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Getting the Dried Whey Protein Concentrate and Its Effect on Pan Bread Evaluation

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Abstract

The aim of study is to obtain dried whey protein concentrate and to study the functional properties and physical, chemical properties. It was incorporated into pan bread made using different levels of dried whey protein concentrate. Pan bread samples were analyzed for sensory, physical and chemical attributes. The results revealed that sweet cheese whey contain 93.14% water, 4.85% lactose, 0.7% soluble protein, 0.11% fat and 0.9% ash contents. While, the produced dried whey protein concentrate contained 7.04% water 92.96% total solids, 10.47% lactose, 66.87% protein, 3.65% fat and 5.63% ash contents and contained higher levels of essential amino acids especially lysine, threonine and valine. Functional properties of dried whey protein concentrate were 4.8%, 2.2%, 50%, 80% and 0.52 g/cm^3 for water absorption capacity, oil absorption capacity, foam capacity, foam stability and bulk density, respectively. Sensory, physical and chemical evaluation revealed that pan bread made using 20% dried whey protein concentrate had the best quality compared with control and other levels of dried whey protein concentrate.

Keywords: Dried whey protein concentrate - Pan bread – Physical and chemical properties - Sensory characteristics - Functional properties.

Introduction

Whey was a serious problem for dairy plants. It was not recycled to the extent it currently. Whey was removed along with sewage, which posed a threat to the ecosystem due to the organic compounds it contained **(Wesołowska - Trojanowska and Targoński, 2014)**. In the case of cheese production, ten parts of milk give nine parts of whey and one part of cheese **(Bylund, 2003)**.

The profitable solution of that environmental problem is to merge and insert waste whey into benefits industries such as food, chemical and pharmaceutical industries **(Damodaran and Paraf, 1997)**. There are many ways to raise the economic values of waste dairy industry (permeate), production of bioactive compounds is one of important method that can be used in the food industry **(Goulas *et al.*, 2007)**.

A tendency to use substitutes of ingredients in recipes of many products has been observed for several years in the food processing industry. It pertains to foods with reduced fat and sugar, or food products for vegetarians and people with lactose intolerance **(Garcia-Serna *et al*., 2014)**. Whey and its preparations may serve as substitutes. According to many sources, their use can have a positive impact not only on the consumers' health, but also on the finances of many companies by reducing the costs of raw materials, and thus lowering production costs **(Singh and Singh, 2012 and Božanić *et al*., 2014)**. Cost reduction is achieved by the use of whey preparations as partial or complete replacements of milk powder **(De Wit, 2001)**, eggs, fat **(Stoliar, 2009)** and sucrose **(Pernot-Barry, 2008)**.

There are two different types of whey: sweet whey and acid whey. Sweet whey is a by-product of ripened cheese production (pH 5.8-6.6) whereas acid whey is obtained from cottage cheeses (pH 3.6-5.1) **(Park and Haenlein, 2013)**.

The so-called whey proteins, which include β-lactoglobulin, α-lactalbumin, lactoperoxidase, and lactoferrin, are the main source of whey health-promoting properties **(Kumar *et al*., 2008)**. The following peptides were identified in the β-lactoglobulin sequences: β-lactoferrin which influences the smooth muscles, β-lactotensin which exhibits hypocholesterolemic and anti-stress activities, and in the α-lactalbumin sequences α-lactoferrin which displays effects similar to that of morphine, namely blood pressure reduction **(Chatterton *et al.*, 2006)**.

Lactoferrin's ability to respond to a variety of physiological and environmental changes is a reason to consider it one of the key components in the host's first line of defense **(Valenti and Antonini, 2005)**.

Precipitation methods are often used at the laboratory scale to obtain whey protein concentrates and produce peptides; however, the chemical composition and functionality of whey protein preparations and peptides are affected by the method used in the protein's concentration process. Chemical additives and factors, such as pressure, temperature, agitation rate and holding time, have been shown to affect solvent pH, protein conformation and yield **(Beolchini *et al.*, 2004 and Casal *et al.*, 2006)**. In particular, protein purity is critical for the biological activity of concentrated products. In addition, the biological properties of the concentrated products are difficult to standardize due to the complex nature of the bioactivities exerted by different whey proteins **(Chollangi and Hossain, 2007).**

Foams and emulsions are dispersed air/water and oil/water systems, respectively **(Kilara and Vaghela, 2018).** Protein function in foam properties as a surfactant by adsorbing at the freshly created air/water interface during bubble formation, and consequently lowers the interfacial tension and promotes bubble formation **(Davis and Foegeding, 2007).** Foaming performance of proteins is assessed by foaming capacity (FC) and foaming stability (FS). Higher FC implies greater incorporation of air bubbles, while FS describes the ability of proteins to form a strong and cohesive film around air bubbles **(Patel and Kilara, 1990)**. Foams function as structuring materials in many food products and represent in the form of bread, ice cream and various baked goods **(Ercelebi and Ibanoglu, 2009).**

Emulsifying properties are usually described as emulsification capacity, which reflects the ability of the protein to rapidly adsorbs at the water/oil interface during the formation of the emulsion and preventing flocculation and coalescence **(Webb *et al*., 2002).** Emulsions can improve the texture, appearance and organoleptic attributes of many food products in general **(Fachin and Viotto, 2005).**

In addition, whey proteins contain a high level of essential amino acids; they are also considered a source of high-quality protein. In addition, they are characterized by a high content of calcium and other minerals, such as potassium and zinc. So, whey protein is a valuable additive to bakery products **(Munaza *et al.*, 2012)**.

Whey possesses potent antioxidant activity mainly contributed by cysteine-rich proteins that aid in the synthesis of glutathione (GSH), a potent intracellular antioxidant, also investigated as an anti-aging agent. Detoxifying property contributed by glutathione peroxidase, which is derived from selenium and cysteine, that converts lipid peroxides into less harmful hydroxy acids and α-lactalbumin, which chelates heavy metals and reduces oxidative stress because of its iron-chelating properties **(Tolson, 2004 and Onwulata and Huth, 2008)**.

Cereal-based foods have vital importance in human diet. Bread is a basic cereal food, which is an important source of carbohydrates, and as a consequence takes an important place in the recommended daily calorie intake **(Dogan and Kücüköner, 1998)**.

The objective of present study was to evaluate the effect of incorporation of dried whey protein concentrate on sensory, physical, chemical, and texture of pan bread.

Materials and Methods

Materials:

Fresh sweet whey samples from both buffalo and cow's milk were obtained from cheddar cheese manufacture at Food Science Department, Cairo University.

Wheat flour (72% extraction) was obtained from the South Cairo flours Mills Company, Cairo, Egypt. Other materials used for the preparation of pan bread including active dry yeast, salt, corn oil and sugar were obtained from the local markets of Giza.

Methods:

Analytical methods:

Moisture, ash, crude fiber, fat and protein contents were determined according to the method described in **A.O.A.C (2000)**. The total carbohydrate was calculated by differences.

The mineral elements of K, Na, Mg, Fe, and Zn in the digested samples were determined by atomic absorption spectrophotometry. Lactose was determined according to the method of **Barnett and Tawab (1957)**.

Preparation of whey protein:

Dried whey proteins concentrate (DWPC) were obtained by thermal treatment of whey as follow: whey was acidified with lactic acid till pH 4.6 then, the temperature was raised to 90°C. After that whey was shocked cooled in cold water bath for about 10 min. Therefore, precipitated whey proteins were aggregated and filtered by clean mucilin cloth and the precipitated proteins were washed several times with distilled water then, dried at 40°C over night according to **Mailliart and Ribadeau-Dumas (1988)**.

Functional properties of concentrated dried whey protein:

Bulk density:

The bulk density (BD) was determined by the method of **Wang and Kinsella (1976)**.

Water absorption capacity:

The water absorption capacity (WAC) was estimated by the method of **Lin *et al.* (1974)** with modification described by **Quinn and Beuch (1975)**.

Fat absorption capacity:

The fat absorption capacity (FAC) was measured by a modified method of **Liu *et al.* (2012)**.

Foaming expansion and stability

Foaming expansion and stability were adapted according to the method of **Patel *et al*. (1988)**.

Determination of total antioxidant activity:

The total antioxidant capacity was evaluated by the method of **Prieto *et al*. (1999).**

Procedure for making experimental pan bread:

The straight dough process for pan bread production was carried out according to the method of **Kent-Jones and Amos (1967).** Pan bread making involved mixing 300 g flour, instant active dry yeast (5 g), sugar (15 g), corn oil (15 g) and salt (3 g), the dried whey protein concentrate was replaced to pan bread flour at different levels of 5, 10, 15, 20, and 25%.

All ingredients were mixed and the resulted dough was let to rest for 30 min (first proofing), then divided into pieces (165 g), rolled and molded automatically in a molding machine. Each piece was placed in baking pans (5x9x8), tightly greased to prevent the loaves from sticking. Pans were let to ferment for 60 min in a cabinet at 30°C and 85% relative humidity. The baking process was carried out in rotaroy electrical oven at 250°C for 25-30 min. After baking; loaves were separated from baking pans and allowed to cool at room temperature for 1 hr before weighing, measuring the volume and performing the organoleptic evaluation.

Blends of hard wheat flour with different substituted levels of dried whey protein concentrated used for the experimental production of pan bread:

Blends	Hard wheat flour (HWF) (%)	Dried whey protein concentrate (DWPC) (%)
Control	100	0
1	95	5
2	90	10
3	85	15
4	80	20
5	75	25

Physical properties of pan bread:

The weight of bread loaves was determined after cooling for one hour. Bread loaf volume was measured by rape seed displacement method as described by **A.A.C.C. (2000)**. Specific volume of bread was calculated by dividing volume of the loaves (cm^3) by their weights (g).

Texture profile analysis of pan bread:

The texture profile analysis of pan bread conducted using CT3 Texture Analyzer (Version 2.1, 10000 Gram unit, Brookfield, Engineering Laboratories, Inc. USA). According to method 74-09 **A.A.C.C. (2000).**

Sensory evaluation:

The sensory evaluation of pan bread produced was done as described by Ali (2012).

Statistical analysis:

The data were presented as means ± SD from three replicates. Data were subjected to one way ANOVA. The means of different treatments were compared using Duncan's multiple range tests at $p \leq 0.05$. Statistical analyses were performed using SPSS statistical software (IBM SPSS Statistics, version 20) **(Snedecor and Cochran, 1980)**.

Results and Discussion

Chemical analysis of liquid cheese whey:

Data in Table (1) shows the chemical composition of liquid cheese whey components. Results revealed that, liquid cheese whey contains about 93.14% water and the following nutrients from the original milk: lactose (4.85%), soluble proteins (0.70%), fat (0.11%) and ash (0.90%). Therefore, those chemical compositions represent (6.86%) total solid and pH value was 5.0 for liquid whey. However, minerals such as Mg 1.278 mg, Na 4.813 ppm, K 0.772 ppm, Fe 0.0 ppm, and Zn 0.08 ppm. These results are in agreement with those results presented by **Panesar *et al.* (2007) and Smith (2012)**. They reported that the raw liquid whey is composed of naturally occurring macronutrients-ie water 93% protein 0.8%, fat 0.3% lactose 4.8% and mineral- referred to as ash 0.5%.

Also, from Table (1) chemical composition of dried whey protein concentrate were 7.04% of moisture and the following nutrients from the original milk: lactose, (10.47%), crude proteins (66.87%), fat (3.65%) and ash (5.63%). Therefore, those chemical compositions represent 92.96% total solids and pH value was 4.68 for dry whey protein concentrate. However, minerals such as Mg 7.76 mg, Na 131 ppm, K 81 ppm, Fe 0.0 ppm, and Zn 0.56 ppm. Whey contains numerous valuable micronutrients like, sodium, potassium, magnesium, citrate and phosphate that help to enhance the functionality of whey proteins **(Zemel, 2004).** Whey is also an excellent source of bioavallable calcium that improves bone health. The composition of whey salts expounded low sodium to potassium ratio that is essential for maintenance of blood pressure. Moreover, calcium from the whey is readily absorbed in the intestine, facilitated by the presence of lactose **(Smithers, 2009).** Also, Mg, K and Na represent good sources of these elements found in dry whey protein concentrate. The result are in agreement with the results presented by **Onwulata *et al.* (2004)** mentioned that dried whey protein concentrate contained moisture 5.3%, crude protein 74.8%, fat 2.3%, ash 2.7%, pH value 4.8% and carbohydrate 15.1% This could be attributed to the high protein and low fat and ash content in WPC (Table 1). It has been reported that the functional properties of whey products are related to the protein content and the composition of the product **(Heino *et al*., 2007 and Ghanimah, 2018).**

Table 1. Physico-chemical composition of liquid and dried whey protein concentrate**.**

Component	Liquid whey protein	Dry whey protein concentrate (DWPC)
Moisture (%)	**93.14**	**7.04**
Total solids (%)	**6.86**	**92.96**
Lactose (%)	**4.85**	**10.47**
Fat (%)	**0.11**	**3.65**
Protein (%)	**0.70**	**66.87**
Ash (%)	**0.90**	**5.63**
K (ppm)	**0.772**	**81**
Mg (ppm)	**1.276**	**7.76**
Na (ppm)	**4.813**	**131**
Fe (ppm)	**Nil**	**Nil**
Zn (ppm)	**0.08**	**0.56**
pH	**4.65**	**4.68**
Total antioxidant		**1200 ppm**

Antioxidant activity of dried whey protein concentrate:

Table (1) shows the antioxidant activities of dried whey protein concentrate products. Data is expressed as antioxidants activity equivalent to ascorbic acid (AAEAA). The values were 1200 ppm for dried whey protein concentrate. The authors showed that low temperature- processed dried whey protein concentrate contains high levels of specific dipeptide (eg glutamyl cysteine) than promote the synthesis of glutathione, an important antioxidant involved in cellular protection and repair processes. **Tseng *et al.* (2006)** showed that dried whey protein concentrate product promotes gluthanion production which in turn enhances antioxidant activity in a pheochromocytoma cell line after acute ethanol exposure. **Hsieh *et al.* (2015)** mentioned the role of milk protein fraction as antioxidant against liquid peroxidation. This finding indicates that the role of milk proteins fractions namely whey protein against the rancidity of fatty foods.

Functional properties of dried whey protein concentrate (DWPC):

Functional properties of DWPC dried whey protein including water absorption capacity, oil absorption capacity, foam capacity, foam stability and bulk density are presented in Table (2). From the obtained results, it could be observed that DWPC was recorded 4.8 and 2.2 g/g for water absorption capacity and oil absorption capacity, respectively. These results are in accordance with those obtained by **Prinyawiwatkul *et al.* (1997).** They mentioned that, protein water absorption capacity is a function of several parameters, including size, shape, steric factors and conformational characteristics hydrophilic- hydrophobic balance of amino acid, in the protein molecules as well as lipids, carbohydrates associated with protein. Carbohydrates contain hydrophilic parts, such as polar or charged side chains, which can enhance water absorption capacity.

From the results presented in the same table, it could be noticed that the foam capacity and stability of DWPC were recorded 50% and 80%, respectively. The results suggested that the DWPC had a more flexible protein structure in aqueous solutions and interacted strongly at the air-water interface to form more stable foam as mentioned by **Lawal *et al*. (2005). Patino *et al.* (2007)** have been demonstrated that the foam stability increased with protein concentration in solution as can be seen in the current work.

Also, the obtained results indicated that bulk density of DWPC was 0.52 g/cm^3. High bulk densities are used as thickeners in food products.

Table 2. Functional properties of dried whey protein concentrate:

Functional properties	Dried whey protein concentrate (DWPC)
Water absorption capacity (g/g)	4.80
Oil absorption capacity (g/g)	2.20
Foam capacity (FC) (%)	50.00
Foam stability (FS) (%)	80.00
Bulk density (BD) (g/cm^3)	0.52

Amino acids composition of dried whey protein concentrate:

Amino acids composition of DWPC is presented in Table (3). Levels of essential amino acids (EAAs) threonine, phenylalanine, valine, methionine, cysteine, isoleucine, leucine, lysine and tryptophan in raw WPC were 4.57, 2.87, 4.21, 1.80, 1.60, 3.41, 5.61, 6.83 and 1.3 g/100g, respectively. It also appeared that lysine, threonine and valine were the first limiting amino acid in whey protein products, with values of 6.83, 4.57 and 4.21 g/100 g DWPC, respectively. **Hulmi *et al*. (2010)** documented essential amino acids values in whey protein concentrate as 61, 122, 102, 33, 30, 68, 18 and 59 mg/g for isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine, correspondingly. The results concerning amino acid profile of whey protein are in conformity with the findings of **Etzel (2004),** who noticed highest concentration of leucine as 118 mg/g whey protein isolate followed by lysine with mean value 95 mg/g.

Table 3. Amino acid composition (g/100 g DWPC) of dried whey protein concentrated**.**

Amino acid	Dried whey protein concentrate
Essential amino acids (EAA):	
Isoleucine	3.41
Leucine	5.61
Lysine	6.83
Methionine	1.80
Cystine	1.69
Phenylalanine	2.87
Tyrosine	1.31
Threonine	4.57
Valine	4.21
Total essential amino acids	32.30
Non-essential amino acids (NEAA):	
Alanine	2.75
Arginine	1.65
Aspartic acid	5.11
Glutamic acid	12.67
Glycine	1.49
Proline	5.38
Serine	2.76
Histidine	1.71
Total non-essential amino acid	33.52
Total amino acids	**65:82**

Chemical composition of pan bread made using concentrated dried whey protein concentrate:

As shown in Table (4) the moisture content of pan bread made using dried whey protein concentrate increase from 28.48% of control treatment to 39.83% of sample No. 4 which contained 20% DWPC. There is a significant difference ($p \geq 0.05$) in moisture content was found in all samples. The increase in moisture content with increasing the level of dried whey protein concentrate may be due to more bound water in the system. These results are in accordance with **Gallagher *et al.* (2005).** They reported that biscuits with dried whey protein concentrate were higher in moisture content compared with control sample.

Protein content in pan bread also increased significantly from 11.80 to 13.53% with increasing the levels of DWPC. The highest value for protein content (13.53%) was observed in pan bread made using (20% DWPC) compared with the lowest value (11.80%) for control sample. Results also revealed that the protein content in all samples was different significantly. Similar results was observed by **Munaza *et al.* (2012)** they found that there was linear increase in protein content in the biscuit samples with increase in level of dried whey protein concentrate.

Fat content of pan bread was increased significantly from 4.69 to 6.46%. The highest value of fat (6.46%) was observed in sample No. 4, while the lowest value (4.69%) was observed in control sample. These results are in accordance with ash content of pan bread which increased significantly from 1.74 to 2.81%. The highest value of ash content (2.81%) was reported in sample No. 4 followed by sample No. 3 (2.71%) and sample No. 2 (2.14%), while the lowest value for ash (1.74%) was observed in control sample. These results are in accordance with **Gallagher *et al.* (2005)**. They found that the increase in ash content in biscuits enriched with dried whey protein concentrate**.**

Fiber content of pan bread decreased significantly from 1.95 to 0.82%. The maximum fiber content of 1.95% was observed in control sample followed by sample No. 1 (1.26%), sample No. 2 (1.00%) however, sample No. 4 showed the lowest fiber content of 0.82%. These results are in accordance with **Gayas *et al.* (2012)** they reported that the decrease in fiber content in biscuits fortified with dried whey protein concentrate.

Finally, the available carbohydrates content of all pan bread were decreased significantly from 79.82 in control sample to 76.38% in sample No. 4 which contained 20% DWPC.

Table 4. Chemical composition of pan bread made using different levels of dried whey protein concentrate (g/100 g).

Sample	Pan bread blends HWF+DWPC	Moisture	Crude protein*	Ether extract*	Ash*	Crude fiber*	Available carbohydrate*@
Control	100 + 0	28.48 ±0.73^{c}	11.80 ±0.55^{bc}	4.69 ±0.32^{c}	1.74 ±0.03^{c}	1.95 ±0.16^{a}	79.82 ±0.85^{a}
1	95 + 5	32.91 ±1.90^{b}	12.02 ±0.18^{c}	5.54 ±0.74^{c}	1.86 ±0.06^{c}	1.26 ±0.3^{b}	79.32 ±0.62^{a}
2	90 + 10	33.66 ±0.59^{b}	12.22 ±0.18^{b}	5.88 ±0.26^{bc}	2.14 ±0.10^{b}	1.00 ±0.13^{bc}	78.76 ±0.70^{b}
3	85 + 15	38.48 ±0.34^{a}	13.04 ±0.15^{a}	6.08 ±0.26^{b}	2.71 ±0.12^{a}	0.91 ±0.4^{c}	77.26 ±0.24^{c}
4	80 + 20	39.83 ±0.23^{a}	13.53 ±0.13^{a}	6.46 ±0.24^{a}	2.81 ±0.05^{a}	0.82 ±0.03^{c}	76.38 ±0.32^{d}

*: On dry weight basis. @: Calculated by difference

a, b …: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter.

Physical properties of pan bread made using dried whey protein concentrate:

Physical properties i.e. weight, volume and specific volume of pan bread made using different levels of dried whey protein concentrate are shown in Table (5). These results declared that, the effect of adding DWPC at different levels to wheat flour (72% ext.) was increase the volume and specific volume gradually with increasing the level of addition as compared to their corresponding control sample. The increase in volume of the prepared pan bread experimental samples could be attributed to the added DWPC and may be due to the interaction between the protein and pan bread ingredients, especially the interaction between water and fat phases during pan bread making which caused increase in water retention in pan bread samples after baking. Dried whey protein concentrate gelation will increase the viscosity and also will give strength to the expanding cells of the dough; as a result, gas retention during baking improves and obtaining better specific volume **(Marco and Rosell, 2008)**

Table 5. Physical properties of pan bread made using dried whey protein concentrate**.**

Sample	Pan bread made from HWF+DWPC	Volume (cm^3)	Weight (g)	Specific volume cm^3/g
Control	100 + 0	496.67±8.82^{c}	142.33±12.55^{a}	3.49±0.24^{b}
1	95 + 5	553.33±8.82^{b}	154.33±10.27^{a}	3.59±0.22^{b}
2	90 + 10	576.67±26.03^{b}	158.00±1.00^{a}	3.65±0.15^{ab}
3	85 + 15	601.67±36.55^{b}	162.33±0.88^{a}	3.71±0.17^{ab}
4	80 + 20	686.67±6.67^{a}	166.67±2.96^{a}	4.12±0.01^{a}

a, b ……: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter

Texture Profile of pan bread made using different levels of dried whey protein concentrate during storage period:

Data illustrated in Table (6) show the effect of adding dried whey protein concentrate on hardness measurements of produced pan bread during storage time for 72 hr at room temperature when comparing with control sample. The results indicated that the increasing addition levels of dried whey protein concentrate up to 20%, the hardness values were decreased more than control. For instance, at 'zero time' hardness values for control sample were 13.50 however for the samples with DWPC were 13.43, 13.40 and 16.90 for 5, 10 and 15%, respectively, while the lowest hardness value for sample No. 2. During storage period time results showed that hardness values for control sample was increased more than all treatments of DWPC.

Cohesiveness as strength of the internal bonds making up the body of the product (**Scheuer *et al*., 2014)** From the results in Table (6) it could be shown the effect of adding dried whey protein concentrate to pan bread on the cohesiveness values which revealed an increasing in cohesiveness values correlated with increasing addition levels of DWPC during storage period when compared with control sample, while during storage time there was a shrinkage of cohesiveness for all treatments but less than control sample.

The gumminess and chewiness are the most indicative characteristic of fresh bread which is acceptable for consumers. As less gumminess and chewiness, the more freshness and staling retard, and vice versa. From Table (6) data showed the effect of increasing addition levels of DWPC during storage period on gumminess and chewiness values of produced pan bread, which revealed a decrease in both gumminess and chewiness values was more than control sample, while during storage time there was an increasing for both gumminess and chewiness values for all treatment. Gumminess and chewiness, are highly depending on hardness rather than cohesiveness or springiness values.

Table 6. Texture properties of pan bread made using dried whey protein concentrate.

Substitution (%)	Storage period (hr)			
	0	24	48	72
Hardness				
Control (0)	13.50^{aB}	16.04^{aAB}	17.86^{Aa}	24.63^{bA}
5	14.43^{aB}	19.08^{aB}	21.63^{Aab}	27.55^{bAB}
10	14.48^{aB}	19.46^{aAB}	24.22^{Ab}	29.23^{bAB}
15	16.90^{aB}	24.81^{aB}	27.48^{Aab}	41.31^{aA}
20	17.52^{aB}	26.29^{aA}	28.87^{Ab}	44.98^{aA}
Cohesiveness				
Control (0)	0.78^{aA}	0.57^{aA}	0.40^{Ab}	0.38^{abB}
5	0.73^{abA}	0.44^{bB}	0.38^{Ab}	0.35^{bB}
10	0.68^{abcA}	0.43^{bB}	0.36^{Ac}	0.33^{bB}
15	0.64^{bcA}	0.41^{bB}	0.36^{Ab}	0.30^{aB}
20	0.61^{cA}	0.40^{bBC}	0.35^{Ab}	0.28^{bC}
Gumminess				
Control (0)	11.10^{aB}	9.28^{aB}	7.90^{aA}	5.55^{bB}
5	11.12^{aA}	9.54^{Ab}	8.68^{Aa}	7.89^{aAB}
10	11.60^{aB}	9.59^{aB}	8.99^{Ab}	8.18^{bA}
15	11.81^{aB}	10.92^{aB}	9.03^{Ab}	8.89^{aA}
20	12.61^{aA}	11.91^{aA}	10.30^{Aab}	9.50^{bB}
Chewiness				
Control (0)	85.60^{aA}	77.10^{aA}	56.70^{aA}	53.00^{aB}
5	72.30^{aB}	62.90^{aB}	51.00^{aAB}	45.60^{bA}
10	68.80^{aA}	55.40^{aAB}	51.00^{aB}	43.70^{bB}
15	65.70^{aA}	53.90^{aA}	47.40^{aA}	40.40^{aA}
20	47.80^{aB}	52.70^{aB}	44.00^{aA}	39.10^{bA}
Adhesivenes				
Control (0)	0.40^{aA}	0.20^{abAB}	0.10^{aB}	0.10^{aA}
5	0.40^{aA}	0.20^{abAB}	0.10^{aA}	0.10^{aA}
10	0.40^{aA}	0.20^{abAB}	0.10^{aB}	0.00^{bB}
15	0.30^{abA}	0.10^{bA}	0.10^{aB}	0.00^{bB}
20	0.20^{abcAB}	0.00^{bA}	0.10^{aA}	0.00^{bB}
Springiness				
Control (0)	5.07^{aBC}	4.98^{aB}	3.73^{cB}	2.82^{dB}
5	5.92^{aA}	5.27^{aA}	4.46^{bcB}	3.92^{aA}
10	6.19^{aA}	5.76^{abB}	5.44^{aA}	4.78^{cC}
15	6.23^{aB}	5.81^{abA}	5.56^{aAB}	5.22^{bcA}
20	6.79^{aA}	6.76^{abA}	6.47^{aAB}	5.64^{aB}
Resilience				
Control (0)	0.28^{dA}	0.17^{aC}	0.15^{aB}	0.14^{aC}
5	0.32^{cdA}	0.18^{aB}	0.16^{aB}	0.15^{bC}
10	0.35^{bcA}	0.21^{aB}	0.16^{aC}	0.15^{bB}
15	0.39^{abA}	0.21^{aB}	0.17^{aBC}	0.15^{bC}
20	0.43^{aA}	0.23^{aB}	0.21^{aB}	0.17^{abB}

a, b ……: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter.
A, B ……: There is no significant difference (P>0.05) between any two means, within the same row have the same superscript letter.

Textural properties, such as resilience usually decreased during storage time with increasing staling and deformation. Resilience increased linearly with moisture content **(Stampfli and Nersten, 1995)**. From previous context and results illustrated in Table (6) it was obvious that during storage period resilience values were decreased for all treatments parallel with losing moisture and staling, however control sample was possessed the lowest resilience values when compared with all treatments during storage time, and instance resilience for pan bread made using 10% DWPC were 0.35, 0.21, 0.16, and 0.15. While, it was

0.28, 0.17, 015 and 0.14 for control sample at 0, 24, 48, and 72 hr. These results are in harmony with **Goesaert *et al.* (2009)** who reported that bread quality decreases during storage period because bread crumb and crust get firmed and lose resilience. These results are in agreement with those obtained by **Ribotta *et al.* (2005).** The adhesiveness and resilience initially decreased and then increased with increasing the level of WP from 0 to 30%. The results above again suggested that when WP was at high concentration (higher than gluten content), the heat induced WP gel became dominant phase and significantly affected quality characteristics of the bread Table (6), at storage time when compared with control, with increasing addition levels.

These results indicated that the addition of concentrated dried whey protein concentrate to the formulations contributed to enhance textural properties, except for adhesiveness and cohesiveness, which is attributed to its high-water retention capacity and gelling properties. This is in agreement with the results presented by **Antunes *et al.* (2003)** they reported that, β-lactoglobulin is the main gelling agent due to the presence of free sulfhydryl groups. Formulations supplemented with concentrated dried whey protein showed greater elasticity. This parameter is strongly related to the formation of intermolecular disulfide bonds **(Shimada and Cheftel, 1989)**.

Sensory evaluation of pan bread made using different levels of dried whey protein concentrate:

The results for the sensory evaluation of pan bread made using different levels of dried whey protein concentrate are given in Table (7) and it is revealed that the DWPC was different impact on sensory attributes like color, texture, taste, flavor, and overall acceptability. The results indicated that the mean score for the color had been increased from11.4 for control treatment to 13.9 for pan bread made using the level of (20% DWPC). Mean score for texture had been increased significantly from 11.9 for control to 13.7 with increasing the level of DWPC to 20% (sample No. 4).

The quality score in response to taste of the pan bread depicted that the highest significant score of 18.0 was shown in blend 4 sample. While the lowest significant mean score of 15.1 was observed in control sample., Results pertaining to flavor of pan bread are presented in the same table, and revealed that, the highest significant score for odor 18.1 was observed in sample No. 4. While, the lowest sgnificant mean score of 15.7 was observed in control sample Data in the same table indicated that the 15 and 20% levels substitution of DWPC were increased the scores of sensory properties of corresponding all samples compared to control. Overall acceptability was determined on the basis of quality scores obtained from the evaluation of color, texture, taste and flavor of the pan bread. The mean score regarding overall acceptability of pan bread revealed that sample No. 4 have the maximum score (90.7) of overall acceptability, while, the sample No. 5 have the minimum score compared to control sample (45.01). The decrease in overall acceptability was due to the decrease in quality score in response to texture, taste and flavor. **Shim and Mulvaney (2001)** reported that in response to the addition of WPC, significantly increased, indicating that the addition of WPC reduced the thermal stability of the starch in dough. The addition of WPC destroyed the continuous gluten network structure and subsequently weakening its protective effect on starch subjected to amylase. As the substitution level of WPC increased. The results obtained are in close with **Singh *et al.* (1993)** they reported similar results regarding overall acceptability score of sensory evaluation. Addition of whey and dried whey protein concentrate improved sensory quality of different baked products and even various traditional foods such as gulabjamun **(Vani and Jayaprakasha, 2004**) and finger millet **(Tripathy *et al.*, 2003**).

Improvement of sensory quality of bread by supplementation of other forms of whey and whey protein products has been extensively reported **(Vetter, 1984; Abdel-Aal *et al.*, 1999; Mannie and Asp, 1999 and Gallagher *et al.*, 2003).**

Table 7. Sensory evaluation of pan bread made using dried whey protein concentrate.

Pan bread blends HWF + DWPC	Crust appearances (15)	Crust color (15)	Crumb color (15)	Texture (15)	Taste (20)	Odor (20)	Overall acceptability (100)
Control 100 + 0	11.4^{c}	11.6^{c}	12.4^{b}	11.9^{c}	15.1^{d}	15.7^{c}	78.1^{c}
95 + 5	12.3^{bc}	13.1^{a}	12.2^{b}	12.4^{b}	16.9^{bc}	17.0^{b}	83.9^{bc}
90 + 10	12.8^{b}	12.0^{b}	13.0^{a}	12.1^{b}	16.4^{c}	17.1^{b}	83.4^{bc}
85 + 15	12.6^{b}	12.9^{ab}	12.4^{b}	13.4^{a}	17.1^{b}	17.1^{b}	85.5^{ab}
80 + 20	13.9^{a}	13.4^{a}	13.6^{a}	13.7^{a}	18.0^{a}	18.1^{a}	90.7^{a}
75 + 25	7.07d	7.29d	6.87c	7.21d	8.43e	8.14d	45.01d

a, b …: There is no significant difference (P>0.05) between any two means, within the same column have the same superscript letter.

Finally, from the obtained results, it could be concluded that the 20% dried whey protein concentrate supplemented pan bread samples were nutritionally rich and have the highest score in most of the sensory evaluation attributes.

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الحصول على مركز بروتين الشرش الجاف وتأثيره على تقييم خبز القوالب

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استهدفت الدراسة الحصول بروتين الشرش المركز المجفف ودراسة الخصائص الوظيفية والفيزيائية والكيميائية له تم إضافة بروتين الشرش المركز المجفف مع خبز القوالب بمستويات (٥، ١٠، ١٥ و ٢٠%) وقد أظهرت النتائج المتحصل عليها أن شرش اللبن الحلو يحتوى على ٩٣.١٤% الماء, ٤,٨٥% اللاكتوز, ٠,٧% بروتينات قابلة للذوبان ٠,١١% دهون, ٠,٩% من الرماد و ٦.٨٦% مواد صلبة كلية, بينما احتوى بروتين الشرش المركز المجفف الناتج على ٧,٠٤% ماء, ٩٢,٩٦% مواد صلبة كلية, ١٠,٤٧% لاكتوز, ٦٦,٨٧% بروتين, ٣,٦٥% دهون و ٥,٦٣% رماد. وبتقدير الخواص الوظيفية لبروتين الشرش المركز المجفف كانت سعة امتصاص الماء ٤,٨%, سعة امتصاص الزيت ٢,٢% , حجم الرغوة ٥٠% , وكان ثبات الرغوة ٨٠% و الكثافة الظاهرية ٠,٥٢% .

كما لوحظ أن بروتينات شرش اللبن المركز المجفف يحتوى على مستويات مرتفعة من الأحماض الأمينية الأساسية خاصة اللايسين, الثريونين والفالين. كما أظهرت نتائج التقييم الحسى والفيزيائى والكيميائى أن خبز القوالب المضاف له ٢٠% من بروتين الشرش المركز المجفف كان أفضل مقارنة بعينة الكنترول وباقى مستويات الإضافة من بروتين الشرش المركز المجفف.

الكلمات الدالة: بروتينات الشرش المركز المجفف – خبز القوالب – الخصائص الفيزيائية والكيميائية – الخصائص الحسية – النشاط المضاد للأكسدة.