Effect of Using Cauliflower (*Brassica oleracea*) to Improve Quality Characteristics of Tuna Fish Burger

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ABSTRACT

This study was conducted to evaluate the effect of processing method (drying and steaming) on chemical composition and bioactive compounds of cauliflower (*Brassica oleracea L.)* and utilization of dehydrated cauliflower powder (DCP) at different ratios (0, 3,6,9 and 12%) to prepare fish burger treatments as a natural source of dietary fiber, antioxidant and antimicrobial activities. Also quality characteristics of fish burger during frozen storage period at (-18^{o}C) up to four months were evaluated. Total phenolics, flavonoid content and antioxidant activity were increased. Incorporation of DCP in preparation of fish burger improved its physicochemical, cooking and microbiological properties. pH, TBA, TVB-N, cooking loss, shrinkage and microbial load of tuna fish burger decreased by increasing the levels of DCP. Generally, samples containing different ratios of DCP had significantly lower microbial load than the control. After cooking, the total bacterial count of all samples were less than 30 cfu/g, meanwhile, coliform group, psychrophilic and yeasts & moulds were not detected within 4 months of storage. The results of organoleptic evaluation showed that all tuna fish burger samples containing DCP were well accepted by the panelists.

Key words: cauliflower, *Brassica oleracea* L., tuna fish, burger, chemical composition, quality parameters, frozen storage stability.

INTRODUCTION

Vegetables occupy an important place among the food crops as they provide adequate amount of many vitamins and minerals for humans. There are rich source of carotene, ascorbic acid, riboflavin, folic acid and minerals like calcium, iron, and phosphorus (Fasuyi, 2006). Vegetables contained a large proportion of water and are susceptible to deterioration. Vegetables can be preserved by various techniques, but the widely used technique for vegetables preservation is drying. Removal of water from foods is key to enhance the shelf life of vegetables (Lussier, 2010).

Nowadays, natural antioxidants have become a major area of scientific research (Sanchez- Moreno *et al.*, 1999), therefore, the importance of searching for and exploiting natural antioxidants, especially those of plant origin, has increased greatly in recent years. There is a growing interest in natural additives as potential antioxidants (Gülcin *et al.*, 2006). In fact, a fundamental property important for life is antioxidant activity and this property may give rise to anti-carcinogenicity, anti-mutagenicity, and anti-aging activity, among others (Liyana-Pathirana and Shahidi, 2006).

Dehydrated fruits and vegetables can be used in the food industry as functional ingredient with excellent results. However, fruit and vegetables fibers has better water and oil binding capacity, colonic fermentability, as well as lower phytic acid content and energy (Viuda-Martos *et al.*, 2010).

Cauliflower (*Brassica oleracea* var. *Botrytis*) is one of the main Brassicaceae crops and important vegetables grown all over the world and has a wide variety of uses directly as a vegetable or as an ingredient in salads, soups, and so forth. Cauliflower occupies an area of 8.88 million hectares, having a production of 16.40 million tons in the world (FAO, 2004). The cultivated area with Cauliflower was 11775 feddan(4710 hectares) in Egypt during 2008, while the productivity was 10.583 ton/feddan with total production of 124680 tons(AOAD, 2009). Cauliflower have been widely described as rich sources of dietary fiber, vitamin B6, folic acid, vitamin B5, and small amounts of other B group vitamins, minerals especially potassium and phosphorus and contain many bioactive compounds, especially organo sulphur phytochemicals possessing anti-carcinogenic activity and other phytochemicals, which are known to possess antioxidant activity . Antioxidants present in these vegetables, contribute to both the first and the second defense lines against oxidative stress. As a result, they may protect humans from chronic diseases, such as cancer and cardiovascular disease. Among Brassica vegetables, kale, Brussels sprouts and broccoli are the richest sources of antioxidant, vitamins and carotenoids(Anwar *et al.* 2013). In spite of the promising possibilities of cauliflower

from a functional and antimicrobial point of view, the intense odour and taste of cauliflower might not be suitable for addition in some ready to eat(RTE) products. However, it would be particularly appropriate in vegetables salad, prepared meat dishes, or ready-to-eat garnishes, which might be possible food matrices for supplementation with these novel natural preservatives.(Sanz-Puig *et al.*, 2014)

Fish burgers are one of the most acceptable food products in the world and commonly used as RTE or precooked products. Fish and fish products are usually consumed after frozen storage and /or after some type of culinary preparation (Bognar, 1998). During frozen storage fish quality may be declined as a result of several factors. Bacterial growth is the main cause of fish spoilage (Suvanich *et al.*, 2000). However microbiological analyses are not extensively used for rapidly determining commercial quality (Ruiz-Capillas and Moral, 2001).

The objectives of this study were to evaluate the effect of processing methods(drying and steaming) on chemical composition and bioactive compounds of cauliflower. Also, the effect of adding different levels of dehydrated cauliflower powder(DCP) as natural source of dietary fiber, antioxidant and antimicrobial on chemical composition, total phenolic, flavonoids content, antioxidant activity, physiochemical, cooking properties, microbiological, texture profile and sensory characteristics of fish burger during frozen storage period for 4 months at - 18^{o}C was studied.

MATERIAL AND METHODS

Materials:

10 Kg of fresh cauliflower (*Brassica oleracea* L. var. botrytis) was purchased from the local vegetables market in Alex., 15 Kg of tuna(*Thunnus thynnus*) were obtained from Abu-Qir fish market in Alex, the fresh fish weight ranged between 1.00 to 1.65kg. For each food additives including rusk powder, sugar, salt, garlic, onion powder and spices mixture (cinnamon, thyme, rosmary and cumin) were bought from the local market in Alex. All chemicals and reagents used in the present study were of food analytical grade.

Methods:

Technological Methods

Preparation of cauliflower

Fresh cauliflower was washed and cleaned by tap water to remove dirt, dust, etc. and then drained. Each whole cauliflower (florets, upper stem and stalks) was cut into 2-3 cm length with stainless steel knife while leaf midribs were discarded**.** Cauliflowers were divided into two parts and the process was completed as following:-

1- Steaming process of cauliflower.

Cauliflower samples were steamed on boiling water vapor for 10 min. Also the steamed samples were cooled under iced water for 2 min. Steamed cauliflower samples were then transferred into transparent polyethylene bags, labeled and stored at -18^{o}C until used.

2- Drying process of cauliflower.

Dehydrated cauliflower powder (DCP)was prepared as follow: The cauliflowers were further cut into small pieces and rapidly immersed under the surface of 1% citric acid solution for 10 min to avoid browning, then which were dried in hot air oven at 60 ^{o}C for 18 h, The dehydrated cauliflower was milled with a stainless steel grinder (Sf stardust, model: Cml-600 mkii , JAPAN) to pass through 100 mesh sieve and dried cauliflower samples were then transferred into transparent polyethylene bags, labeled and stored at room temperature for further analysis.

Preparation of fish mince

Fresh tuna fin fish were washed in chilled water and transported to the processing hall in insulated box containing ice in the ratio of 1:1(fish : ice). The fish samples were thoroughly washed and dressed to remove scales, head and viscera. There were washed once again in chilled water and deboned manually to obtain fillets. Fish mince was prepared by mechanical mincer initially with 5 mm holes mincer plate (15 cm diameter) and later with 2 mm holes mincer plate.

Preliminary experiments

Preliminary experiments were carried out to choose the best processed cauliflower form (dried or steamed) in fish burger treatments by using different ratios of steamed cauliflower(0, 5,10,15, 20 and 25%) and DCP(0, 3, 6, 9 and 12%) then comparison with them through experiments sensory evaluation and physical characteristics including cooking yield, cooking loss and shrinkage.

Preparation of tuna fish burger with different levels of DCP

Fish burgers were processed as described by Mahmoudzadeh *et al.*,(2010). The control sample was prepared according to the following formula: tuna fin mince (85%), rusk powder(5.0%), ice water (5.0%), sugar(0.5%), salt (2. 0%), garlic powder (1.0%), onion powder(1.0%) and spices mixture (0.5%). To prepare the tuna fin fish burger treatments, the minced tuna fish in the formula was replaced with 0, 3, 6, 9 and 12% of DCP. Once the homogeneous mixture became smooth, 50 g was placed between two sheets of transparent casings and pressed gently to give the burger the required texture. All treatments were aerobically packaged in a foam plate, wrapped with polyethylene film and stored at -18°C for 4 months. Samples were taken for analysis every month periodically.

Chemical methods

Chemical analysis

Proximate chemical composition including moisture, crude ether extract, crude protein(N×6.25), crude fibers and ash were determined according to the methods AOAC(2005) unless otherwise stated. Nitrogen free extract was calculated by difference. Energy value was calculated using the universally acceptable conversion factors by multiplying protein and carbohydrates by 4.00 and fat by 9.00 Kcal/g.

Thiobarbituric acid (TBA) and the total volatile nitrogen (TVN) of tuna fish burger samples were determined using the method published by(Kirk and Sawyer, 1991). The pH values were measured by using a Beckman model pH meter according to AOAC (2005).

Dietary fibers fractions of the fresh, DCP and steamed cauliflower including neutral detergent fibers (NDF), acid detergent fibers(ADF) and hemicellulose were analyzed using the method of Goering and Van Soest (1970).

Minerals such as Ca, Mg, Fe, Zn were measured using Perkin Elmer Atomic Absorption Spectrophotometer (Model 2380, Japan), as described in the AOAC (2005). On the other hand, Na and K were determined using Flame Photometer (Model PE P7, England).

Determination of total phenolic, flavonoid contents and antioxidant activity:

The total phenolic contents as (mg Gallic acid equivalent/100g) of the fresh, DCP, steamed cauliflower and different fish burger extract were determined by Folin-Denis reagent after extracting with 80% methanol according to the method of Maurya and Singh (2010). Total flavonoid content was determined according to the method of Zarina and Tan (2013). Antioxidant activity was determined by scavenging the radical 1, 1-diphenyl-2-picryhydrazyl (DPPH) as described by Ramesh and Satakopan (2010).

Technological methods

Cooking yield and cooking loss were determined as described by Alesson-carbonell *et al.*(2005). Shrinkage (%) was determined as described by AMSA (1995).

Texture profile analysis:

Texture profile analysis of different burger treatments was determined by a universal testing machine (Cometech, B type, Taiwan) provided with software. An Aluminum 25 mm diameter cylindrical probe was used in a ‘‘Texture Profile Analysis’’ (TPA) double compression test to penetrate to 50% depth, at 1 mm/ s speed test. Firmness (N), gumminess, chewiness, cohesiveness and springiness were calculated from the TPA graphic. Springiness give information about the after stress recovery capacity (Bourne, 2003).

Microbiological analysis

Total plate count (TPC) was determined by using pour plate method and plate count agar as medium according to ISO 8443(2003). For coliform group bacteria, pour plate procedure and Violet Red bile Agar medium were used according to ISO 4832 (1991). Psychrophilic was determined by surface plate method using plate count agar medium according to ISO 17410(2001). Yeasts & moulds were determined by plating 0.05 ml of diluted sample on potato dextrose agar(Oxoid CM) incubated for 5 days at 25 ^{O}C, yeasts & moulds colonies were counted separately according to ICMSF (1978).

Organoleptic evaluation

Sensory properties of tuna fish burgers were carried out by 10 panelists of Food Technol. Lab., Food Technol. Research Inst., Agricultural Research Center of Sabahia, Alexandria, using a 9 point hedonic scale according to Vijayan (1984). Frozen tuna Fish burger samples were thawed and deep fried in refined vegetable oil at 180^{o}C for 1-2 min until the surface became a uniform brown in colour. The sensory attributes covered by the taste panel were colour, odour, taste, texture and overall acceptability. The observation was converted to equivalent numerical scores and a sensory score of 4 was taken as the borderline of overall acceptability.

Statistical analysis

Statistical analysis system(SAS) software program(SAS Institute 2004) using one and two factor factorial analysis of variance(ANOVA) was followed. The differences among means were determined for significance at P≤0.05 using t Tests (LSD).

RESULTS AND DISCUSSION

Chemical composition, pH values, minerals and microbial load of fresh and processed cauliflower

The proximate chemical composition, pH value, minerals and microbial load of fresh and processed cauliflower (dehydrated powder (DCP) and steamed) was shown in Table (1). It could be noticed that the drying of cauliflower led to significant reduction in moisture content and significant increase in dry mater which recorded 8.18 and 91.82%, respectively. While steaming of cauliflower led to significant increase in moisture content (93.84%) and significant reduction in dry mater (6.16%) compared with fresh cauliflower (90.45 and 9.55%, respectively). These results were very close to that found by Baloch *et al*. (2015) who reported that moisture and dry mater of fresh cauliflower were 90.62 and 9.38%, respectively meanwhile 9.99 and 90.01%, respectively in DCP. Also, Abou-Taleb (2015) found that steamed cauliflower contained 93.52% moisture content and 6.71% dry mater. Crude protein content of cauliflower was reduced significantly as a result of drying and steaming; it was 21.83% for fresh cauliflower and

became 21.18% and 20.97% for dehydrated and steamed, respectively on dry weight basis. This reduction might be due to loss of some proteins during immersion in 1.0% citric acid solution and also during steaming processes as observed by Ahmed and Ali (2013). The highest reduction in protein content was occurred during steaming the cauliflower.

As stated in Table (1), fresh cauliflower generally have low crude ether extract, being 2.73% on dry weight basis. This value was decreased significantly by drying and steaming to 2.66 and 2.50%, respectively. These results are in agreement with those reported by Ahmed and Ali (2013). Similarly both of crude fibers and ash contents of cauliflower were reduced significantly as a result of drying and steaming, the highest loss of crude fibers and ash was recorded for the steamed cauliflower since crude fibers and ash were 10.38 and 10.17% for fresh and became 9.95 and 9.79% for steamed cauliflower, respectively. Significant ($p \leq 0.05$) difference in N-free extract content were observed between fresh, dried and steamed cauliflower which recorded 54.89, 56.17 and 56.79%, respectively on dry weight basis.

The pH values of fresh, dehydrated and steamed cauliflower were 6.70, 5.20 and 6.97, respectively with significant differences between them as shown in Table (1). The reduction of pH in DCP may be due to the reduction of moisture content as a results drying.

Also, no significant ($p \geq 0.05$) difference in energy value was observed between dehydrated and steamed cauliflower, meanwhile significant ($P \leq 0.05$) difference was noted between fresh cauliflower and above mentioned treatments. The energy of fresh, DCP and steamed cauliflower were 331.45, 333.34 and 333.54 Kcal/100g dry matter, respectively (Table 1). The energy value of edible cauliflower is generally low which allows them to be used in low energy diets. These results are agreement with Birgül *et al.*,(2011) who mentioned that Kale (*Brassica oleraceae* L. var. *acephala* DC.) is a low-calorie food and has a high concentration of vitamins(mainly vitamin C, E),micronutrients(iron, zinc and manganese) and macronutrients(calcium and magnesium)

Results in Table (1) showed that fresh cauliflower had the highest content of all minerals. On the other hand the greatest reduction in mineral contents was observed for steamed cauliflower. This might be due to loss of some soluble minerals in water during steaming process. These results agreed well with those reported by Abou-Taleb (2015) who found that mineral contents were decreased from(428.28 to 350.44mg/100g) Na,(191.85 to 175.22 mg/100g) Ca, (3954.93 to33.85 mg/100g) K,(260.42 to 216.26 mg/100g) Mg, (3.03 to 2.16 mg/100g) Fe and(1.26 to 1.14 mg/100g) Zn in fresh to steaming of cauliflower, respectively.

Table1: Chemical composition, pH value, mineral and microbial load of fresh, dehydrated and steamed cauliflower (on dry weight basis)

Items	Fresh*	Dehydrated powder*	Steamed*	LSD
Chemical composition (%) **				
Moisture (%)	90.45b±0.04	8.18c±0.11	93.84a± 0.04	0.14
Dry matter (%)	9.55b±0.4	91.82a±0.11	6.16c±0.04	0.14
Crude protein (%)	21.83a±0.03	21.18b±0.02	20.97c±0.04	0.06
Crude ether extract (%)	2.73a±0.03	2.66b±0.01	2.50c±0.02	0.04
Crude fibers (%)	10.38a±0.02	10.11b±0.02	9.95c±0.01	0.04
Ash (%)	10.17a±0.30	9.88b±0.02	9.79c±0.01	0
N- free extract (NFE)***(%)	54.89c±0.06	56.17b±0.01	56.79a±0.04	0.09
pH values	6.70b±0.10	5.20c±0.10	6.97a±0.05	0.18
Energy value (Kcal /100g dry	331.45b±0.30	333.34a±0.07	333.54a±0.07	0.37
Minerals (mg/100g)				
Na	312.94	300.4	275.32	
Ca	185.5	163.11	155.24	
Mg	304.75	275.75	257.42	
K	3016.04	2849.2	2674.33	
Fe	5.81	5.32	5.07	
Zn	5.39	4.95	4.78	
Microbiology analysis (log cfu/g)				
Total bacterial counts	5.65±0.10	2.52±0.06	2.53±0.05	
Coliform group	ND	ND	ND	
Psychrophilic bacteria counts	ND	ND	ND	
Yeasts & Moulds counts	2.36±0.06	ND	ND	

Means with different letters in the same row imply significant differences at $P \leq 0.05$.

*Mean of three replicates ± SD. **On dry weight bases

***Calculated by difference. ND = Not detected

LSD = Least significant differences at 0.05 % level.

Also, K had the major element (ranged from 2674.33 to 3016.04 mg/100g) in all samples followed by Na and Mg. Meanwhile Zn and Fe were found in trace amounts. These results are in line with the findings of Abou-Taleb (2015).

Also, Table (1) showed that the total bacterial count of fresh cauliflower was higher (5.65 log cfu/g) than of dehydrated (2.52 log cfu/g) and steamed cauliflower (2.53 log cfu/g). While, coliform group bacteria, psychrophilic bacteria and yeasts & moulds of dried and steamed cauliflower were not detected. These results indicated that DCP was safe to be used in the processing to produce fish burger.

Dietary fibers, total phenolic compounds, flavonoid content (mg/100g) and antioxidant activity (%) of fresh and processed cauliflower

Dietary fibers fractions which including neutral detergent fibers (NDF %), acid detergent fibers (ADF %) and hemicellulose (NDF %- ADF%) of fresh, dehydrated and steamed cauliflower were presented in Table(2). From these data it could be noticed that, drying and steaming process of cauliflower led to significant decrease ($p \leq 0.05$) both of NDF (30.32and 29.22%) and ADF (19.24 AND 17.33%), respectively and significant increase of hemicellulose (NDF-ADF) values (11.08 and 11.89%), respectively compared with fresh cauliflower which recorded 31.26% NDF, 20.85% ADF and 10.41% hemicellulose. Generally these results are in agreement with those obtained by Abou-Taleb (2015) who concluded that cauliflower was rich in dietary fibers that have braver health benefits.

From data in Table(2), it could be noticed that the drying and steaming process caused significant decrement in total phenolic, total flavonoids contents and antioxidant activity when compared with fresh cauliflower. The highest contents of total phenolic and flavonoids were found in fresh cauliflower (1074.29 and 197.34 mg/100), respectively followed by DCP (756.26 and 155.83 mg/100g), respectively, while steamed cauliflower had the lowest values (620.40 and 136.54mg/100g), respectively on dry weight basis. These results agreed well with those reported by Ahmed and Ali (2013) who found that total phenolic and total flavonoids contents were decreased from 782.43 and 267mg/100g in fresh cauliflower to 645.25 and 208.48mg/100g, respectively by steaming of cauliflower. Also, Miean and Mohamed (2001) found that broccoli, cauliflower, cabbage, Chinese cabbage, and kailan contained between 148 and 219 mg/kg flavonoids. Data in Table (2) revealed that fresh cauliflower had significantly higher antioxidant activity (69.34%) than that of dehydrated and steamed cauliflower (54.67 and 43.55%), respectively**.** Finally, from the previous results, there was negative effect ($p \leq 0.05$) of processing methods on total phenolic, total flavonoids contents and antioxidant activity. However, drying method had lower reduction in above mentioned parameters than steaming method. These results confirmed the possibility of using fresh, steamed cauliflower and its dehydrated powder as an antioxidant source.

Chemical composition, pH value, minerals and microbial load of tuna flesh.

Fresh tuna flesh contained 71.09% moisture on wet weight basis, 85.51% crude protein, 7.47% lipid, 4.84% ash and 2.18% N- free extracts content on dry weight basis. The pH value of flesh fresh tuna was 6.70 as shown in Table (3). These results are in line with the findings of Peng *et al.,(*2013) found that Yellow fin tuna and Bigeye tuna contained 72.89 and 73.57% moisture, 23.52 and 23.72% crude protein, 1.93and 2.06% lipid and 1.54 and 1.77% ash on wet weight basis. Also, FAO (2005) reported that chemical composition of tuna fish was71% moisture, 4.1% crude fat and 25.2% crude protein on wet weight basis.

Also, from the same Table, it could be noticed that tuna flesh contain high amount of K(1445.86 mg/100g) followed by Mg(433.24 mg/100g), and moderate amount of both Na (144.69 % mg/100g) and Ca(138.36 mg/100g) on dry weight basis, respectively. On the other hand, Fe (64.68 mg/100g) and Zn (5.60 mg/100g) on dry weight basis were found in trace amount compared above mentioned minerals. These results are in line with the findings of FAO (2005) reported that mineral contents of flesh tuna fish ranged from (30-134mg/100g) Na ,(19-502mg/100g) K, (19-502 mg/100g) Ca and (4.5-452 mg/g) Mg, respectively.

Table 2: Dietary fibers content(%), total phenolic compounds, flavonoid contents(mg/100g) and antioxidant activity (%) of fresh, dehydrated and steamed cauliflower on dry weight basis

Component (%)	Fresh *	Dehydrated powder*	Steamed*	LSD
Neutral detergent fibers (NDF)	31.26a±0.00	30.32b±0.02	29.22c±0.02	0.03
Acid detergent fibers (ADF)	20.85a±0.03	19.24b±0.05	17.33c±0.03	0.07
Hemicellulose (NDF-ADF)	10.41c±0.03	11.08b±0.06	11.89a±0.02	0.08
Total phenolic contents (mg /100g DW)**	1074.29a±2.02	756.26b±3.96	620.40c±1.85	5.55
Total flavonoids (mg/ 100 g DW) ***	197.37a±1.95	155.83b±2.41	136.54c±2.30	4.45
Antioxidant activity (%)	69.34a±0.92	54.67b±1.11	43.55c±0.91	1.96

Means with different letters in the same row imply significant differences at $P \leq 0.05$.
*Mean of three replicates ± SD. LSD = Least significant differences at 0.05 % level.
DW: dry weight basis. **Gallic acid equivalent. ***Quercetin equivalent.

Table 3: Chemical composition, pH value, minerals and microbial load of fresh tuna flesh.

Parameters	Value *	
	Fresh weight basis	Dry weight basis
Chemical composition (%)		
Moisture	71.09±0.41	-
Protein	24.72±0.20	85.51±0.70
Lipid	2.16±0.03	7.47±0.22
Ash	1.40±0.03	4.84±0.11
N- free extract (NFE) **	0.63±0.38	2.18±1.32
pH	6.70±0.1	-
Minerals (mg/100g)		
K	417.92	1445.86
Mg	125.25	433.24
Na	41.83	144.69
Ca	40	138.36
Fe	18.7	64.68
Zn	1.62	5.6
Microbial load (log cfu/g)		
Total bacterial count	4.62±0.02	-
Coliform group bacteria	2.25±1.16	-
Psychrophilic count	1.34±0.63	-
Yeasts & moulds counts	2.46 ± 0.46	-

*Mean of three replicates ± SD.
**Calculated by difference. Cfu/g: colony forming unit per gram.

Also Fe and Zn concentrations in the present study were generally in agreement with results by Hussein and Khaled (2014) they found that the levels of Fe and Zn in tuna fish were found in Abu-Qir Bay (13.98 to 19.14mg/100g) and (1.65 to 2.2mg/100g), respectively.

Total bacterial count of fresh tuna flesh was(4.62 log cfu/g) which indicated that raw fish was safe to be used in the processing, since the level of contamination was below the maximum level set by the International Commission on Microbiological Specification for fish, which is 10^7 bacteria/g as mentioned by Ismail *et al.*(2005) and Egyptian standard specification of burger(ESS 1688/2005)(10^5 cfu/g). Also, counts of coliform group, psychrophilic bacteria and yeasts & moulds were 2.25, 1.34 and 2.46 log cfu/g, respectively.

Selection of the best processed cauliflower forrm(dried or steamed) in fish burger preparation.

The obtained results of the preliminary experiments showed that the panelists preferred fish burger containing DCP, in addition to fish burger containing different levels of steamed cauliflower had high cooking loss and shrinkage and less cooking yield when comparing with fish burger containing DCP. Furthermore steamed cauliflower had high moisture content and need to both high freezing energy and wide location to storage while DCP more stable for storage at ambient temperature and microbiological load. Therefore, DCP was used to preparing fish burger in this study.

Proximate chemical composition and mineral contents of different uncooked fish burger

Chemical composition of uncooked fish burger treatments containing different ratios of DCP (0, 3, 6, 9 and 12%) was determined and the results were presented in Table (4). Data revealed that the moisture content was significantly ($P \leq 0.05$) decreased from 65.60% for control sample to 63.74, 61.47, 59.45 and 58.08% by increasing incorporation level of DCP to 3, 6, 9 and 12%, respectively due to lower moisture content in DCP (8.18%) than minced fish (71.09%) as shown in Tables (1 and 3).

Also, replacement of minced fish with different levels of DCP led to decrease the protein content in fish burger treatments and it ranged from 49.21 to 62.53%. Control sample (62.53%) had significantly ($P \leq 0.05$) higher protein content than other fish burgers treatments.

Fat content of different fish burger treatments ranged from 8.55 to 7.11% with no significant differences ($P \geq 0.05$) between fish burger containing 9 and 12% DCP. On the other hand, addition of DCP with different levels to fish burger treatments led to significant increase ($P \leq 0.05$) in both of crude fibers, ash and N-free extract. Crude fiber and ash were significantly increased from 1.45 and 7.30% for control sample to 2.45 and 7.92% for burger containing 3% DCP, 2.90 and 8.04% for burger containing 6% DCP, 3.60 and 8.04% for burger containing 9% DCP and finally 4.10 and 8.30% for burger containing 12% DCP, respectively.

Table 4: Proximate chemical composition and mineral contents of different uncooked fish burger treatments (on dry weight basis)

Component (%)	Treatments					
	Control	**3% DCP**	**6% DCP**	**9% DCP**	**12% DCP**	**LSD**
Chemical composition (%)						
Moisture	$65.60^{a}\pm0.60$	$63.74^{b}\pm0.31$	$61.47^{c}\pm0.15$	$59.45^{d}\pm0.72$	$58.08^{e}\pm0.11$	0.82
Crude protein	$62.53^{a}\pm0.10$	$58.88^{ab}\pm0.10$	$54.99^{c}\pm0.23$	$51.86^{b}\pm0.23$	$49.21^{e}\pm0.20$	0.33
Crude fat	$8.55^{a}\pm0.17$	$8.14^{b}\pm0.13$	$7.68^{c}\pm0.13$	$7.32^{d}\pm0.17$	$7.11^{d}\pm0.13$	0.27
Ash	$7.30^{c}\pm0.19$	$7.92^{b}\pm0.23$	$8.02^{ab}\pm0.15$	$8.04^{ab}\pm0.15$	$8.30^{a}\pm0.17$	0.33
Crude fiber	$1.45^{e}\pm0.21$	$2.45^{d}\pm0.23$	$2.90^{c}\pm0.13$	$3.60^{b}\pm0.13$	$4.10^{a}\pm0.11$	0.3
N-free extract*	$20.17^{e}\pm0.42$	$22.61^{d}\pm0.29$	$26.41^{c}\pm0.26$	$29.18^{b}\pm0.59$	$31.28^{a}\pm0.52$	0.79
Minerals (mg/100g)						
Na	7039.1	6918.92	6889.49	1564.81	6818.92	
K	1576.28	1559.57	1497.35	1467.74	1513.67	
Mg	551.6	543.98	558.01	566.58	562.38	
Ca	134.59	139.24	144.33	152.35	150.64	
Fe	45	41.73	37.71	34.62	32.13	
Zn	4.8	5.1	5.087	5.18	5.13	

DCP: dehydrated cauliflower powder LSD = Least significant differences at 0.05 % level
Data are expressed as means± standard deviation (n=3). * Calculated by difference.
Means with different letters in the same row imply significant differences at $P\leq 0.05$.

Also, control sample had significantly lower N-free extract (20.17%) than fish burgers containing 3, 6, 9 and 12% DCP which recorded 22.61, 26.41, 29.18 and 31.28%, respectively on dry weight basis. These results are partially agreement with those obtained by Maria (2012) who found that the burgers formulated with 10% flour (wheat, corn and potato) contained 66.36, 66.30 and 66.21% moisture, 3.62%, 3.66 and 3.86% fat, 18.31, 16.40 and 16.97% protein and 1.99, 2.06 and 2.07% ash, respectively on fresh weight basis.

Also**,** data in Table (4) indicated that the addition of DCP to fish burger led to increase Mg, Ca and Zn contents except Na, K and Fe content which showed decrement. The mineral contents of different fish burger treatments ranged from 6818.92 to 7039.10 mg/100g Na, 1513.67 to 1576.28 mg/100g K, 543.98 to 551.60 mg/100g Mg, 134.59 to 152.35 mg/100g Ca, 23.13 to 45 mg/100g Fe and 4.80 to 5.18 mg/100g Zn, respectively. High level of Na content in each fish burger treatments might be due to salt addition with 2% during manufacturing process. However, the studied fish burger still considered as a good source for minerals needed for human.

Total phenols, total flavonoids and antioxidant activity of different fish burger treatments immediately after processing

Total phenols, total flavonoids content and antioxidant activity of fish burger treatments to both control sample and samples containing DCP at different levels (3,6, 9 and 12%) are graphically illustrated in Figs (1, 2 and 3). In general, total phenols, total flavonoids and antioxidant activity of fish burger treatments were increased by increasing DCP levels. From Fig (1), it could be noticed that, the lowest total phenols content (52.55 mg/100g) was recorded for control sample, this value increased to 85.40, 115.43, 137.06 and 154.73 mg/100g by increasing incorporation level of DCP to 3, 6, 9 and 12%, respectively.

Flavonoids possess strong antioxidant activity and inhibit oxidative stress (Souci *et al*., 1994). Total flavonoids content was also increased by increasing incorporation levels of DCP in fish burger whereas 9% and 12% DCP had higher flavonoids content (50.13 and 55.31 mg/100g, respectively) than fish burger containing 3 and 6% DCP (35.63 and 40.06 mg/100g, respectively) or control sample which recorded low value of flavonoids content (30.65 mg/100g) as shown in Fig (2).

Antioxidant activity in burgers containing 9 and 12% DCP recorded high percentage which were 48.74% and 48.87, respectively followed by burgers containing 6 and 3% DCP(47.89 and 46.52%, respectively), while the lowest percentage(40.52%) was recorded for control burger(Fig 3). In this concern, Yen *et al.* (1993) reported that phenolic compounds are associated with antioxidant activity and play an important role in stabilizing lipid peroxidation.

Technological characteristics of different fish burger treatments during storage period up to 4 months at -18^{o}C

Table (5) showed the changes of shrinkage, cooking loss and cooking yield (%) in different fish burger treatments during the period of frozen storage. Statistical analysis of these data indicated that the above mentioned parameters were affected ($p\leq0.05$) not only by addition of DCP and its level but also by storage period. Control sample had

significantly higher shrinking and cooking loss than other samples containing DCP this might be due to DCP is able to bind water and fat, consequently improved the cooking loss and shrinking. These results are in line with those reported by Metwalli (2005) who found that shrinkage of beef burger decreased with adding soy bean hull fibers. Similar results were obtained by Bessar(2008**)** who reported that, the reduction of shrinkage in beef burgers increased as a result of increasing orange and apple peels levels.

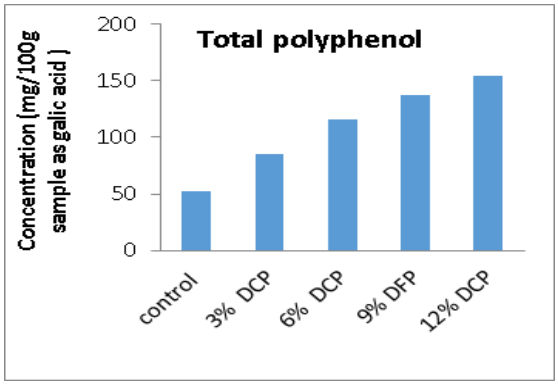

Figure 1: Total phenolic content of different formulations fish burger.

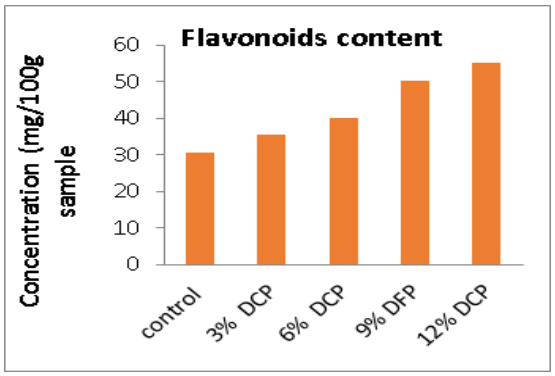

Figure 2: Total Flavonoids of different formulations fish burger.

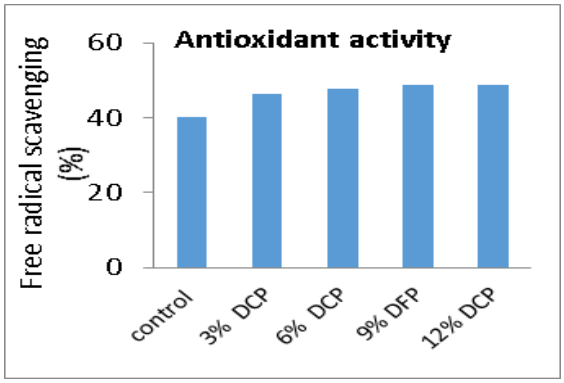

Figure 3: Antioxidant activity of different formulation fish burger.

Table 5: Technological characteristics of different fish burger treatments during storage period at -18°C up to 4 months

Treatments	Storage period (month)					Mean
	0	1	2	3	4	
			Shrinkage *(%)			
Control	13.26±0.34	14.26±0.21	15.08±0.18	16.03±0.16	16.85±0.10	15.11 ^{A}
3% DCP	11.29±0.05	12.48±0.037	13.29±0.17	13.78±0.20	14.34±0.08	13.04 ^{B}
6% DCP	10.38±0.09	11.35±0.20	11.79±0.24	12.36±0.08	12.72±0.18	11.74 ^{C}
9% DCP	9.27±0.21	10.25±0.12	10.91±0.10	11.33±0.26	11.50±0.05	10.28 ^{D}
12% DCP	8.36±0.21	9.14±0.06	9.75±0.17	10.22±0.17	10.69±0.16	9.75 ^{E}
Mean	10.33 ^{e}	11.42 ^{d}	12.18 ^{c}	12.78 ^{b}	13.22 ^{a}	LSD=0.12
			Cooking loss *(%)			
Control	26.27±0.08	26.64±0.10	27.20±0.06	28.76±0.04	29.33±0.12	27.64^{A}
3% DCP	22.55±0.10	22.85±0.08	23.19±0.09	24.28±0.55	24.97±0.11	23.57^{B}
6% DCP	19.10±0.08	19.49±0.05	20.76±0.02	21.25±0.06	21.29±0.12	20.38^{C}
9% DCP	16.79±0.05	17.04±0.82	17.34±0.06	17.88±0.43	18.24±0.06	17.46^{D}
12% DCP	14.83±0.04	15.19±0.15	15.53±0.20	15.92±0.22	16.73±0.17	15.64^{E}
Mean	19.90^{e}	20.24^{d}	20.80^{c}	21.68^{b}	22.11^{a}	LSD=0.097
			Cooking yield* (%)			
Control	73.73±0.08	73.35±0.09	72.80±0.06	71.24±0.04	70.67±0.11	72.36^{E}
3% DCP	77.45±0.10	77.15±0.08	76.81±0.90	75.72±0.07	75.03±0.02	76.43^{D}
6% DCP	80.90±0.08	80.51±0.05	79.24±0.02	78.75±0.06	78.71±0.11	79.62^{C}
9% DCP	83.20±0.05	82.96±0.08	82.66±0.06	82.12±0.43	81.76±0.06	82.54^{B}
12% DCP	85.17±0.04	84.81±0.14	84.47±0.19	84.08±0.22	83.27±0.17	84.36^{A}
Mean	80.09^{a}	79.76^{b}	79.19^{c}	78.38^{d}	77.89^{e}	LSD=0.097

DCP: dehydrated cauliflower powder LSD = Least significant differences at 0.05 % level

*Data are expressed as means± standard deviation (n=3).

**Means with different superscripts in a raw or column are significantly different at p≤0.05 level.

Also, data in Table(5) indicated that, cooking yield was increased ($p\leq0.05$) by increasing ratio of DCP in burger treatments and gradually decreased ($p\leq0.05$) during storage period but the rate of decrement was lower in DCP treatments than control sample. The mean of cooking yield was increased significantly from 72.36% for control sample to76.43, 79.62, 82.54 and 84.36 for burger treatments containing 3, 6, 9 and 12% DCP, respectively. These results were in line with Hassaballa *et al.* (2009) who found that addition of cauliflower fiber improved the cooking yield of beef burger. The decrement of cooking yield during storage might be due to protein denaturation and loss of protein solubility which decrease water holding capacity consequently increase moisture loss during cooking(Osheba *et al.*, 2013).

Physicochemical quality characteristics of different fish burger treatments during frozen storage at -18ºC

The changes in pH values of different fish burger treatments during frozen storage were presented in Table (6). The mean of pH values decreased significantly ($P\leq0.05$) to 6.60, 6.51, 6.46, 6.45 with increasing the ratio of DCP were 3,6,9 and 12%, respectively compared with control sample (6.68), while the mean of pH values increased significantly ($P\leq0.05$) during frozen storage period except for second and third month showed no significant difference ($P\geq0.05$) between them. The obtained results similar to those obtained by Bett and Dionigi (1997) They reported that, decomposition of nitrogenous components in post mortem period causes to increase in pH in fish flesh. The increment of pH values during storage could be associated with the production of basic components induced by the growth of bacteria (Simeonidou *et al.*, 1998).

Results in Table (6) indicated that all fish burger treatments under study were at the acceptance limit of quality. Also, these results showed that, burgers containing DCP had significantly lower TBA value than control sample; this may be related to the effect of polyphenols and flavonoids as antioxidant compounds in DCP. TBA values in all samples were increased significantly ($P\leq0.05$) as frozen storage time increased, this may be result of interaction of decomposition products of proteins with malondialdehyde and formation of tertiary products (Hernández -Herrero *et al*., 1999). In general this value of TBA is below the maximum level of 4 mg malondialdehyde /kg reported in literature for the development of rancid taste (Scott *et al*., 1992). Thus, this result implies that rancidity would not be a problem to the quality of the product.

Table 6: Physiochemical quality index of different fish burger treatments during frozen storage at-18ºC

Treatments	Storage period (month)					Mean treatment**
	0	1	2	3	4	
			pH*			
Control	6.56±0.05	6.63±0.05	6.70±0.10	6.73±0.06	6.76±0.06	6.68^{A}
3% DCP	6.40±0.05	6.50±0.06	6.63±0.06	6.66±0.06	6.73±0.06	6.60^{B}
6% DCP	6.40±0.10	6.43±0.06	6.53±0.06	6.6±0.06	6.63±0.06	6.51^{C}
9% DCP	6.37±0.06	6.43±0.06	6.46±0.06	6.46±0.06	6.56±0.06	6.46^{D}
12% DCP	6.37±0.06	6.43±0.06	6.43±0.06	6.47±0.06	6.53±0.06	6.45^{D}
Mean Time	6.42^{d}	6.49^{c}	6.55^{b}	6.58^{b}	6.64^{a}	LSD=0.046
			TBA*(mg/kg)			
Control	0.57±0.01	0.88±0.03	1.15±0.06	2.27±0.03	3.15±0.06	1.61^{A}
3% DCP	0.52± 0.01	0.68±0.03	0.77±0.40	1.54±0.11	2.53±0.07	1.21^{B}
6% DCP	0.49±0.00	0.57±0.02	0.73±0.00	1.28±0.03	2.29±0.05	1.07^{C}
9% DCP	0.47±0.01	0.56±0.01	0.72±0.00	1.11±0.04	1.97±0.11	0.97^{D}
12% DCP	0.44±0.01	0.53±0.01	0.71±0.00	0.98±0.01	1.83±0.10	0.89^{E}
Mean Time	0.50^{e}	0.64^{d}	0.77^{c}	1.44^{b}	2.34^{a}	LSD=0.033
			TVB-N *(mgN/100g)			
Control	10.47±0.31	12.23±0.12	13.80±0.05	15.45±0.16	17.67±0.11	13.93^{A}
Control	10.13±0.12	10.72±0.09	11.20±0.13	13.23±0.13	15.43±0.26	12.14^{B}
3% DCP	9.88±0.07	10.31±0.05	10.63±0.09	12.36±0.09	14.64±0.42	11.56^{C}
6% DCP	9.67±0.07	10.15±0.03	10.38±0.02	11.65±0.12	13.38±0.10	11.05^{D}
9% DCP	9.50±0.07	9.43±0.54	10.14±0.06	11.42±0.08	12.78±0.12	10.65^{E}
Mean Time**	9.93^{e}	10.57^{d}	11.23^{c}	12.82^{b}	14.78^{a}	LSD=0.133

DCP: dehydrated cauliflower powder

*Data are expressed as means± standard deviation (n=3).

** Means with different superscripts in a raw or column are significantly different at $p\leq0.05$ level.

The results in Table(6) revealed that the mean values of TVB-N in control sample and other burger treatments prepared with 3, 6, 9 and 12% DCP significantly increased (P≤0.05) by increasing storage time. On the other hand TVB-N value significantly decreased (P≤0.05) as a function of increasing ratio of DCP from 3 to 12 %. Control sample had significantly higher TVB-N value than other samples. Similar results were obtained by Ninan *et al.*(2010) observed significant increase in TVBN during the frozen storage of fish cutlet prepared from tilapia fish. Also, Pandey and Kulkarni(2007) observed a significant increase in the TVBN value of grass carp fish cutlet and fish finger during the frozen storage for 6 months.

Microbiological evaluation

Microbial load represented in total bacterial count(TBC), coliform group bacteria, psychrophilic bacteria and yeasts & moulds count(cfu/gm) of fish burger treatments as affected not only by addition of DCP and its level but also by storage period shown in Table(7).

Total bacterial count is considered a quality indicator for food samples meanwhile there is no correlation between it and the presence of pathogenic microorganisms (Arvanitoyannis *et al.*, 2005).The total bacterial count of fish burger treatments was decreased by increasing ratio of DCP which recorded 4.93, 4.85, 4.73, 4.69 and 4.66 log cfu/g for samples containing 0, 3, 6, 9 and 12% DCP, respectively immediately after processing. Slight decreased in total bacterial count was observed during frozen storage period in all treatments. Generally, TBC of all fish burgers at any time of storage did not exceed the maximum limits (7 log cfu/g) of microbiological criteria for fresh and frozen fish as given by the ICMSF (1978).

As shown in Table (7), the initial load of coliform group bacteria in fish burger containing 3, 6, 9, 12 % DCP were 2.56, 2.51, 2.45 and 2.53 log cfu/g, respectively compared with control sample (2.54 log cfu/g), these results indicated that further contamination during processing could be limited. Due to their sensitivity to freezing, frozen storage reduced coliform load. At the third month of storage period, coliform numbers decreased to 1.90, 1.80, 1.77 and 1.77 log cfu/ g in fish burgers containing 3, 6, 9 and 12% DCP, respectively compared with control sample (1.98 log cfu/g), while at the end of storage period coliform group bacteria was not detected in all treatments. These results are in agreement with those obtained by Ahmadi *et al*. (2010). Also, counts of coliform bacteria in all treatments not exceed the maximum level for coliform group in fish products (400cfu/g) as reported by ICMSF (1978).

Table7: Microbiological evaluation of different fish burger treatments during frozen storage at -18ºC

Treatments	Storage period (month)				
	0	1	2	3	4
Total bacterial count *(log cfu/g)					
Control	4.93±0.04	4.65±0.08	4.47±0.06	4.30±0.02	4.22±0.03
3% DCP	4.85±0.02	4.55±0.05	4.34±0.09	4.20±0.07	3.84±0.09
6% DCP	4.73±0.02	4.54±0.06	4.30±0.02	4.17±0.11	3.76±0.19
9% DCP	4.69±0.06	4.50±0.03	4.17±0.11	4.01±0.09	3.63±0.07
12% DCP	4.66±0.05	4.47±0.06	3.93±0.01	3.79±0.01	3.58±0.19
Coliform group bacteria*(log cfu/g)					
Control	2.54±0.06	2.43±0.02	2.11±0.03	1.98±0.02	N.D
3% DCP	2.56±0.01	2.34±0.05	2.10±0.04	1.90±0.05	N.D
6% DCP	2.51±0.03	2.34±0.011	2.10±0.04	1.8±0.06	N.D
9% DCP	2.45±0.01	2.27±0.01	2.04±0.03	1.77±0.07	N.D
12% DCP	2.53±0.01	2.22±0.04	2.01±0.02	1.77±0.07	N.D
Psychrophilic bacteria *(log cfu/g)					
Control	3.16±0.02	2.98±0.02	2.80±0.02	N.D	N.D
3% DCP	3.12±0.02	2.77±0.07	2.57±0.04	N.D	N.D
6% DCP	3.04±0.04	2.73±0.04	2.56±0.05	N.D	N.D
9% DCP	3.08±0.004	2.72±0.03	2.51±0.04	N.D	N.D
12% DCP	3.13±0.04	2.66±0.08	2.49±0.1	N.D	N.D
Yeasts & moulds counts *(log cfu/g)					
Control	2.38±0.044	2.26±0.01	2.14±0.03	2.06±0.02	2.04±0.04
3% DCP	2.37±0.03	2.13±0.04	2.01±0.02	N.D	N.D
6% DCP	2.38±0.02	2.10±0.04	2.00±0.0	N.D	N.D
9% DCP	2.39±0.03	2.01±0.02	2.00±0.00	N.D	N.D
12% DCP	2.36±0.04	2.09±0.02	2.00±00	N.D	N.D

DCP: dehydrated cauliflower powder

*Data are expressed as means± standard deviation (n=3). ND=Not detected

The initial counts of psychrophilic bacteria ranged from 3.04 to 3.16 log cfu/g for all fish burger treatments. By advancement of frozen storage period, the counts of psychrophilic bacteria were decreased until the second month while no growth was observed during the third and the fourth month. These results are in agreement with those reported by Ahmadi *et al.* (2010). A proposed limit of psychrophilic bacteria is 10^3 to 10^4 cfu/g which is consistent with others studies (Pons-Sanchez-Cascado *et al.*, 2006).

The result in Table(7) indicated that the yeasts & moulds counts were decreased during frozen storage until the second month in all treatments while no growth was observed during the third and the fourth month except control sample which recorded 2.06 and 2.04 log cfu/g, respectively. Generally, the rapid reduction in microbial load could be explained due to the ability of DCP to destroy microorganisms due to its containing some phenolic and flavonoids compounds which have powerful antimicrobial effect.(Sanz-Puig *et al.*, 2014).

After cooking, the total bacterial count of all samples was less than 30 cfu/g, meanwhile, coliform group, psychrophilic and yeasts & moulds were not detected within 4 months of storage(data not shown) this indicating that the cooked products were microbiologically safe and stable(ISIRI, 2007).

Texture Profile Analysis (TPA) of cooked fish burger treatments as affected by incorporation levels of DCP and storage period

Figs (4) showed the texture attributes (firmness, cohesiveness, gumminess, chewiness and springiness) of different cooked fish burger treatments during frozen storage periods. Results in Fig (4) indicated that firmness of cooked fish burger treatments decreased by increasing replacement of minced fish with DCP which decreased from 47.26 for control to 28.88, 26.38, 23.58 and 18.38 for 3, 6, 9, and 12% DCP, respectively at zero time of storage. On the other hand, firmness values were decreased during storage period whereas the highest reduction rate was recorded for control compared with all treated samples.

Similar trend was also recorded for both gumminess and chewiness(Fig 4). Addition of DCP into fish burger reduces the gumminess and chewiness attributes.

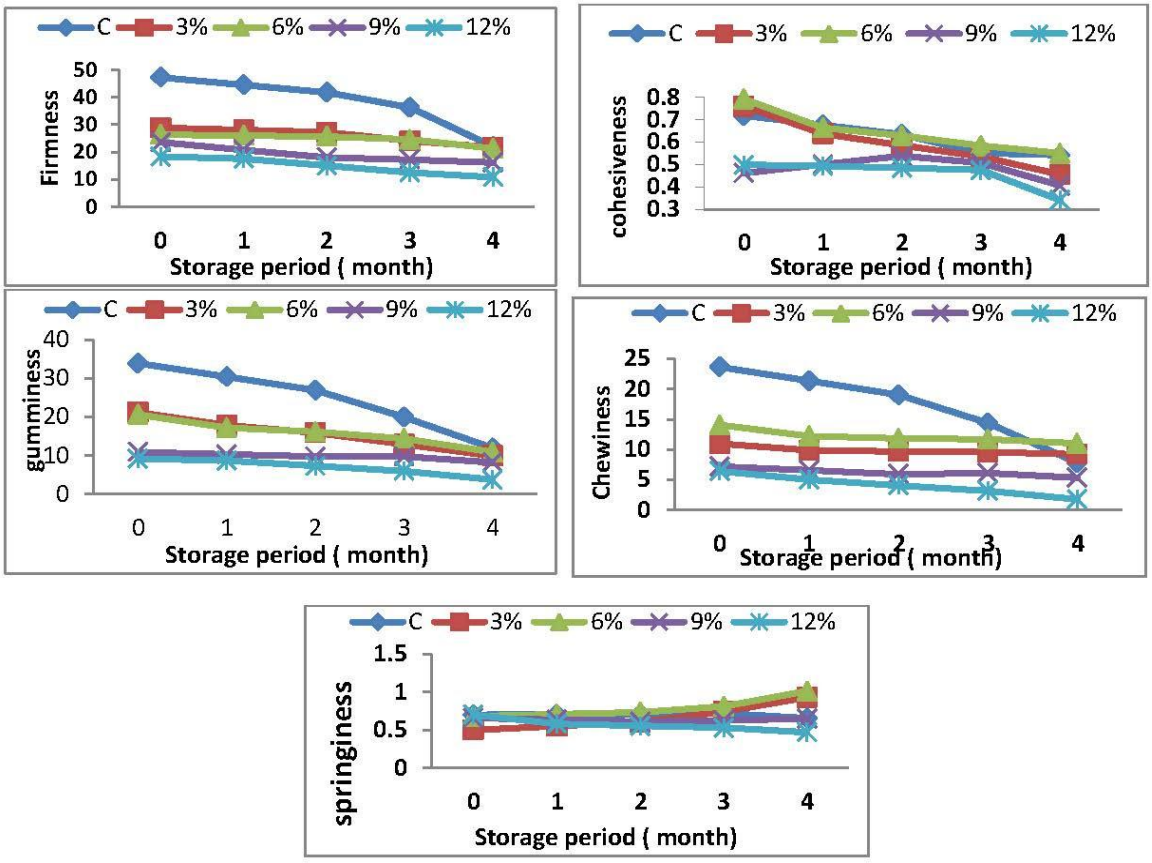

Figure 4: Changes of rheological parameters of cooked treatments fish burger with different ratio of DCP during storage period at -18 ºC.

Fish burgers containing 3, 6, 9 and 12% DCP had lower gumminess (21.192, 20.62, 10.884 and 9.177, respectively) and chewiness (10.96, 14.042, 7.182 and 6.433, respectively) than control sample(33.895 and 23.65, respectively) at zero time of storage. Moreover, the gumminess and chewiness of all samples were decreased with advancement of storage time. Control sample had the highest reduction rates of both gumminess and chewiness compared with other treated samples.

Result in Fig (4) showed that the cohesiveness was increased by increasing DCP levels until 6%, which recorded 0.717, 0.759 and 0.792 for 0, 3 and 6% DCP, respectively then decreased by increasing DCP levels to 9 and 12 % which recorded 0.462 and 0.499, respectively at zero time. The cohesiveness of fish burger containing (0, 3, and 6 % DCP) decreased by increasing storage period but the cohesiveness in fish burger containing 9 and 12% DCP slightly increased up to the second month and then decreased until the end of storage.

The highest springiness value (0.701) was recorded for sample containing 12% DCP followed by control sample (0.698), while the lowest springiness value was found in sample contained 3% DCP (0.50) as shown in Fig (4). On the other hand, the springiness attribute of samples containing 3 and 6 % DCP increased by increasing time storage while this attribute in sample containing 12%DCP was decreased. The springiness values in sample containing 9% DCP were nearly stable during storage period.

Table 8: Organoleptic evaluation during storage period at-18 ^{o}C.

Treatments	Storage period (month)					Mean treatment**
	0	1	2	3	4	
Colour*						
Control	6.50±0.71	6.70±0.67	6.70±0.95	7.00±0.94	6.6±0.70	6.70^{C}
3% DCP	7.20±0.92	7.50±0.85	7.70±1.05	7.30±0.95	7.10±0.87	7.36^{AB}
6% DCP	7.40±0.70	7.70±0.82	7.5±0.70	7.80±0.92	7.00±0.47	7.48^{A}
9% DCP	7.50±0.85	7.60±0.70	7.50±0.52	7.70±0.95	7.40±0.70	7.54^{A}
12% DCP	6.90±1.00	7.10±0.88	7.50±0.85	7.30±0.94	6.90±0.88	7.14^{B}
Mean time	7.10^{ab}	7.32^{ab}	7.38^{a}	7.42^{a}	7.00^{b}	LSD=0.33
Odour*						
Control	6.70±0.67	6.90±0.56	7.10±0.74	7.20±0.52	6.90±0.56	6.96^{C}
3% DCP	7.50±0.52	7.60±1.00	7.70±0.67	8.00±0.82	7.5±0.85	7.66^{A}
6% DCP	7.70±0.48	7.8±0.56	7.80±0.47	8.20±0.63	7.60±0.52	7.76^{A}
9% DCP	7.70±0.32	7.9±0.85	7.9±0.92	7.9±0.70	7.6±0.94	7.78^{A}
12% DCP	7.1±0.74	7.2±0.79	7.4±0..70	7.6±0.52	6.80±0.63	7.22^{B}
Mean time	7.34^{bc}	7.48^{abc}	7.58^{ab}	7.70^{a}	7.28^{c}	LSD=0.26
Taste*						
Control	6.60±0.52	6.80±0.59	7.00±0.48	6.70±0.47	6.60±0.52	6.72^{B}
3% DCP	7.30±0.48	7.60±8.5	7.40±0.75	7.80±0.70	7.50±0.53	7.52^{A}
6% DCP	7.70±0.85	7.80±0.97	8.00±0.69	7.50±1.03	7.30±1.17	7.66^{A}
9% DCP	7.50±0.67	7.60±0.53	7.80±0.63	7.60±0.66	7.40±0.67	7.58^{A}
12% DCP	6.60±0.74	6.70±0.47	7.00±0.87	6.7±0.48	6.60±0.63	6.72^{B}
Mean time	7.14^{b}	7.28^{ab}	7.44^{a}	7.26^{ab}	7.08^{b}	LSD=0.27
Texture*						
Control	6.30±0.48	6.40±0.52	6.60±0.70	6.40±0.70	6.30±0.48	6.40^{C}
3% DCP	7.10±0.88	7.30±0.94	7.10±0.99	7.50±1.18	7.20±0.78	7.24^{B}
6% DCP	7.30±0.48	7.70±0.48	7.90±0.56	7.90±0.32	7.60±0.70	7.68^{A}
9% DCP	7.60±0.52	7.80±0.63	7.80±0.79	7.90±0.56	7.50±0.52	7.72^{A}
12% DCP	6.90±0.99	7.10±0.87	7.3±0.95	7.5±0.85	6.90±0.88	7.14^{B}
Mean time	7.04^{c}	7.26^{abc}	7.34^{ab}	7.44^{a}	7.10^{bc}	LSD=0.29
Overall acceptability*						
Control	6.80±0.79	6.90±0.88	7.00±0.81	7.1±0.87	6.7±0.82	6.90^{B}
3% DCP	7.30±0.67	7.5±0.95	7.60±0.97	7.80±0.92	7.30±0.67	7.50^{A}
6% DCP	7.40±0.84	7.40±0.70	7.80±0.79	7.60±0.84	7.50±0.70	7.68^{A}
9% DCP	7.5±0.97	7.70±1.05	7.90±0.88	7.80±1.10	7.5±1.08	7.54^{A}
12% DCP	7.00±0.81	7.10±0.88	7.30±0.87	7.3±0.82	7.10±0.87	7.16^{B}
Mean time**	7.20^{a}	7.32^{a}	7.52^{a}	7.52^{a}	7.22^{a}	LSD=0.34

*Data are expressed as means± standard deviation (n=3).

** Means with different superscripts in a raw or column are significantly different at $p \leq 0.05$ level.

Generally, these results are in agreement with Femenia et al. (1997) they found that, incorporation of stem and floret cauliflower fibers to beef burger model gave a lower hared texture which recorded 0.73 and 0.80 N, respectively than control which recorded 1.06 N. Firmness of products also improved when stem and floret sample were incorporated.

Sensory evaluation

The results in Table (8) showed that the mean scores of sensory characteristics increased with increasing ratio of DCP compared with control. According to the statistical analysis results, there were observed no significant differences ($P \geq 0.05$) in mean scores of colour, odour, taste, texture and overall acceptability between samples containing 6% and 9% DCP also no significant differences ($P \geq 0.05$) in mean scores of taste and overall acceptability between control and sample containing 12% DCP, but a significant difference ($P \leq 0.05$) was observed in mean scores of colour between control sample and other treatments.

The storage period had positive effect on all tested sensory attributes which increased during the three months of storage period then decreased in the fourth month of storage period. The increase of mean scores of sensory characteristics during storage was not significant ($p \geq 0.05$) between 1, 2 and 3 th month of storage period.

Generally, the results of sensory evaluation of fish burger showed that fish burger containing 6% and 9% DCP had better sensory attributes than other treatments, followed by 3 and 12% DCP, while the lowest mean scores was observed in control.

CONCLUSION

It can be revealed that DCP could be used as a successful source of dietary fiber to improve texture attributes, also used as a natural fish preservatives with both antioxidants and antimicrobial activities against food borne pathogens and spoilage organisms, and therefore may be useful in maintaining the fish quality, extending shelf- life of fish products, preventing economic loss and providing the consumer with food containing natural additives, which are considered more healthful than those of synthetic origin.

REFERENCES

Abou-Taleb,A.A.M.A (**2015**). Effect of Some Heat Treatments on nutritional and Heath realated constituents of Broccoli and Cauliflower as functional Foods. Master of Science in Food Science and Technology. Faculty of Agriculture, Alexandria university.

Ahmadi H.; Mohammadi M. and Khaksar, R.(**2010**). Quality assessment of fish burgers from deep flounder (Pseudorhombus elevatus) and brush tooth lizardfish (Saurida undosquamis) during storage at -18ºC. Iranian Journal of Fisheries Sciences. **9**, 111-126.

Ahmed., A., F ., Ali, R. F. M(**2013**). Bioactive Compounds and Antioxidant Activity of Fresh and Processed White Cauliflower. BioMed Research International, 1-9.

Alesson-Carbonell, L., Fermandez-Lopez, J., Perez-Alvarez, J. A. and Kuri, V.(**2005**). Characteristics of beef burger as influenced by various types of lemon albedo. Innovative Food Science Emerging Technology, **6**: 247-255.

AMSA. (**1995**). Research Guidelines for Cookery, Sensory Evaluation and Instrumental Tenderness Measurements of Fresh Beef. American Meat Science Assoc., Chicago, U.S.A.

Anwar, F., Kalsoom, U., Sultana, B., Mushtaq, M., Mehmood, T. and Arshad, H. A.(**2013**). Effect of drying method and extraction solvent on the total phenolics and antioxidant activity of cauliflower(Brassica oleracea L.) extracts. International Journal of Food Research, **20**: 653-659.

AOAC(**2005**). Association of Official Analytical Chemists. 18th edition. Gaithersburg, Maryland, USA.

AOAD(**2009**). Arab Agricultural Statistics Yearbook. Vol. No.(29).

Arvanitoyannis, I.S., Tsitsika, E.V. and Panagiotaki, P.(**2005**). Implementation of quality control methods (physicochemical, microbiological and sensory) in conjunction with multivariate analysis towards fish authenticity. International Journal of Food Science and Technology, **40**: 37-263.

Baloch, A. B., Xia, X., Sheikh, S.A.(**2015**). Proximate and mineral compositions of dried cauliflower(Brassica Oleracea L.) grown in Sindh, Pakistan. Journal of Food and Nutrition Research, 3: 213-219.

Bessar, B. A.(**2008**). Effect of using orange and apple peels as fat replacers on the sensory, physical and nutritional evaluation of beef burgers. Journal of Agricultural Research, **34**: 1035-1055.

Bett, K.L. and Dionigi, C., P.(**1997**).Detecting sea food off-flavors: Limitations of sensory evaluation. Food Technology. **51**: 70-79.

Birgül, V. K., Nurçin, K., Fulya, B.Y., and Asim, Ö.(**2011**). Effects of kale (Brassica oleracea L. var. acephala DC) leaves extracts on the susceptibility of very low and low density lipoproteins to oxidation. Indian Journal of Biochemistry & Biophysics. **48**: 361-364

Bognar, A.(**1998**). Comparative study of frying to the other cooking techniques. Influence on the nutritive value. Grasas y Aceites, **49**: 250-260.

Bourne, M.C.(**2003**). Food Texture and Viscosity: Concept and Measurement. Elsevier Press, New York, London.

ESS. **2005**. Egyptian standard specification. Egyptian standard specification for frozen burger (**1688**). Egyptian organization for standardization and quality control. Egypt.

FAO STAT.(**2004**). "Database," Agricultural Data, http://www .fao.org/home/en/.

FAO. **(2005**). Quality and quality changes in fresh fish. FAO fisheries technical paper - 348, Rome. 195 pp.

Fasuyi, A.O.(**2006**). Nutritional potentials of some tropical vegetable leaf meals. Chemical characterization and functional properties. African Journal of Biotechnology, **5**: 49-53.

Femenia, A., Lefebvre, A. C., Thebaudin, J., Robertson, Y. J. A and Bourgeois, C. M.(**1997**). Physical and sensory properties of model foods supplemented with cauliflower fiber. Journal of food science, **62**: 635- 639.

Goering, H. K. and Van Soest, P.J.(**1970**). Forage Fiber Analysis (apparatus, reagents, prosedures and some applications).USDA Agricultural Handbook No. 379.

Gülcin, I., Mshvildadze, V., Gepdiremen, A. and Elias, R.(**2006**). Screening of antioxidant and antiradical activity of monodesmosides and crude extract from Leontice smirnowii Tuber. Phytomedicine, **20**: 130-134.

Hassaballa, A. Z., Mohamed, G.F., Ibrahim H.M. and Abd-Elmageed, M.A.,(**2009**). Frozen Cooked Catfish Burger "effect of different cooking methods and storage on its quality" . Global Veterinaria, **3**: 216-226.

Hernández-Herrero M., Roig-Sagués A. X., Rodríguez-Jerez J. J. and Mora Ventura M. T.(**1999**). Halotolerant and halophilic histamine-forming bacteria isolated during the ripening of salted anchovies(Engraulis encrasicolus). Journal of Food Protection . **62**: 509–51

Hussein, A. and Azza Khaled., A. (**2014**). Determination of metals in tuna species and bivalves from Alexandria, Egypt. Egyptian Journal of Aquatic Research 40: 9–17.

ICMSF.(**1978**). Microorganisms in foods. The International Commission on Microbiological Specifications for Foods. Vol. 1, Toronto, Canada.

ISIRI.,(**2007**).(Institute of Standards and Industrial Research of Iran) Vinegar—Specifications, Iranian National Standards No. 355(5th revision), Institute of Standards and Industrial Research of Iran

Ismail, M. A., Stefan, K. Hamed, A. and Sultan, A. (**2005**). Evaluating the quality and storage stability of fish burgers during frozen storage. Fisheries Science, **71**: 648–654.

ISO, 4832.(**1991**). General guidance for the enumeration of coliforms-colony count technique. International Organization for Standardization.

ISO,17410.(**2001**). Horizontal method for the enumeration of psychrotrophic microorganisms. International Organization Standardization.

ISO, 8443.(**2003**). Horizontal method for the enumeration of microorganisms-colony count technique at 30ºC. International Organization for Standardization.

Kirk, R.S. and Sawyer, R.(**1991**). Fats and Oils. In: Pearson's Composition and Analysis of Foods, 9th edn. Longman Group Limited, UK p. 641.

Liyana-Pathirana, C. M. and Shahidi, F.(**2006**). Antioxidant properties of commercial soft and hard winter wheats (Triticum aestivum L.) and their milling fractions. Journal of the Science of Food and Agriculture, 86: 477-485.

Lussier, N.(**2010**). Nutritional value of leafy green vegetables, nutritious value- of-leafy-green vs. root vegetables. Accessed on December 16, **2010** Retrieved from http://www.helium.com/items/766413.

Mahmoudzadeh, M., Motallebi, A., Hosseini, H., Khaksar, R., Ahmadi, H., Jenab, E., Shahraz, F. and Kamran, M.(**2010**).Quality changes of fish burgers prepared from deep flounder (*Pseudorhombuselevatus* Ogilby, 1912) with and without coating during frozen storage -18 °C). International Journal of the Science and Technology, **45**: 374-379.

Maria, M.(**2012**). Chemical composition physical and sensory properties of fish burgere prepped from minced muscle of farmed gilthead sea bream (Sparus aurata) using various types of powder. Journal of Animal and Veterinary Advances, 11: 3327-3333.

Maurya, S.and Singh, D.(**2010**). Quantitative analysis of total phenolic content in adhatoda vasica nees extracts. International Journal of Pharm Tech Research. **2 (4)**: 2403 -2406.

Metwalli, A. A.(**2005**).Utilization of some foods for reducing blood cholesterol.Ph.D. thesis, Food Technology Dept., Fac. of Agric., Kafrelsheikh, Tanta Univ., Egypt.

Miean, K. H. and Mohamed, S.(**2001**). Flavonoid (Myricetin, Quercetin, Kaempferol, Luteolinand Apigenin) Content of Edible Tropical Plants, Journal of Agriculture and Food Chemistry, Vol. **49**: 106-112.

Ninan, G., Bindu, J and Joseph, J.(**2010**). Frozen storage studies of value added mince based products from tilapia (Oreochromis mossambicus, Peters 1852). Journal of Food Processing and Preservation, **34**: 255-271.

Osheba, A.S., Hussien, S.A. and El-Dashlouty, A.A.(**2013**). Evaluation of some vegetal colloids on the quality attributes of beef sausage. Advance Journal of Food Science and Technology, **6**: 743-751.

Pandey, B.N and Kulkarni, G.K.(**2007**). Astudy on the deep frozen fish cutlets and fingers prepared from different carp species. Fisheries and Fish Toxicology, 75- 90.

Peng, S., Chen, c., Shi, Z. and Wang, L.(**2013**) Amino Acid and Fatty Acid Composition of the Muscle Tissue of Yellow fin Tuna (Thunnus albacares) and Bigeye Tuna (Thunnus obesus). Journal of Food and Nutrition Research.**1**: 42-45.

Pons-Sanchez-Cascado, S., Vidal-Carou, M.C., Nunes, M.L. and Veciana-Nogues, M.T.(**2006**). Sensory analysis to assess the freshness of Mediterranean anchovies (Engraulis encrasicholus) stored in ice. Food Control, 17: 564–569.

Ramesh, B. and Satakopan, V. N.(**2010**). Invitro antioxidant activities of Ocimum species: Ocimum basilicum and Ocimum sanctum. Journal of Cell and Tissue Culture Research , **10** : 2145-2150.

Ruiz-Capillas, C. and Moral, A. (**2001**). Correlation between biochemical and sensory quality indices in hake srored in ice. Food Research International, **34**: 441-447.

Sanchez-Moreno, C., Larrauri , J.A. and Saura-Calixto, F.(**1999**).Free radical scavenging capacity and inhibition of lipid oxidation of wines, grape juices and related polyphenolic constituents. Food Research International **32**: 407-412.

SAS (**2004**). SAS Institute Inc. SAS/ETS® 9.1 User'SAS Institute Inc. 2004. User's Guide. Cary, NC.

Sanz-Puig, M., Pina-Pérez, M.C., Rodrigo,D. and Martínez-López.,bA.b (**2014**). Antimicrobial activity of cauliflower (Brassica oleracea var. Botrytis) by-product against Listeria monocytogenes. Food Control **10**: 9-31.

Scott, D.N., Fletcher, G.C., Charrles, J.C., Charles, J.C. and Wong, R.J.(**1992**). Spoilage changes in deep water fish, smooth oreo dory during storage in ice. International Journal of Food Science Technology., **27**: 577-588.

Sanz-Puig, M., Pina-Pérez, M.C., Rodrigo,D. and Martínez-López, A. (**2014**). Antimicrobial activity of cauliflower(Brassica oleracea var. Botrytis) by-product against Listeria monocytogenes . Food Control, 798–813.

Simeonidou, S., Govans, A. and Vareltzis, K.(**1998**). Quality assessment of seven Mediterranean fish species during storage on ice. Food Research International, **30**: 479-484.

Souci, S.W., Fachmann, W. and Kraut, H.(**1994**). Food Composition and Nutrition Tables, CRC Press, Medpharm Scientific Publishers, New York, NY, USA, 5th edition.

Suvanich, V., Marshall, D.L. and Jahncke, M.L.(**2000**). Microbiological and color quality changes of channel catfish frame mince during chilled and frozen storage. Journal of Food Science, **65**: 151-154.

Vijayan, P.K.(**1984**). Report on training programme on retort pouch processing of fish and fish analysis at Tropical Development and Research Institute and Metal Box (R & D), UK, Central Institute of Fisheries Technology, Cochin.

Viuda-Martos, M., Ruiz–Navajas, Y., Fernandez–Lopez, J. and Perez Alvarez, J.A.(**2010**). Effect of orange dietary fibre, oregano oil and packaging conditions on shelf-life of bologna sausages. Food Control, **21**: 436- 443.

Yen, G.C., Duh ,P. D. andTsai., C.L.(**1993**). Relationship between antioxidant activity and maturity of peanut hulls. Journal of Agricultural and Food Chemistry. **41**: 67-70.

Zarina, Z. and Tan S. Y.(**2013**). Determination of flavonoids in Citrus grandis (Pomelo) peels and their inhibition activity on lipid peroxidation in fish tissue. International Food Research Journal **20**: 313-317.

الملخص العربي

تأثير اضافة القرنبيط لتحسين خصائص جودة برجر سمك التونه

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اجريت هذه الدراسة بغرض تقييم تأثير العمليات التصنيعية(التجفيف والسلق) على التركيب الكيماوى والمركبات النشطة الموجودة فى القرنبيط ثم استخدام بودر القرنبيط المجفف بنسب(١٢,٩,٦,٣,٠%) فى اعداد برجر سمك التونه كمصدر طبيعى للالياف الغذائية والنشاط المضاد للأكسدة والميكروبات. تم تقييم خصائص برجر السمك خلال فترة التخزين المجمد لمدة اربعة أشهر(– ١٨م°) وقد اظهرت النتائج زيادة نسبة المركبات الفينولية والفلافونيدات والنشاط المضاد للاكسدة بزيادة نسبة اضافة القرنبيط المجفف لبرجرالسمك وحدث تحسن فى الخواص التكنولوجية والميكروبيولوجية. اظهرت ايضا النتائج أن قيم الرقم الهيدروجينى وحامض الثيوبربتيوريك والقواعد النيتروجونية الطيارة والفقد فى الطبخ والانكماش وكذلك الحمل الميكروبى إنخفضت بزيادة نسبة اضافة بودر القرنبيط الى برجر السمك وكان الحمل الميكروبى للبرجر المحتوى على بودر القرنبيط اقل من الحمل الموجود فى البرجر الخالى من القرنبيط. وكذلك اظهرت النتائج ان الحمل الميكروبى للبرجر بعد عملية الطبخ كان اقل من ٣٠ خلية/جرام ولم تظهربه كلا من بكتريا الكوليفورم والبكتريا المحبة للبرودة psychrophilic والخمائر والفطريات وذلك خلال فترة التخزين مجمد لمدة اربعة اشهر كما اظهرت نتائج التقييم الحسى ان برجر السمك المحتوى على بودر القرنبيط كان مقبولا من قبل المحكمين.