Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 25(4): 323 – 335 (2021)
www.ejabf.journals.ekb.eg

Effect of Different Hydrocolloids on the Quality Criteria of Fish Fingers during Frozen Storage

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ARTICLE INFO

Article History:
Received: Aug. 29, 2021
Accepted: Sept. 17, 2021
Online: Oct. 14, 2021

Keywords:
Fish fingers,
Alginate,
Carrageenan,
Hydroxypropyl methylcellulose,
Xanthan,
Chitosan

ABSTRACT

The effect of some hydrocolloids on the quality of common carp fish fingers were evaluated during frozen storage for six months. Sodium alginate (ALG), carrageenan (CGN), hydroxyl propyl methylcellulose (HPMC), xanthan gum (XG), and chitosan (CH) were used as additives (5g/kg) in common carp fish fingers, and the proximate composition and physical, chemical, microbiological, and sensory properties were evaluated at regular intervals in common carp fish fingers. The results showed that, the moisture, protein, lipid, and ash of minced common carp fish samples, raw common carp fish fingers, and pre-fried common carp fish fingers were 75.15, 18.55%, 4.01%, and 4.30; 71.80%, 17.75%, 2.56%, and 5.90%, and 66.29%, 17.30%, 5.95%, and 6.28%, respectively. The changes in chemical composition between fresh common carp fish, fish fingers, and pre-fried fish fingers were found significant ($P< 0.05$). The values of pH, total volatile basic nitrogen, trimethylamine, thibarbituric acid total bacterial count, psychrophilic bacteria, and yeast & molds counts increased significantly during the storage period, but the values were within the acceptable limits. Organoleptic evaluation revealed that, the different added hydrocolloids didn't significantly affect the flavor of common carp fish fingers, while chitosan and carrageenan improved the taste, textures, and appearance of common carp fish fingers significantly in comparison to the control and other trails. In conclusion, different types of fish fingers were acceptable even at the end of the storage period; also, different hydrocolloids were effective in retaining the quality properties of treated fish fingers and showed better performance than the control.

INTRODUCTION

Hydrocolloids confer stability to the products that undergo successive freeze-thaw cycles due to their high water retention capacity **(Lee *et al.*, 2002)**. Hydrocolloids have wide applications in meat and fish products as emulsifying, stabilizing, gilling, thickening and suspending agents. Alginate carboxymethyl-cellulose and konjac are already used in different ready to eat products such as sausages, frunkfurters, and patties **(Jiménez-Colmenero *et al.*, 2010)**. **Da Ponte *et al.* (1985)** used carrageenans and carboxymethyl celluloses as additives (5 g/kg) for frozen minced cod. **Tangestani *et al.* (2010)** studied the sensory properties of three types of silver carp fish fingers. **Izci (2010)** studied the quality of Prussian carp (*Carassius gibelio*) fish fingers. **Hasanpour *et al.* (2012)**

evaluated the effects of 0, 5, and 10% soy protein concentrate and 0, 0.25, and 0.5% xanthan gum soy on physical properties of silver carp surimi during frozen storage at –18ºC for three months. **Jamshidi *et al*. (2012)** studied the effects of xanthan, alginate, CMC, and thawing properties on the quality of silver carp fish fingers. **Shabanpour and Jamshidi (2013)** studied the effects of edible films of xanthan, carrageenan, alginate, soy protein isolate, and hydroxypropyl methylcellulose gums on the quality of fried rainbow trout fillets. **Jamshidi and Shabanpour (2013)** evaluated the impact of hydroxypropyl methylcellulose on the storage conditions and improvement of frozen fish nuggets. **Santana *et al*. (2013)** added carboxymethyl-cellulose, alginate, and konjac to improve the physicochemical properties and sensory characteristics of fish sausage formulated with surimi powder. In addition, **Shaviklo and Fahim (2014)** investigated the effect of pectin, breadcrumbs and soy protein on the quality properties of silver carp fish fingers. On the other hand, **Hauzoukim *et al*. (2019)** found that the incorporation of 1% chitosan compared to alginate and gelatin in the batter formulation of fish fingers led to improve their biochemical properties, oil reduction, and coating characteristics. The aim of the present study was to evaluate the impact of using of sodium alginate, carrageenan, hydroxyl propyl methylcellulose, xanthan gum, and chitosan on the proximate composition, physical, chemical, microbiological, and sensory properties of common carp fish fingers during storage at -18°C for six months.

MATERIALS AND METHODS

Materials

Fish samples

Fresh common carp fish (*Cyprinus carpio*) samples with average weight and length of (2039.13 g and 47.36 cm) were purchased from El-Obor city fish market and immediately brought into Fish Processing and Technology Laboratory, El-Kanater El-Khairia, National Institute of Oceanography and Fisheries within 2 hours using iceboxes. Upon arrival, fish samples were washed, cleaned, beheaded, descaled, gutted, washed carefully again to remove slime and blood, and then filleted. The yield of muscle obtained by hand; manually filleting, was 36.45%. Common carp fish fillets were minced using a kitchen meat mincer with a 3 mm diameter holes plate.

Ingredients and chemicals

Salt, spices, sugar, wheat flour, and edible oils were purchased from Ragab Sons market, Cairo, Egypt. All chemicals used in this study were of analytical grade and were purchased from El-Gomhoria Company for drugs and medical supplies.

Fish finger processing

Fish finger processing from common carp fish samples were carried out according to the **Egyptian Standard Specification (2005)**. Carp fish fingers were processed using 75% minced carp, 2.5% salt, 1% sugar, 8% starch, 9% palm oil, 2.5% onion, 0.5% garlic, 0.40% sodium bicarbonate, 0.30% sodium polyphosphate, and 2% spices mixture consisting of 0.23% cumin, 0.42% black pepper, 5% cardamom, 5% ginger, 2% cloves, 2% cubeb, 2% coriander, and 1% red pepper. A kitchen blender was used for

homogenization of the fish fingers ingredients. The preparation of batter containing different hydrocolloids was done according to the method of **Hauzoukim *et al*. (2019)** using 77.5 g wheat flour, 10 g corn flour, 5 g hydrocolloid (replaced with wheat flour in treatments except control). Hydrocolloid solutions were prepared by dissolving in distilled water, stirring until the solution became clear and then mixed with batter powder and adjusted the ratio with further water. While, chitosan was prepared by dissolving in 0.5% (v/v) acetic acid aqueous solution under continuous stirring at room temperature for 30 min, filtered to remove the insoluble residue, and then the resulting viscous solution was added to the remaining batter mix for making the final coating batter.

Analytical methods

Moisture, protein, lipid, and ash contents of fresh fish and its processed products were determined in triplicate according to the **AOAC's (2000)** methodology**.** Total volatile basic nitrogen (TVB-N) contents were performed according to the method of **Pearson (1976)**. While, the thiobarbituric acid (TBA) value was measured according to the method of **Tarladgis *et al*. (1960)**. The pH value was carried out according to the procedure of **AOAC (2000)**. Microbiological analysis (total bacterial counts, psychrophilic bacteria, and yeasts & molds) of the carp fish finger samples was performed using standard methods of **APHA (2005)**. Sensory evaluation of fish fingers was carried out according to **Fernández-López *et al*. (2006)** by ten trained judges. The statistical analysis was performed according to **Snedecor and Cochran (1980)** using (ANOVA), while the least significant difference procedure was used to test the difference between means significance that was defined at $p<0.05$.

RESULTS and DISCUSSION

Proximate composition

The proximate chemical compositions of both fresh common carp fish and fish fingers are represented in Table (1). The moisture, protein, lipid and ash of minced common carp fish samples, raw common carp fish fingers, and pre-fried common carp fish fingers were 75.15, 18.55%, 4.01%, 2.03; 71.80%, 17.75%, 2.56%, 5.90%; 66.29%, 17.30%, 5.95%, and 6.28%, respectively. The obtained results showed significant differences in chemical composition of fish fingers after frying process. The fat and ash contents showed a significant increase ($P<0.05$), while moisture and protein contents were significantly decreased ($P<0.05$). These results generally are similarto those of **El-Sahn *et al.* (1990**) who found that moisture, protein, lipids and ash of fresh *Atherina mochon* species ranged 71.9-73.1%; 19.0-20.4%; 5.1-5.2%; and 2.4-2.6%, respectively. **Antony *et al.* (1994)** reported that the initial chemical composition of the raw big eye croaker fish fingers before frying recorded 71.16% moisture, 14.82% protein, 4.74% lipid, and 3.80% ash. No significant effect was detected on chemical composition with respect to gums added to fish products **(Hsu & Chiang, 2002)**. On the other hand, **Kalogeropoulos *et al.* (2004)** reported that the moisture, lipids and protein of raw and

pan-fried *A. boyeri* were 766.3 and 571.2 g/kg; 21.1 and 142.3 g/kg; and 172.1 and 208.8 g/kg, respectively. **Cakli *et al.* (2005)** produced fish fingers from *Sardina pilchardus*, *Merlangius merlangus*, and *Sander lucioperca*. They were reported that moisture, protein, lipids, and ash contents of fresh fish samples ranged from 64.47, 82.10, and 82.00 %; 16.04, 15.26, and 16.36%; 18.70, 0.98, and 0.68%; and 1.20, 0.93, and 2.00 %, respectively; while the values of moisture, protein, lipids, and ash of fish fingers showed changed to 52.04, 63.01, and 69.73 %; 16.16, 15.98, and 15.75 %; 14.39, 6.71, and 4.28%; and 61, 3.33, and 2.75 %, respectively. **Izci (2010)** reported that Prussian carp fish fingers contained 56.543±0.113 moisture, 10.507±0.116 lipids, 15.577±0.382 protein, and 2.027±0.133 ash. Moreover, **Izci *et al.* (2011)**depicted a slight decrease in moisture content of processed fish fingers and an increase of fat, protein, and ash. In their research, **Tokur *et al.* (2006)** found that moisture, protein, lipid, and ash of unwashed minced carp fish fingers and washed minced fish were 68.50, 15.5, 6.00, and 2.20%; and 70.23, 10.8, 2.14%, and 1.80%, respectively. The increase in fat content in fried fish finger samples may be due to the absorption of lipids by the processed product. Raw and fried fish fingers contains high amounts of carbohydrates and this may be due to coating substances that contains flour and starch, which considered carbohydrate rich ingredients. This result coincides with that of **Sayar (2001)** who reported that fish fingers contained 15.2% carbohydrate. Additionally, **Tokur *et al.* (2006)** found 7.76% and 15.05% carbohydrate levels in fish fingers.

Table 1. Chemical composition of fresh common carp fish, raw fish fingers, and pre-fried fish fingers

Parameter	Fresh common carp fish mince	Raw common carp fish fingers	Pre-fried common carp fish fingers
Moisture (%)	75.15	71.80	66.29
Protein (%)	18.55	17.75	17.30
Lipids (%)	4.01	2.56	5.95
Ash (%)	2.03	5.90	6.28

Physicochemical analysis

The pH value

The effect of some hydrocolloids on the pH values of common carp fish fingers stored at –18°C is illustrated in Fig. (1). The pH values of the control, the ALG, CGN, HPMC, XG, and CH at zero time were (6.86, 6.60, 6.70, 6.65, 6.80, and 6.75, respectively), while theydecreased significantly after 180 days of frozen storage recording values of(6.20, 6.30, 6.40, 6.25, 6.30, and 6.50, respectively). The current results showed that the control, XG, and CH treatments had the highest amounts of pH values in comparisonto the ALG, CGN, and HPMC treatments at zero time. While, after 180 days of frozen storage, the lowest values of pH were recorded in the control, the

ALG, the HPMC, and the XG treatments, whereas the highest amounts were recorded in CH and CGN, respectively. On the other hand, the pH values were fluctuated till 90 days of storage, then they significantly increased at 120 days, then they decreased again till the end of 180 days of frozen storage. Results showed that, Alginate significantly decreased the pH value of common carp fish fingers followed by HPMC, CGN, CH, and XG. The results were almost similar to other studies of fish fingers. **Ünlüsayin *et al.* (2002)** reported that the pH values of pike perch and tench fish balls were significantly increased at the end of the cold storage period at 4±1°C in comparison to the initial values. In addition, **Tokur *et al.* (2006)** found that the pH values of unwashed and washed minced carp fish fingers were determined as 6.74 ± 0.00 and 6.67 ± 0.06, respectively, at the end of the storage period. Moreover, **Izci *et al.* (2011)** reported that, the pH values of fresh sand smelt fish and its fish fingers were 6.520 ± 0.012 and 6.737 ± 0.012, respectively.

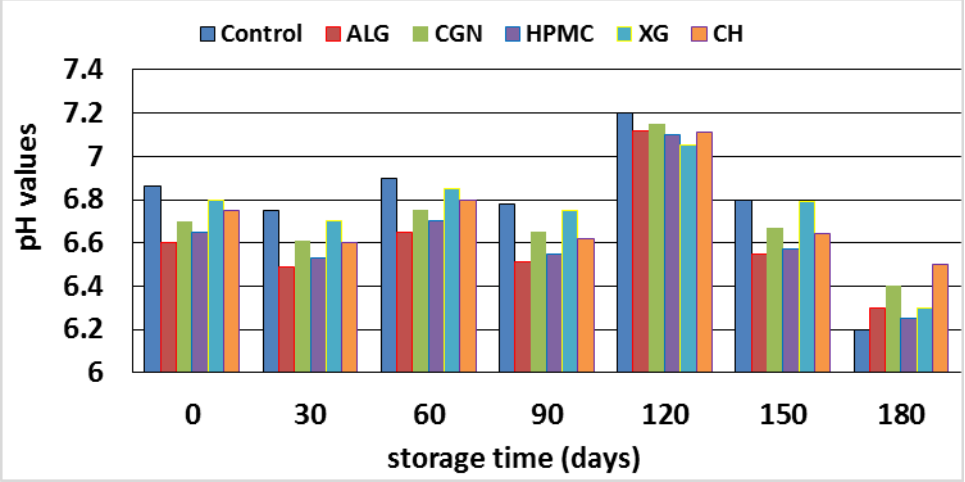

Fig. 1. Effect of some hydrocolloids on pH values of fish fingers during frozen storage

Total Volatile Basic Nitrogen (TVBN)

Fig. (2) shows the effect of some hydrocolloids on TVB-N (mg/100 g) of common carp fish fingers during frozen storage. The TVB-N recorded values of the control, ALG, CGN, HPMC, XG, and CH at zero time were 12.24, 12.44, 12.29, 12.34, and 12.27 mg/100 g, respectively; while theyincreased significantly after 180 days of frozen storage (29.50, 29.50, 27.18, 28.30, 30.28, and 28.15 mg/100 g, respectively). The present results showed that the incorporation of different hydrocolloids didn't affect the TVB-N values significantly at zero time, while after one month of frozen storage, the CH and ALG treatments decreased the TVB-N values significantly in comparison to the recorded values of CGN, XG, and HPMC, respectively. Generally, TVB-N showed a significant increase during the frozen storage of fish fingers. **Antony *et al.* (1994)** found that the TVN values of the big eye croaker fish fingers increased slowly and steadily within limits during the storage period at –18°C, but in the control sample, high values were reached in the 4th week correlating with the sensory evaluation results. **Izci *et al.* (2011)** found that, the initial TVB-N value of sand smelt fish fingers was 17.140 ± 0.289

mg/100 g, and it was significantly increased during storage. The increase in TVBN value of fish fingers during the frozen storage might be due to the formation of ammonia, mono ethylamine, dimethylamine, and trimethylamine as a result of enzymes' actions which led to off-flavors fish characteristics **(Debevere & Boskou, 1996)**. Furthermore, **Ocano-Higuera *et al.* (2011)** claimed that, the increase in the TVB-N levels is attributed to the activity of autolytic enzymes and microbiological activity, which caused oxidation of amines, deamination of free amino acids, and degradation of nucleotides.

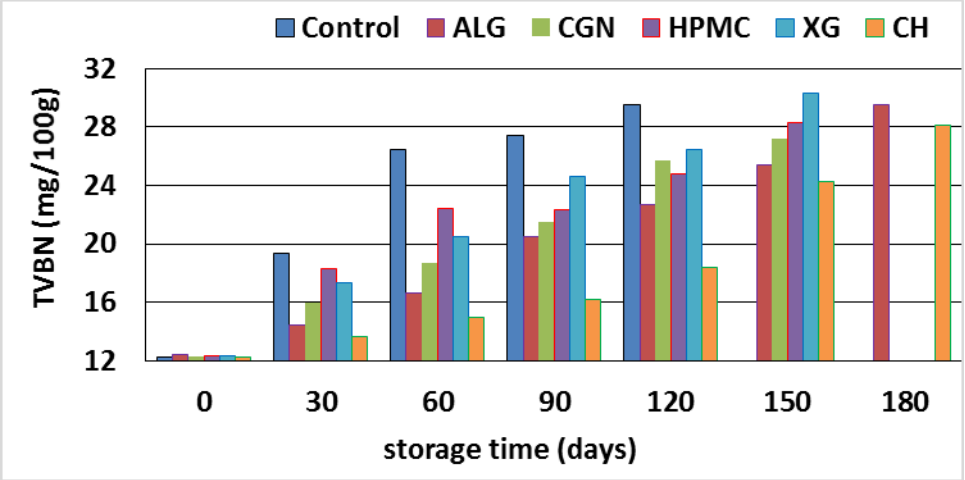

Fig. 2. Effect of some hydrocolloids on TVBN (mg/100 g) values of fish fingers during frozen storage

Trimethylamine (TMA)

The effect of some hydrocolloids on TMA (mg/100 g) of common carp fish fingers during frozen storage is illustrated in Fig. (3). The TMA recorded values of the control, the ALG, CGN, HPMC, XG, and CH at zero time were 0.65, 0.50, 0.45, 0.47, 0.55, and 0.40 mg/100 g, respectively; while theyincreased significantly after 180 days of frozen storage (3.30, 2.60, 2.77, 2.80, 3.00, and 2.42 mg/100 g, respectively). Results showed that the incorporation of different hydrocolloids didn't affectthe TMA values significantly at zero time; while after one month of frozen storage, the CH and ALG treatments witnessed a significant decrease in the TMA values followed by HPMC, CGN, and XG, respectively. Generally, the TMA showed a significant increase during frozen storage of fish fingers. These results are parallel with the values of **Cakli *et al.* (2005)** who found slightly increased TMA values of fish fingers processed from sardine, whiting and pike perch, and stored at –18°C for 8 months.

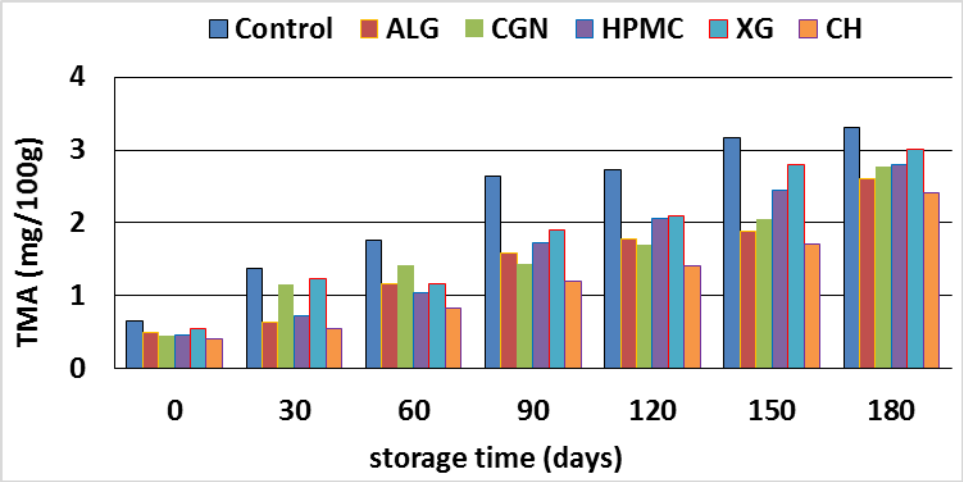

Fig. 3. Effect of some hydrocolloids on TMA (mg/100 g) values of fish fingers during frozen storage

Thiobarbituric acid values (TBA)

The thiobarbituric acid values (mg MDA/kg) of common carp fish fingers as affected by some hydrocolloids during frozen storage are illustrated in Fig. (4).

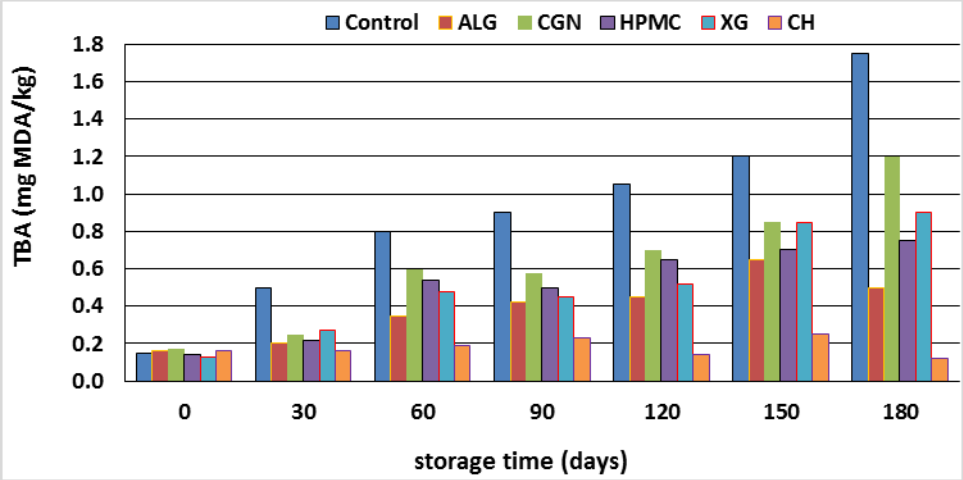

Fig. 4. Effect of some hydrocolloids on TBA (mg MDA/kg) values of fish fingers during frozen storage.

The TBA recorded values of the control, ALG, CGN, HPMC, XG, and CH at zero time were 0.15, 0.16, 0.17, 0.14, 0.13, and 0.16 mg MDA/kg, respectively; while they significantly increased after 180 days of frozen storage (1.75, 0.5, 1.2, 0.75, 0.90, and 0.12 mg MDA/kg, respectively). The results indicated that the incorporation of different hydrocolloids didn't affectthe TBA values significantly at zero time. On the other hand, TBA showed a significant increase during frozen storage of fish fingers in all treatments except for ALG and CH, where values increased and then decreased with prolongation storage periods and was followed with an increase and decrease at the 150 days of

storage, and then decreased till the end of the frozen storage period. The decrease in TBA number in some trials during storage may be due to the retardation of lipid oxidation by the lipid hydrolysis products **(Castell *et al.*, 1966)** and the interaction of malonaldehyde/aldehydes with proteins **(Reddy *et al.*, 1992)**. **Tokur *et al.* (2006)** reported that, the TBA values of the unwashed and washed carp minced fish fingers were 0.27 ± 0.03 and 0.25 ± 0.02 mg MDA/kg, respectively. Moreover, **Izci *et al.* (2011)** claimed that, the recorded TBA value of sand smelt fish finger was 0.293 ± 0.013 µg MDA/g at the end of the storage period after the sixth month.

Microbiological analysis

Total bacterial count

Total bacterial count (log cfu/g) of common carp fish fingers as affected by some hydrocolloids during frozen storageis shown in Fig. (5).

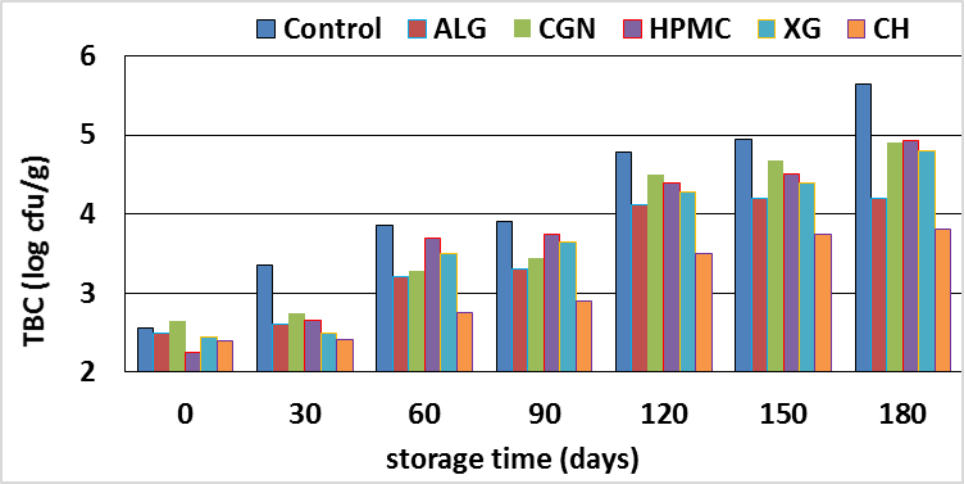

Fig. 5. Effect of some hydrocolloids on TBC (log cfu/g) counts of fish fingers during frozen storage

The TBC recorded values of the control, ALG, CGN, HPMC, XG, and CH at zero time were 2.55, 2.50, 2.65, 2.25, 2.45, and 2.40 log cfu/g, respectively; while they significantly increased after 180 days of the frozen storage period (5.64, 4.20, 4.90, 4.92, 4.80, and 3.80 log cfu/g, respectively). The results indicated that, the incorporation of different hydrocolloids didn't affect TBC counts significantly at zero time. On the other hand, TBC showed a significant increase during the frozen storage of fish fingers in all treatments. In addition, chitosan was more effectivein reducing the TBC counts during the frozen storage of fish fingers followed by XG, ALG, HPMC, and CGN, respectively. The TBC countsdid not exceed the maximum permissible limits set by Egyptian standard specifications and International Commission Specifications for food. Generally, the current results show similarity withthe findingof **Çolakolu *et al.* (2004)** who reported that, the total bacteria counts of *Rutilus rutilus* and *Coregenus sp* fish balls decreased after the frying process. Furthermore, **Çakli *et al.* (2005)** reported that, the total aerobic counts of sardine fingers and whiting fingers pike perch fingers at zero time were 4.61,

4.62, and 4.50 log cfu/g, respectively; while values decreased to reach 4.34, 3.86, and 3.73 log cfu/g at the end of storage, respectively. **Tokur *et al.* (2006)** pointed out that, the total bacteria count did not exceed the permissible limits. On the other hand, results disagree with those of **Reddy *et al*. (1992)** who detected a decrease in the bacterial counts in both fish fingers throughout the storage.

Psychrophilic bacterial count

Psychrophilic bacteria (log cfu/g) of common carp fish fingers as affected by some hydrocolloids during frozen storageare illustrated in Fig. (6). Psychrophilic bacterial recorded counts of the control, ALG, CGN, HPMC, XG, and CH at zero time were 1.55, 1.15, 1.45, 1.35, 1.40, and 1.10 log cfu/g, respectively; while values were significantly increased after 180 days of frozen storage (3.70, 2.25, 2.33, 2.65, 2.80, and 2.12 log cfu/g, respectively). The results indicated that, the incorporation of different hydrocolloids didn't affectthe psychrophilic bacteria counts significantly at zero time. On the other hand, the psychrophilic bacteria showed a significant increase during the frozen storage of fish fingers in all treatments. Moreover, chitosan and alginate were more effective for reducing the counts of psychrophilic bacteria during the frozen storage of fish fingers followed by, XG, ALG, HPMC, and CGN, respectively.

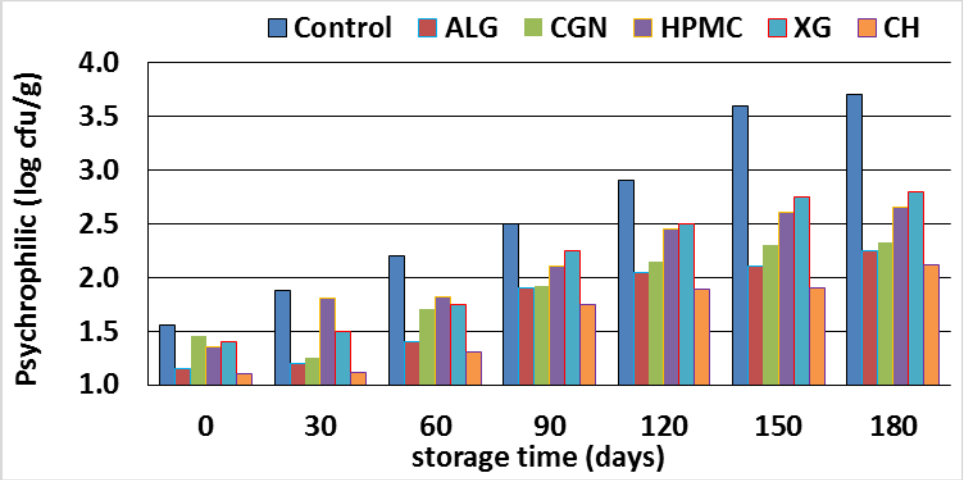

Fig. 6. Effect of some hydrocolloids on psychrophilic bacteria (log cfu/g) counts of fish fingers during frozen storage

Yeasts and molds

Yeasts and molds count (Y&M, log cfu/g) of common carp fish fingers as affected by some hydrocolloids during frozen storageis illustrated in Fig. (7). The Y&M recorded values of the control, ALG, CGN, HPMC, XG, and CH at zero time were 1.25, 1.15, 1.20, 1.15, and 1.10 cfu/g, respectively; while they were significantly increased after 180 days of frozen storage (2.80, 1.90, 2.33, 2.65, 2.70, and 1.78 cfu/g, respectively). The results indicated that, the incorporation of different hydrocolloids didn't affect Y&M counts significantly at zero time. On the other hand, Y&M showed a significant increase during the frozen storage of fish fingers in all treatments.

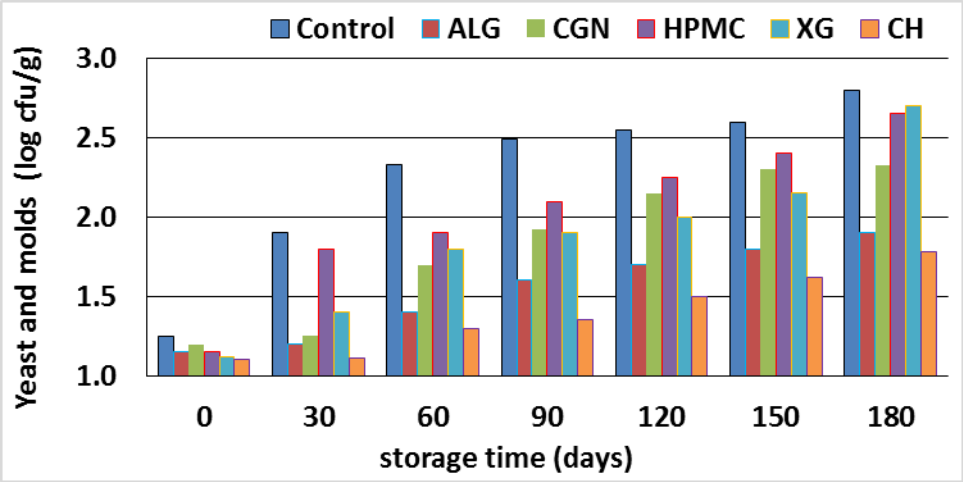

Fig. 7. Effect of some hydrocolloids on yeasts and molds (cfu/g) counts of fish fingers during frozen storage

Sensory evaluation

Sensory evaluation of fish fingers as affected by adding some hydrocolloids is shown in Fig. (8).

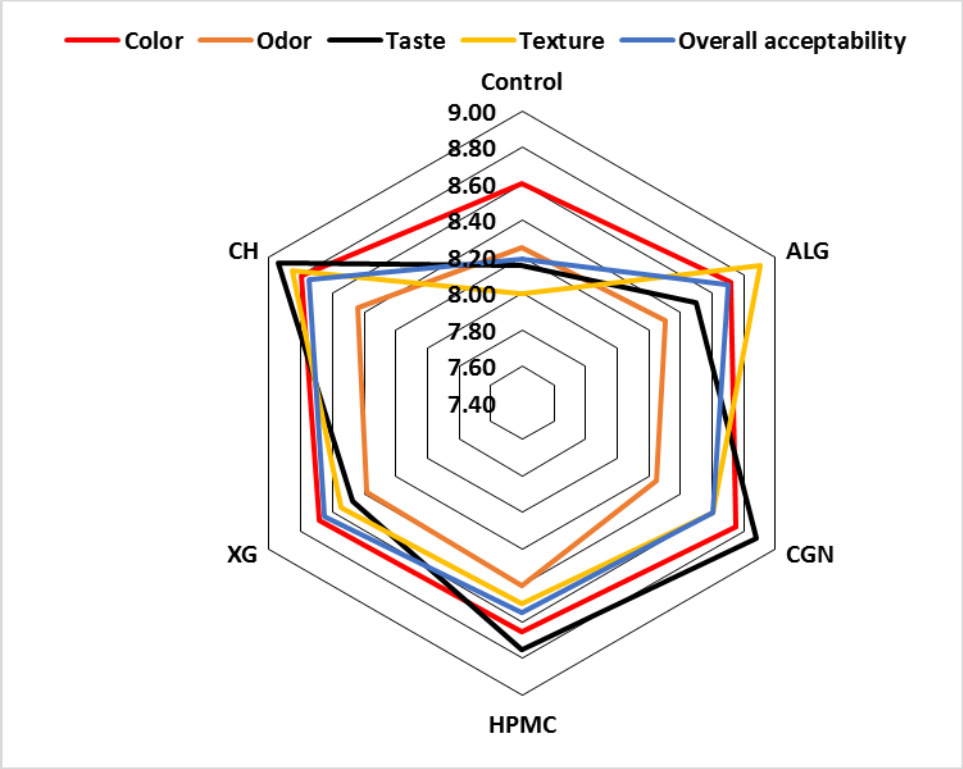

Fig. 8. Effect of some hydrocolloids on sensory evaluation of fish fingers

The different added hydrocolloids didn't affect the taste of common carp fish fingerssignificantly, while CH and CGN were significantly improvedwith respect to the texture, taste, and appearance of common carp fish fingers in comparison to the control

and other trails. The best treatments in overall acceptability were chitosan and alginate followed by XG, CGN, and HPMC, respectively.The current resultsare in agreement with those of **Sehgal and Sehgal (2002)** who found that, the overall acceptability of car and *C. gibelio* fish fingers were determined as 7.12 and 8.471, respectively. **Izci (2010)** reported that fried fish fingers had 8.235±0.207 flavor, 8.412±0.193 texture, 8.294±0.206 color, 8.353±0.170 odor, and 8.471±0.151 overall acceptability. In addition, **Santana *et al*. (2013)** found that, the textural and sensorial quality properties of fish sausages formulated with surimi powder were improved due to the addition of CMC, alginate, and konjac at 0.5% final concentration.

CONCLUSION

Using different hydrocolloids in batter formulation improved final product properties and sensory properties in some trails of fish fingers. From this study it can be concluded that, the examined hydrocolloids positively affected common carp fish finger shelf-life stability and also improved physicochemical, microbiological, and sensory properties of common carp fish fingers during frozen storage. By adding hydrocolloids, it was possible to develop a large variety of analogues based on modification of the functional and textural properties of fishery products. Further studies are needed to evaluate the chemical composition of the studied hydrocolloids and investigate the structure function relationship of those compounds that may be applied in different fishery products to extend its shelf life.

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