cake samples prepared with 5 and 10% of orange waste and carrot pomace had no significant differences ( $P>0.05$ ) with control cake. However, there were significant differences between cake samples containing the same type of fiber source at 5, 10, 15 and 20% replacement levels. The highest and lowest scores in the same type of fiber source for all attributes were that achieved by cake samples with fiber source at 5 and 20% replacement levels, respectively. Texture properties of cake were affected by replacement levels of fiber source. The results indicated that OW, CP, PP and GPP by-products can serve as a good source of dietary fibres..

**Keywords:** food processing by-products; dietary fibers; orange waste, carrot pomace, potato peels, green pea peels; cakes; rheological, sensory and texture characteristics

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### 1. Introduction

Dietary fibre (DF) consists of a variety of non starch polysaccharides which include cellulose, hemicellulose, pectin, B-glucans, gums and lignin [22,34]. Fiber is often classified as soluble dietary fibre (SDF) and insoluble dietary fibre (IDF) [25]. Because solubility refers simply to fibres that are dispersible in water, the term is somewhat inaccurate. Originally it was thought that this

categorization might provide a simple way to predict physiological function, but this has not always been the case [22]. However, the SDF/IDF ratio is important for both, dietary and functional properties. It is generally accepted that those fibre sources suitable for use as food ingredient should have an SDF/IDF ratio close to 1:2 [30]. Dietary fibre is composed mainly by remnants of edible plant cells; parenchymatous tissues are known to be the most

important source of vegetable fibre [12,14]. Cell walls of fruits, vegetables, pulses and cereals make up most of the dietary fibre intake [31].

Dietary fibre plays an important role in human health, they acts as a protective agent against cardiovascular diseases, diverticulosis, constipation, irritable colon, colon cancer and diabetes [25,45]. DF content has become a key component in promoting the belief that diets based on a significant intake of fruit and vegetables has long term benefits [42]. Fibre derived from fruits and vegetables have a considerably higher proportion of soluble dietary fibre, whereas cereal fibres contain more insoluble cellulose and hemicellulose [29].

The physiological effects are related to the physicochemical and functional properties of dietary fibre. It is widely known that dietary fibres obtained by different methods and from different sources, behave differently during their transit through the gastrointestinal tract, depending on their chemical composition and physicochemical characteristics and on the processing that food undergo [10,29,31]. While a few years ago the sub products generated during the processing of plant food constituted an economic and environmental problem, today they are considered a promising source of functional compounds [7].

They are many fruits, for example orange, apple and peach, which are used for the extraction of their juices. They all contain a by-product from which can be recovered different high-added value compounds; among those, it is remarkable the fibre fraction that has a great potential in the preparation of functional foods. There are also several vegetables, such as carrot, potato, green pea, pepper, artichoke, onion and asparagus that originate a waste during their processing [44,45] and it contains both soluble and insoluble fibre compounds that can be used for designing new 'functional foods'. Orange and lemon sub-products, which are abundant and cheap, also constitute an important source of fibre since they are very rich in pectins [4]. Other fruits such as grapes, apples, bananas, mango, guava, etc. which are mainly commercialized in processed form originate great amounts of sub-products consisting of peels, bones and seeds. This material could be a

restrictive factor in the commercialization of these products if it is not usefully recovered, because it represents significant losses with respect to the raw material, which considerably increases the price of the processed products [50].

Potato peel consider as a rich source of fibers, since it contains about 9.7 to 68% from its total weight, Mullin *et al.* (1993) [39]. The potatoes are the most commonly consumed vegetables worldwide, whereas the potatoes production stands at 293 million metric tons. The annual production of Egypt is 2.2 million tons. As results, a large quantity of potato peel waste is generated.

Green peas (*Pisum Sativum*) which is one of the most important vegetable processing crop in Egypt and it's by product (peels) resembles about 50%. Dietary fibres from different sources have been used to replace wheat flour in the preparation of bakery products. Potato peel, a by-product from potato industry, rich in dietary fibre, was used as a source of dietary fibre in bread making [57].

Plant fibres show some functional properties, such us water-holding capacity (WHC) and swelling capacity (SWC) which have been more useful for understanding the physiological effect of dietary fibre, than the chemical composition alone [18,22]. These properties are related to the porous matrix structure formed by polysaccharide chains which can hold large amounts of water through hydrogen bonds [11,32]. Functional properties of plant fibre depend on the IDF/SDF ratio, particle size, extraction condition and, vegetable source [30]. Currently, there is a great variety of raw materials, mainly processing by-products, from which dietary fibre powders are obtained [18]. The main characteristics of the commercialized fibre product are: total dietary fibre content above 50%, moisture lower than 9%, low content of lipids, a low caloric value and neutral flavour and taste [36,37]. In order to take advantage of the dietary and functional properties of fibre, some high dietary fibre formulated foods are currently being developed [27,29,58]. To be acceptable, a dietary fibre added to a food product must perform in a satisfactory manner as a food ingredient [30]. According to Larrauri (1999) [37], the "ideal dietary fibre" should meet, among others, the following requirements; have no nutritionally objectionable components, be as concentrated as possible, be bland

in taste, colour and odour; have a balanced composition and adequate amount of associated bioactive compounds; have a good shelf life; be compatible with food processing; have the expected physiological effects. It must be kept in mind that fibre enrichment not only influences the overall quality of food by changing its physiological properties, but also significantly affects the sensorial properties of a product. When plant fibres are added to a food product, they contribute to water holding properties and viscosity of the product [32]. Dietary fibres from cereals are more frequently used than those from fruits; however, fruit fibre have better quality due to higher total and soluble fibre content, water and oil holding capacity and colonic fermentability, as well as lower phytic acid content and caloric value. Therefore, it becomes necessary to develop processes for the preparation of fruit fibres that minimize the losses of associated bioactive compounds which may exert higher health-promoting effects than dietary fibre itself [37]. Dietary fibre can be used in various application in the food industry with excellent results. Fibers with 15% of SDF are able to bind and retain several times their weight of water [29]. Residues from orange juice extraction are potentially an excellent source of DF because this material is rich in pectin and may be available in large quantities [26]. Citrus and apple fibres have better quality than other dietary fibres due to the presence of associated bioactive compounds, such as flavonoids, polyphenols and carotenes [19,61]. An increase in the level of dietary fibre in the daily diet has been recommended (25–30 g/day).

Because of this, it is interesting to increase the consumption of all foods that can supply fibre to daily food intake. Fiber incorporation, in frequently consumed food, could help to overcome the fibre deficit [19].

Dietary fibres are not only desirable for their nutritional properties, but also for their functional and technological properties and because of those they can also be used to upgrade agricultural products and by products for use as food ingredients [50,56]. The industry of fruit juice produces significant amounts of by-products which could cause problems in their disposal. Usually, these products are used in animal feeding.

However, their high amount of dietary fibre could permit the use of them in developing new natural ingredients for the food industry. According to Sloan (2001) [52], the demand for a unique fibre ingredient will continue. With a well established market for dietary fibre it is quite clear that a new ingredient, particularly one that could be linked to the possibility of obtaining nutritional requirements through normal dietary practices, would be very well received.

According to the Statistical Database of the Food and Agriculture Organization of the United Nations (FAOSTAT), world orange production in 2007 was estimated to be 63,906,094 tons. A high percentage of this production (70%) is used to manufacture products such as juice or marmalade. Moreover, approximately 50–60% of the processed fruit is transformed into citrus peel waste, which is composed of the peel, seeds and membrane residues [60]. In order to prevent problems related to the disposal of this product and environmental concerns, this waste must be properly processed. Under current environmental legislation, all waste must be considered raw material if a valorization procedure is to be developed.

Accordingly, the purpose of this work was carried out to evaluate some functional properties of fibre obtained from orange waste, carrot pomace, potato peels and green pea peels by-products, in order to use them as a dietary fibres source in the enrichment of cakes. The obtained cakes were evaluated mechanically, physically and organoleptically.

## 2. Materials and Methods

### *Materials:*

*Wheat flour:* Wheat flour (soft) (72%), were obtained from the South Cairo Mills Company, Cairo, Egypt.

*Baking Ingredients:* skim dry milk, sugar, margarine, corn oil, eggs, vanilla and baking powder were obtained from local market Kaha city, Kaliobia, Egypt.

*Orange waste (Citrus sinensis) Balady orange variety:* were obtained from Kaha company for canned food, Kaha city, Kaliobia, Egypt.

*Carrot pomace (Daucus carota L.):* was obtained from Kaha company for canned food, Kaha city, Kaliobia, Egypt.

*Potato peels (Solanum tuberosum L.):* were obtained as a waste from Egypt Foods factory for chipsty products, Industrial zone, Minufiya, Egypt.

*Green pea peels (Pisum Sativum):* were obtained from Kaha Company for canned food, Kaha city, Kaliobia, Egypt.

#### Preparation dietary fibre powders

- *Orange waste fibres:* the by-products obtained from orange peel and the remaining pulp after juice extraction could be suitable sources of DF by cutting, extraction of juice, peel residue chopping, the material was washed under mild conditions to avoid or minimize losses of some soluble fibre components (such as pectins and pentosans) as well as bioactive components (such as flavonoids, polyphenols and carotenes) [36], then dried at temperatures below 65 °C avoids changes in the functional properties and in the content of polyphenols, tannins, anthocyanidins and proteins for 12 hrs. in an electric oven drier, and grinding to a particle size of 500–600 µm, according to [32].
- *Carrot pomace fibre:* Carrot pomace was washed twice with warm water (30 °C); then it was dried at 60 °C for 12 hrs. in an electric oven drier and ground to a particle size of 500–600 µm. to pass through 20 mesh sieve packed in polyethylene bags and stored in refrigerator until use.
- *Potato peels fibre:* potato peels obtained and thoroughly washed on a multilayer of cheese cloth using tape water and then dried in an electric oven at 60 °C for 12 hrs. to prepare dried potato peels.
- *Green pea peels fibre:* green pea peels were washed with water; then it was dried at 60 °C for 12 hrs. in an electric oven drier and ground to a particle size of 500–600 µm. to pass through 20 mesh sieve packed in polyethylene bags and stored in refrigerator until use.

The fibre materials were then finely milled using the laboratory hammer mill, and sieved through a 500-µm sieve size into fine powder. Four batches of fibre flours were prepared. The fibres were assigned names, orange waste fibre (OWF), Carrot pomace fibre (CPF), Potato peels fibre (PPF) and

Green pea peels fibre (GPPF), then packaged in polythene bags protected from light and moisture and stored at refrigerator temperature until further analysed.

#### Processing:

*Preparation of cakes:* The corn oil was beaten thoroughly, the sugar was added to butter and mixed until got smooth like cream, and then a well blended egg with vanillia were added and mixed together. The blends soft wheat flour (72%) with dietary fibre sources (orange waste fibre (OWF), Carrot pomace fibre (CPF), Potato peels fibre (PPF) and Green pea peels fibre (GPPF) these by-products were replaced with wheat flour at 5, 10, 15 and 20% levels, baking powder were stirred together and added alternately to the egg mixture. The mixture was whipped until got smooth. The dough transferred to a greased pan and was baked for 25 min. at 200±5°C then was cooled at room temperature [1]. Cakes were prepared according to the formula is shown in Table (I).

**Table (I):** Cake formula

Weight (g)	Ingredients
150	Soft wheat flour (72% extraction)
6.81	Baking powder
3.4	Salt
75	Sugar
31.83	Corn oil
39.75	Fresh whole egg
14.76	Skim dry milk
1.5	Vanilla

#### Analytical methods:

*Determination of dietary fibre contents:* Total dietary fibre (TDF), soluble dietary fibre (SDF) and insoluble dietary fibre (IDF) contents of samples were determined with an enzymatic–gravimetric procedure according to AOAC Method 991.43, [3,38].

*Proximate chemical composition:* Moisture, crude protein, crude lipid, ash and carbohydrate contents were determined using the appropriate AOAC (2000) [3].

Carbohydrates were determined by difference from the total dietary fibre, lipids, protein and ash contents [10].

*Functional properties:* Water holding capacity (WHC) and oil holding capacity (OHC) were

measured according the methods reported by Femenia *et al.* (1997) and Robertson *et al.* (2000) [18,43].

Swelling capacity (SWC): was measured using the bed volume technique described by Kuniak and Marchessault (1972) [33]. Approximately 0.2 g of the sample material was weighed into a 50 mL graduated glass cylinder. After making up the volume to 50 mL with de-ionized water and the mixtures were then vigorously stirred, the material was left overnight at room temperature for equilibration. The volume of the swollen sample was noted. Results of SWC were expressed as the ratio of volume (mL) of swollen sample to the weight (g) of dry initial sample.

Triplicate measurements were taken for all WHC, OHC and SWC.

*Rheological characteristics:* Fruits and vegetables waste blends at 0, 5, 10, 15 and 20% levels were prepared by replacing wheat flour. The effect of fruits and vegetables fibre on the mixing profile of the dough was studied using farinograph (Brabender, Duisburg, Germany) according to the standard AACC methods (2000) [1]. Farinograph test was carried out to determine the water absorption, arrival time, dough development time, dough stability and degree of weakening.

The elastic properties of the dough were studied using extensograph (Brabender, Duisburg, Germany) according to the standard AACC methods (2000) [1]. Extensograph test was carried out to determine resistance to extension (B.U.), extensibility (mm), proportional number and energy (cm<sup>2</sup>).

*Physical characteristics for cakes:* The weight (g) for cake was determined individually within one hour after baking the average was recorded.

The volume (cm<sup>3</sup>) of different types of produced cakes was determined by rape seeds displacement method according to (AACC, 2000) [1].

*Specific volume* was calculated according to the method of (AACC, 2000) [1], using the following equation

Specific volume = Volume (cm<sup>3</sup>)/Weight (g).

*Texture characteristics:* The texture of the cakes was measured objectively using food texturometer (TAHDi, Stable Micro System, UK) as per the standard AACC methods (2000) [1]. A test speed of 2.0 mm s<sup>-1</sup> were used. A 35 mm diameter cylinder aluminum probe (P-35), was used to measure the required compression force. Force required to compress 25% of the cake slice (2.54 cm) was recorded. All measurements were performed at ambient temperature 25±2°C according to Gomez *et al.* (2007) [23].

*Mechanical properties measurements:* All mechanical properties were made using the Instron Universal Testing Machine (Model 4401) equipped with: 5-mm diameter tip probe for penetration test (with 100, 500, 1000 and 5000 N load cell). All testing was performed at room temperature (25±2°C).

*Penetration test (PT):* Each piece of tested cakes was placed in a hole of the bevelled ring. The pin penetrated with a constant speed 10 mm.min<sup>-1</sup> into each piece of cakes tested. Three penetration points at different parts for each piece of cakes and 5 piece for each sample were taken for each test condition, recording the force profile at 1 cm of probe penetration [18]. Force – deformation curves were recorded and hardness was derived as indicators of textural properties. Each sample was used for only one measurement.

#### **Mechanical measurements analysis:**

- 1- The force corresponding to the maximum puncture is defined as the maximum force (F<sub>max</sub>). The maximum puncture force (F<sub>max</sub>) was measured in Newtons (N), as mentioned by Sharoba *et al.* (2012) and Saleh *et al.* (2012) [47,51].
- 2- Maximum deformation: the distance from beginning to distance at maximum force.
- 3- Hardness = Maximum force (N) / Maximum deformation (mm), as mentioned by Sharoba *et al.* (2012) and Saleh *et al.* (2012) [47,51].

*Sensory analysis:* Sensory evaluation of cakes were carried out in a standardized test room in morning sessions (11:00-13:00 h) by a 12 trained sensory panel, and were carried out by a properly well trained panel of 12 panelists.

They were selected if their individual scores in 10 different tests showed a reproducibility of 90%. The 12 member internal panel evaluated on a five point hedonic scale, scoring was based on a 100 point scale (10-100) where (90-100) = excellent, (70-80) = very good, (50-60) = good, (30-40) = fair and (10-20) = poor. Mineral water was used by the panelists to rinse the mouth between samples, according to the method described by (AACC, 2000) [1], cake samples were left to cool at room temperature for 1 hr. after baking. Then cake was cut with a sharp knife and subjected to panel test. Cells 30 (uniformity 10, size of cells 10, and thickness of walls 10), grain 20, texture 30 (moistness 10, tenderness 10, and softness 10), crumb color 10, flavor 10 and overall acceptability 100 degrees.

**Statistical analysis:** Each sample was prepared in triplicate and analysed twice. Data are presented as the average of three analyses and data was analysed using the analysis of variance (ANOVA)  $p < 0.05$  was considered to be statistically significant, followed by multiple comparisons using least significant difference, (L.S.D.<sub>0.05</sub>) [23].

### 3.Results and Discussion

Nowadays, there is a considerable interest in studying the feasibility of using by-products from food processing plants as raw materials for production of dietary fibre powder since these wastes are inexpensive and highly abundant. Fruits and vegetables wastes or residues are among the most promising by-products with high dietary fiber content, and possess a good balance between SDF and IDF

**Proximate chemical composition of wheat flour (72 %):** Data in Table (1) represent the proximate chemical composition of wheat flour (72 %) of protein, fat, ash, crude fiber, total carbohydrates contents on (dry weight basis) and moisture contents. From these results the wheat flour was suitable for used to make cake.

**Table 1.** Chemical composition of wheat flour (72 %).

Components	%
Moisture	11.99 ± 0.292
Protein*	11.85 ± 0.401
Fat*	1.06 ± 0.068
Ash*	0.52 ± 0.018
Crude fiber*	0.54 ± 0.034
Available carbohydrates*	86.04

**Chemical composition, fibre content and functional properties of used fruits and vegetables by-products:** Although interest in fibre as a food ingredient has waned in recent years, the importance of fibre cannot be overlooked. The health benefits coupled with functional properties such as water and fat holding capacity properties have created a renewed interest in fiber, particularly in the nutraceutical industry. Many of the fiber supplements which have been researched are obtained from by-products resulting from the processing of fruits and vegetables. Increased use of fiber supplementation would therefore not only improve the health benefits and functional properties of many foods. Data in Table (2) represent the proximate chemical composition of fruits and vegetables wastes, the results are in agreement with results were obtained by Sosulski and Wu (1988); Camire and Flint (1991); Ralet *et al.* (1993); Camire *et al.*, (1997) and Chantaro *et al.* (2008) [5,6,9,41,53].

**Functional properties:** It is well known that the functional properties of dietary fibers have the greatest effect on their functions in foods El-Refai *et al.*, 2006 [16]. The results of the functional properties of fruits and vegetables wastes are given in Table (3). The functional properties of plant fibre depend on the IDF/SDF ratio, particle size, extraction condition, structure of the plant polysaccharides and vegetable source. The water holding capacity (WHC) is the quantity of water that remains bound to the hydrated fiber following the application of an external force (pressure or centrifugation), also WHC is the ability of a moist material to retain water when subjected to an external centrifugal gravity force or compression. It consists of the sum of bound water, hydrodynamic water and, mainly, physically trapped water [40,59]. It is an important property of DF from both a physiological and technological point of view.

Dietary fibre holds water by adsorption and absorption phenomena and some water is also retained outside the fibre matrix (free water). WHC depends on (i) fibre processing: washing increases WHC probably due to the removal of sugars, (ii) particle size and (iii) the chemical and physical structure: the water-holding capacity is related to the SDF content, and high levels of SDF produce a high WHC because soluble fibres, such as pectin and gums, possess a higher WHC than cellulosic fibres. WHC of different dietary fiber sources; orange waste,

carrot pomace, potato peels and green pea peels are presented in Table 3. Relatively high values of WHC were obtained compared with the values obtained with other agricultural by-products including apple pomace and pear pomace [27]. The high WHC values were related to the soluble dietary fiber fraction and pectic substances contained in the peels might account for their high WHC in orange waste. High WHC was also previously reported for orange waste and carrot pomace. The water holding capacity of carrot pomace was higher than that of orange waste. The higher WHC for the samples under study because we used suitable drying temperature to prepare dietary fiber sources. The WHC was lower at a higher drying temperature; this might be due to the degradation of some soluble dietary fiber components, leading to the loss of ability to retain water in the sample. The values of WHC are 16.39, 19.72, 15.62 and 13.48 for orange waste, carrot pomace, potato peels and green pea peels, respectively which are higher than those reported for others fibrous residues such as grape, mango, peach and tomato (7.8-9.4 g water/g product) [16], bambangans peel (11.6 g water/g product), apple pomace (8.4 g water/g product) [28,55], and other dietary fibre products such as date paste (1.3 g water/g product) [48] and similar with other dietary fibre products such as carrot peel (21.89 g water/g product) [9]. The high WHC values could indicate a lightness improve of food products where they were added.

The SWC of carrot pomace are presented in Table (3). The results showed that DF powder from carrot pomace possessed high SWC. These values are of similar order with those of cauliflower fiber [18], coconut fiber [40] and carrot fiber [9] but higher than those reported for citrus residues [21]. Blanching had a significant effect on the SWC. During blanching carrot, some components might be lost with water and the change of structural tissues might enhance the water uptake. However, the other fiber sources blanching step don't occurred. Furthermore, a very high correlation between the SWC and WHC was obtained at each dietary fibre sources. In addition to chemical

compositions, some physical properties, such as structure, particle size, porosity, pH, temperature, ionic strength, types of ions in solutions and density are important to the understanding of the deferent behaviors of samples during hydration.

The two hydration properties, SWC and WHC, which are mainly determined by the food content (like dietary fiber) have been shown to be closely related, oil-holding capacity OHC is another important property of food ingredients used in formulated food. The (OHC) is also a technological property related to the chemical structure of the plant polysaccharides and depends on surface properties, overall charge density, thickness, and hydrophobic nature of the fibre particle [8,20,21]; it is also related with the (i) IDF content, (ii) particle size and (iii) drying., dehydration promotes a general decrease in fibre OHC compared with the fresh fibre. The fibre sources show an OHC of 1.27, 3.95, 8.63 and 6.89 g oil/g dry fibre respectively. This is similar the OHC of orange by-products ( 1.81 g oil/g fibre), lemon by-products (6.60 g oil/g fibre) and tiger nut by-product (6.90 g oil/g fibre) [35,49]. For this reason, foods added with potato peels or green pea peels will not retain high amounts of oil, both in the case that it will be added as ingredient in the food product, or in the case that it will be used for frying processes.

This suggested that the all fiber sources in this study would be able to stabilize food emulsions with a high percentage of fat. Basically, the mechanism of OHC is mainly due to the physical entrapment of oil by capillary attraction. Moreover, the hydrophobicity of proteins also plays a major role in fat absorption. Therefore, among the fiber sources samples, the variations in OHC may be partially due to the deferent proportions of polar side chains of the amino acids on the surfaces of their protein molecules. Furthermore, the OHC of fiber sources samples are also related to the particle size, overall charge density and hydrophilic nature of the individual particles.

Similarly, the correlation between OHC and total amount of protein and TDF was very high. This implied that the OHC of the fiber sources samples might also depend on the total content of protein and TDF present.

**Table 2.** Proximate chemical composition of used fruits and vegetables by-products

Components	dietary fibers source			
	Orange waste	Carrot pomace	Potato peels	Green pea peels
Moisture (%)	4.15±0.32	4.61±0.21	3.58±0.63	4.28±0.27
Total ash (%)	10.03±0.54	7.29±0.32	6.92±0.27	7.18±0.34
Total fat (%)	1.57±0.02	1.75±0.01	2.25±0.08	1.34±0.03
Total protein (%)	8.72±0.36	10.06±0.18	12.16±0.48	13.27±0.51
Total dietary fibre (%)	63.45	69.85	73.25	71.3
Insoluble fibre (%)	41.17±1.28	45.12±1.08	53.39±0.94	51.48±1.34
Soluble fibre (%)	22.28±0.93	24.73±1.22	19.86±1.47	19.82±1.36

**Table 3.** Functional properties of fruits and vegetables by-products which used as dietary fiber source

Components	dietary fibers source			
	Orange waste	Carrot pomace	Potato peels	Green pea peels
Water holding capacity (WHC) (g water/g dry fibre source)	16.39±0.47	19.72±0.38	15.62±0.67	13.48±0.14
Swelling capacity (SWC)	20.74±0.62	23.96±0.58	16.27±0.38	14.93±0.41
Oil holding capacity (OHC) (g oil/g dry fibre source)	1.27±0.01	3.95±0.17	8.63±0.48	6.89±0.35

**Table 4.** Effect of dietary fibers sources addition at different levels to wheat flour on farinograph parameters of dough.

Dietary fiber source	Replacement levels	Farinograph parameters				
	(%)	Water absorption (%)	Arrival time (min)	Dough development (min)	Dough stability (min)	Degree of weakening (B.U.)
Control	0	61.5	1.5	2.75	6	95.25
	5	67.4	1.75	3.3	6.4	80.25
Orange waste	10	68.1	2.3	4.25	6.85	75.25
	15	70.9	3	5.5	7.25	69.75
	20	72.45	4.1	6	7.7	54
	5	63.3	1.9	3.2	6.4	83.8
Carrot pomace	10	65.15	2.3	3.9	6.9	77.5
	15	68.95	2.9	4.3	7.3	69.9
	20	71.95	3.8	5.1	7.95	57.8
	5	63.5	1.85	3.1	6.8	83.4
Potato peels	10	65.95	2.25	3.75	7.45	69
	15	67.55	2.55	4.25	8.25	57.2
	20	69.85	2.9	4.6	9.1	47.95
	5	62.75	1.7	3	6.75	77.1
Green pea peels	10	63.45	2.1	3.45	7.85	60.2
	15	64.75	2.25	3.8	9.4	48.65
	20	65.9	2.45	4.05	10.8	35.6

**Table 5.** Effect of dietary fibers sources addition at different levels to wheat flour on extensograms parameters of dough

Dietary fiber source	Replacement levels		Extensograph parameters			
	(%)	Resistance to extension	Extensibility	Proportional number	Energy	
		(B.U.)	(m.m.)	(R / E)	(cm <sup>2</sup> )	
Control	0	781.25	157.5	4.96	127.5	
	5	790	133.8	5.9	113.75	
	10	786.85	125	6.29	105	
Orange waste	15	748.95	113.8	6.58	101.5	
	20	691.1	108.3	6.38	96	
	5	729.5	154.5	4.72	125.2	
Carrot pomace	10	715.35	145.05	4.93	115.8	
	15	683.2	133.35	5.12	106.4	
	20	675	125.8	5.37	99.3	
Potato peels	5	795.6	129	6.17	119.4	
	10	742.45	121.45	6.11	107.95	
	15	695.5	116.35	5.98	98.65	
Green pea peels	20	639	110	5.81	90.8	
	5	840.05	113.5	7.4	118.95	
	10	808.35	103	7.85	111	
	15	783.5	90.55	8.65	103.95	
	20	744.7	82.8	8.99	93.45	

**Table 7.** Effect of addition dietary fiber sources on hardness measurement (mechanical properties) of cakes

Characteristics	Replacement levels (%)	Dietary fiber sources			
		Orange waste	Carrot pomace	Potato peels	Green pea peels
Firmness	0 (Control)	8.905	8.905	8.905	8.905
	5	9.736	10.331	9.792	10.277
	10	11.629	12.035	10.72	13.056
	15	13.681	14.168	12.297	15.641
	20	16.751	16.738	14.638	17.356
Cohesiveness	0 (Control)	0.683	0.683	0.683	0.683
	5	0.602	0.581	0.521	0.624
	10	0.492	0.346	0.453	0.537
	15	0.308	0.292	0.258	0.395
	20	0.239	0.207	0.171	0.311
Gumminess	0 (Control)	2.894	2.894	2.894	2.894
	5	3.132	3.028	2.947	3.354
	10	3.538	3.387	3.205	3.725
	15	3.892	3.897	3.439	3.962
	20	3.984	3.972	3.62	4.108
Chewiness	0 (Control)	2.963	2.963	2.963	2.963
	5	2.985	3.025	2.974	3.342
	10	3.129	3.195	3.047	3.649
	15	3.367	3.408	3.115	3.803
	20	3.658	3.827	3.248	3.958
Springiness	0 (Control)	0.742	0.742	0.742	0.742
	5	0.692	0.655	0.673	0.718
	10	0.583	0.525	0.534	0.634
	15	0.49	0.497	0.468	0.587
	20	0.405	0.378	0.361	0.435
Resilience	0 (Control)	0.697	0.697	0.697	0.697
	5	0.612	0.607	0.53	0.581
	10	0.542	0.51	0.401	0.421
	15	0.421	0.383	0.252	0.382
	20	0.31	0.306	0.197	0.285

**Table 8.** Effect of addition dietary fiber sources on sensory evaluation of produced cakes (mean±SD).

Dietary fiber sources	Substituted levels	Sensory attributes									
		Uniformity -10	Siz of cells -10	Thickne ss -10	Grain -20	Moistne ss -10	Tender ness -10	Softn ess -10	Crumb color -10	Flavor -10	Overall acceptability (100)
Control	0	9.65 <sup>a</sup> ±0.19	9.10 <sup>a</sup> ±0.10	9.75 <sup>a</sup> ±0.47	19.60 <sup>a</sup> ±0.29	9.45 <sup>a</sup> ±0.13	9.60 <sup>a</sup> ±0.11	9.70 <sup>a</sup> ±0.30	9.30 <sup>a</sup> ±0.18	9.75 <sup>a</sup> ±0.16	97.65 <sup>a</sup> ±1.95
	5	9.60 <sup>a</sup> ±0.28	9.00 <sup>a</sup> ±0.14	9.50 <sup>a</sup> ±0.14	19.10 <sup>a</sup> ±0.26	9.10 <sup>a</sup> ±0.15	9.20 <sup>a</sup> ±0.18	9.70 <sup>a</sup> ±0.20	9.40 <sup>a</sup> ±0.16	9.30 <sup>a</sup> ±0.18	97.20 <sup>a</sup> ±1.55
Orange waste	10	9.05 <sup>a</sup> ±0.21	8.90 <sup>ab</sup> ±0.20	9.10 <sup>ab</sup> ±0.36	18.80 <sup>ab</sup> ±0.28	8.95 <sup>ab</sup> ±0.21	8.95 <sup>ab</sup> ±0.18	9.35 <sup>a</sup> ±0.21	9.15 <sup>a</sup> ±0.25	8.95 <sup>ab</sup> ±0.27	96.40 <sup>ba</sup> ±1.88
	15	8.75 <sup>a</sup> ±0.09	8.75 <sup>ab</sup> ±0.24	8.85 <sup>ab</sup> ±0.17	18.40 <sup>ab</sup> ±0.48	8.60 <sup>ab</sup> ±0.27	8.70 <sup>ab</sup> ±0.15	8.90 <sup>a</sup> ±0.32	8.85 <sup>a</sup> ±0.35	8.80 <sup>ab</sup> ±0.13	93.60 <sup>ba</sup> ±1.92
	20	7.80 <sup>ab</sup> ±0.44	7.85 <sup>b</sup> ±0.32	7.95 <sup>ab</sup> ±0.21	17.60 <sup>ab</sup> ±0.27	7.80 <sup>b</sup> ±0.22	7.70 <sup>b</sup> ±0.41	7.70 <sup>a</sup> ±0.21	7.60 <sup>b</sup> ±0.26	7.80 <sup>b</sup> ±0.21	88.90 <sup>b</sup> ±2.02
Carrot pomace	5	9.50 <sup>a</sup> ±0.41	9.30 <sup>a</sup> ±0.71	9.45 <sup>a</sup> ±0.40	19.20 <sup>a</sup> ±0.20	9.70 <sup>a</sup> ±0.84	9.40 <sup>a</sup> ±0.32	9.45 <sup>a</sup> ±0.52	9.65 <sup>a</sup> ±0.42	9.65 <sup>a</sup> ±0.33	97.95 <sup>a</sup> ±2.42
	10	9.05 <sup>a</sup> ±0.37	9.00 <sup>a</sup> ±0.47	9.10 <sup>a</sup> ±0.38	18.80 <sup>a</sup> ±0.39	9.15 <sup>a</sup> ±0.72	9.00 <sup>a</sup> ±0.36	9.05 <sup>a</sup> ±0.79	9.05 <sup>a</sup> ±0.62	8.75 <sup>a</sup> ±0.31	93.35 <sup>a</sup> ±2.27
	15	8.15 <sup>a</sup> ±0.28	8.20 <sup>ab</sup> ±0.41	8.15 <sup>ab</sup> ±0.34	18.00 <sup>ab</sup> ±0.40	8.20 <sup>ab</sup> ±0.37	8.10 <sup>ab</sup> ±0.32	8.40 <sup>a</sup> ±0.32	8.55 <sup>a</sup> ±0.91	8.60 <sup>ab</sup> ±0.34	90.30 <sup>ba</sup> ±2.35
	20	7.10 <sup>ab</sup> ±0.38	7.60 <sup>ab</sup> ±0.65	7.45 <sup>ab</sup> ±0.57	17.10 <sup>ab</sup> ±0.41	7.55 <sup>ab</sup> ±0.32	7.40 <sup>b</sup> ±0.39	7.50 <sup>a</sup> ±0.67	7.45 <sup>ab</sup> ±0.29	7.25 <sup>ab</sup> ±0.47	86.35 <sup>ba</sup> ±2.13
Potato peels	5	9.05 <sup>a</sup> ±0.27	8.65 <sup>a</sup> ±0.38	9.05 <sup>a</sup> ±0.42	18.10 <sup>a</sup> ±0.22	9.00 <sup>a</sup> ±0.51	9.10 <sup>a</sup> ±0.48	8.75 <sup>a</sup> ±0.37	8.40 <sup>a</sup> ±0.58	9.10 <sup>a</sup> ±0.34	95.15 <sup>a</sup> ±2.55
	10	8.50 <sup>a</sup> ±0.24	8.00 <sup>a</sup> ±0.38	8.40 <sup>a</sup> ±0.44	17.60 <sup>a</sup> ±0.21	8.10 <sup>a</sup> ±0.19	8.20 <sup>a</sup> ±0.12	8.10 <sup>a</sup> ±0.50	8.10 <sup>a</sup> ±0.10	8.30 <sup>a</sup> ±0.64	88.90 <sup>a</sup> ±2.02
	15	7.45 <sup>ab</sup> ±0.45	7.60 <sup>b</sup> ±0.34	7.55 <sup>ab</sup> ±0.29	16.40 <sup>ab</sup> ±0.28	7.50 <sup>b</sup> ±0.31	7.40 <sup>b</sup> ±0.54	7.20 <sup>a</sup> ±0.37	7.40 <sup>b</sup> ±0.38	7.20 <sup>b</sup> ±0.67	81.80 <sup>b</sup> ±2.46
	20	6.30 <sup>b</sup> ±0.63	6.20 <sup>b</sup> ±0.34	6.60 <sup>b</sup> ±0.43	15.70 <sup>b</sup> ±0.53	6.40 <sup>b</sup> ±0.53	6.80 <sup>b</sup> ±0.64	6.40 <sup>a</sup> ±0.52	6.60 <sup>b</sup> ±0.59	6.45 <sup>b</sup> ±0.56	79.50 <sup>b</sup> ±2.76
Green pea peels	5	9.10 <sup>a</sup> ±0.24	9.00 <sup>a</sup> ±0.48	9.70 <sup>a</sup> ±0.22	19.10 <sup>a</sup> ±0.28	9.25 <sup>a</sup> ±0.32	9.00 <sup>a</sup> ±0.41	9.25 <sup>a</sup> ±0.35	9.10 <sup>a</sup> ±0.58	9.15 <sup>a</sup> ±0.29	94.10 <sup>a</sup> ±1.99
	10	8.25 <sup>a</sup> ±0.55	8.40 <sup>ab</sup> ±0.62	8.10 <sup>ab</sup> ±0.45	17.40 <sup>ab</sup> ±0.51	8.10 <sup>ab</sup> ±0.28	8.20 <sup>ab</sup> ±0.39	8.40 <sup>a</sup> ±0.17	8.50 <sup>a</sup> ±0.28	8.40 <sup>ab</sup> ±0.24	89.45 <sup>ba</sup> ±2.88
	15	7.00 <sup>b</sup> ±0.61	7.20 <sup>b</sup> ±0.33	7.60 <sup>b</sup> ±0.40	16.30 <sup>b</sup> ±0.63	7.30 <sup>b</sup> ±0.51	7.50 <sup>b</sup> ±0.60	7.50 <sup>a</sup> ±0.58	7.45 <sup>b</sup> ±0.51	7.45 <sup>b</sup> ±0.71	84.75 <sup>b</sup> ±2.85
	20	6.85 <sup>ab</sup> ±0.68	7.00 <sup>b</sup> ±0.61	7.10 <sup>ab</sup> ±0.24	15.20 <sup>ab</sup> ±0.24	6.90 <sup>b</sup> ±0.32	6.95 <sup>b</sup> ±0.34	7.00 <sup>a</sup> ±0.40	6.95 <sup>b</sup> ±0.39	7.05 <sup>b</sup> ±0.30	81.90 <sup>b</sup> ±2.46
<b>L.S.D at P&lt;0.05</b>		0.79	0.91	0.84	1.43	0.86	0.89	1.02	1.07	1.14	3.72

<sup>a,b</sup> There is no significant different (P > 0.05) between any two means, within the same attribute have the same lette

**Table 9.** Effect of addition dietary fiber sources on physical properties of produced cake

Dietary fiber sources	Specific volume	Volume	Weight	Substituted levels (%)
	(cm <sup>3</sup> )/g	(cm <sup>3</sup> )	(g)	
Control	2.385	1084.93	454.95	0
Orange waste	2.578	1174.52	455.68	5
	2.745	1254.37	456.91	10
	2.931	1343.85	458.49	15
	3.212	1481.28	461.12	20
Carrot pomace	2.481	1127.58	454.47	5
	2.728	1245.91	456.69	10
	2.816	1289.07	457.82	15
	2.961	1357.19	458.37	20
Potato peels	2.397	1097.57	457.88	5
	2.545	1174.32	461.45	10
	2.591	1203.85	464.58	15
	2.741	1286.59	469.37	20
Green pea peels	2.615	1182.63	452.18	5
	2.772	1257.37	453.64	10
	2.933	1328.06	452.87	15
	3.065	1391.24	453.93	20

**Rheological properties:** Dough produced from blends of wheat flour 72% and different levels of dietary fibers sources (orange waste, carrot pomace, potato peels and green pea peels) were tested to know the effect of fiber sources and levels on rheological properties.

**Farinograph parameters of wheat flours dough blended with dried fibers sources:**

The effect of replacing wheat flour with different levels (5, 10, 15 and 20 %) of dried dietary fiber sources (orange waste, carrot pomace, potato peels and green pea peels) on mixing dough properties are presented in Table (4). Data in Table (4) shows the effect of blending fibre sources with wheat flour (72 %) on the farinograph parameters, i.e. water absorption, arrival time, dough development time, dough stability and dough weakening.

The results indicate that water absorption, arrival time and dough development time were increased due to the increase of wheat flour replacement levels. This might be due to the increase in the fiber level in dietary fiber sources blends. These results agree with those obtained by Abd El-Moniem and Yassen (1993) [2]; who reported that addition of fiber sources caused an increase in the water absorption of the produced dough. This may be due to higher water hydration capacity of fibers. Dough stability increased due to the increase of wheat flour replacement with dietary fiber sources. These results confirmed increased stability with those obtained by Doweidar (2001) [13]; who found that the addition of dietary fiber source (dry carrot and pectin). Also, reported that the addition of dietary carrot led to increase water absorption and stability. Degree of weakening decreased due to the increase replacement levels of wheat flour with dietary fiber sources, this might be due to increasing of fibrous materials, which contribute gluten net development. Water absorption of the control (wheat flour 72% ext.) showed a value of 61.5 ml. While, wheat flour blended with different ratios of fibre sources, 5, 10, 15 and 20% showed a gradual increase in parallel with fibre sources increasing, this may be due to the high fiber contents in fibre sources. Arrival time showed a time in min ranged between 1.30 to 4.10 min.. Dough development time of blends with fibre sources at the ratios of 5, 10, 15 and 20% resulted

in (2.75 to 6 min). Dough stability showed its maximum value (10.8 min.), when the blend contained 20% dry green pea peels and 80% wheat flours 72% extraction followed by 20% dry potato peel and 80% wheat flours 72% extraction (9.1 min.). From the above mentioned data, it could be concluded that, the replacement of fibre sources at different ratios improved the gluten network and farinograph parameters of the wheat flour dough. From the aforementioned data, it could be concluded that blending with fibre sources had a good farinograph parameters.

**Extensograph parameters of wheat flours dough (72% extraction) blended with dried fibre sources:**

Data in Table (5) shows the effect of addition fibre sources (in ratios of 5, 10, 15 and 20%) with wheat flours (72% extraction) dough on the extensograph parameters, i.e. extensibility (E), resistance to extension (R) and the ratio between them and also the energy. The results show that the resistance was 781.25 B.U. for the control sample (wheat flour 72% ext.), while it decreased with increasing the levels of fibre sources in prepared blends. Also, the resistance value of dough produced from blends of wheat flour (72% ext.) with dry green pea peels or potato peels more than of dough produced from blends for wheat flours (72% ext.) with orange waste or carrot pomace but both still decreased than the control sample with increasing the fibre sources ratio. Extensibility (E) showed a value of 157.5 mm for the control sample (wheat flour 72% ext.). Blending with fibre sources showed a slight decrease due to the dried fibre sources. The lowest extensibility value was recorded due to the blend containing 20% green pea peels. The ratio between resistances to extension of extensibility reflects the effect of blends on the elasticity of the produced dough. Concerning the energy, the control sample resulted in the highest value while, other treatments resulted in the following decreasing. From the above mentioned data, it could be concluded that addition of fibre sources had a good extensograph parameters like the control sample.

**Effect of addition dietary fiber sources on texture measurement (mechanical properties) of cakes substituted by different levels fiber:**

The results presented in Table (6) show the mechanical properties of cake contained different types of fiber source, firmness must be explained by the different

chemical interactions between oil, protein starch and fibre that affect its retrogradation, the interactions between the swollen starch granules, fibre and the protein network actively contribute to crumb firming, the results showed increased of cake firmness, with the exception of control cake sample. Cake contained the different levels of the dietary fiber sources led to the hardest with a firmness higher than that of the control cake sample. Fiber can provoke a crumb firmness increase probably due to the thickening of the crumb cells surrounding the air spaces. Also firmness was increase may be a result of molecular entanglements between fiber and gluten proteins [24].

An increase in chewiness and gumminess values with ageing was observed in all recipes. Chewiness is one of the texture parameters easily correlated with sensory evaluation through trained panels [17]. Both, gumminess and chewiness, are parameters dependant on firmness. Therefore, their values followed a similar trend than that of firmness. Cohesiveness quantifies the internal resistance of food structure. As happened with firmness, cake cohesiveness depended on the addition of fiber. A similar result was also obtained in other baked goods [17]. A subjective evaluation of springiness is normally made by consumers and consists of slightly pressing the piece of food, by hand or with the mouth, and verifying how easily it returns to the original size. Finally, the addition of dietary fibre sources to wheat flour to produced cake improved the texture properties of cake due to high water holding capacity of fibre, these results are in agree with many researchers which have shown in their studies that remarkable the lack of any clear relationship between cake water contents and its firmness. Decreased crumb firmness did not improve crumb texture, which showed increased crumbliness.

**Effect of addition types of dietary fiber source on hardness measurement (mechanical properties) of cake:** Data listed in Table (7) show the effect of addition different types of fiber sources with wheat flour (72%) to produced cake on compression properties (hardness measurement). The results show that, all additions were increase hardness by increasing addition

levels comparing with control sample. The results in the same table showed that, the addition fiber sources to produced cakes improved the hardness due to the effect of fibers, the fibers' function had high adsorption capacity of oil and water and therefore the hardness increased with adding fibers. These results agree with Sowmya *et al.* (2009) [54]. The hardness of the cake ranged from 0.524 to 0.820 for control sample and the addition of 20% green pea peels sample, respectively. The above results indicated that the addition of types of fiber sources is beneficial in improving the maximum force and texture.

**Sensory evaluation of fiber substituted cakes at 5, 10, 15 and 20% replacement levels:** The sensory evaluation of produced high fiber cake samples were evaluated. Twelve trained sensory panelists evaluated the products under investigation for their uniformity, size of cells, thickness, grain, moistness, tenderness, softness, crumb color, flavor and overall acceptability. The mean values were statistically analyzed using analysis of variance and least significant difference (LSD). In general, cake samples were significantly different from control sample for all sensory properties. The results indicated that, the replacement of wheat flour caused a significant decrease in cake properties scores. The results in Table (8) showed that all high fiber substituted cake samples were significantly lower than control cake sample in all sensory characteristics. significant differences ( $P>0.05$ ) in uniformity, size of cells, thickness, grain, moistness, tenderness, softness, crumb color, flavor and overall acceptability characteristics with control cake sample. The results indicated that replacement of fiber with wheat flour substitutes caused a significant decrease in cake properties. However, there were significant differences between cake samples containing the same type of fiber source at 5, 10, 15 and 20% replacement levels. The highest score in the same type of fiber source for all attributes were that achieved by cake samples with fiber source at 5% replacement level. On the other hand, the lowest scores in the same type of fiber source for all attributes were that achieved by cake samples with fiber source at 20% replacement level. For overall acceptability. Also for the all sensory attributes the cake samples at 0% substitution level (cake control) had the highest score, followed by 5% substitution level of all treatments for all attributes, then 10%

substitution level for every type of fiber sources in all sensory characteristics. The cake samples at 20% substitution level had the lowest score. Samples prepared by using orange waste and carrot pomace had a slight higher score, but the lowest score were for samples prepared by potato and green pea peels. The above results are in agreement with those obtained by Doweidar (2001); El-Hadidi (2006) and Saeed (2010) [13,15,46] who reported that statistical analysis of sensory evaluation of the control cakes versus cakes containing some fibre powders showed insignificant differences.

**Effect of addition dietary fiber sources on physical properties of produced cakes:** Data presented in Table (9) show that, the addition of dietary fiber sources was increased volume of cake under investigation, From this results indicated the important of adding dietary fiber sources on the volume of cake. Also, addition of dietary fiber sources was increased specific volume. The trend of increasing in the specific volume was go high after adding dietary fiber sources. These results are in agreement with Saeed (2010) [46].

#### 4. Conclusion

This study demonstrated the feasibility of using some by-product from plants of food industry to produce dietary fiber powder which may be used as a food ingredient. The results showed that the sources of dietary fiber had significant effects on the dietary fiber composition and technological properties. Moreover, the high effect on hydration properties which would affect the further application in real food system. Furthermore, carrot and orange fibers had high WHC and SWC values, which are good for food applications. Overall, the results suggested that orange waste, carrot pomace, potato peels and green pea peels could be used as a good raw material to produce dietary fiber powders. From industrial point of view, the fiber sources which are the residues from processing could be further processed to add value to the products in Egypt.

**Future trends:** Used new raw materials by-products, which containing a high amount of soluble and insoluble fractions of fibers and associated bioactive compounds. A good control of

the parameters involved in this process (mainly in the washing and drying steps) could also be taken into account in order to minimize losses in the soluble dietary fibre components and in the biological activity of the associated compounds.

#### Compliance with Ethics Requirements:

Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human and/or animal subjects (if exists) respect the specific regulations and standards.

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