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Effect of Hot Smoking on the Quality and Shelf-Life of Fish Luncheon Stored at Cold and Ambient Conditions

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ABSTRACT

A growing increase in the global demand for innovative smoked fishery products has recently emerged. Thus, the present study was designed to adapt the hot smoke processing technique for improving the sensorial, physicochemical, and microbial qualities of common carp and little tuna fish luncheon as innovative fish products with extended shelf- life. The hot smoking for 5- 6 hours at 40- 90°C (2 hours at 40-5 0°C, 2 hours at 60-80°C, and 2 hours at 90°C) with citrus sawdusts was applied to process smoked fish luncheon. The smoked carp and little tuna fish luncheon obtained higher sensory attributes and suppressed bacterial growth, pH, total volatile basic nitrogen, trimethylamine and thiobarbituric acid at an optimum smoking time of 25min using citrus sawdust. On the other hand, moisture, protein, lipid and overall acceptability scores were siginificantly decreased ($P\leq$ 0.05) during chilled and ambient temperature, while ash, carbohydrates, pH, TVB-N, TMA-N, TBA, TMBC, TPBC, TPC and YMC were siginificantly increased ($P\leq$ 0.05) as affected by chilled and ambient temperature, without surpassing the maximum permissible limits. Based on the sensory analysis, the shelf-life of both types of smoked fish luncheon was determined to be 18 days. Moreover, the wheat flour treatment was identified as the best, followed by soybean flour and starch. The overall findings indicated that the hot smoking technology with fish luncheoun could be effective in achieving good sensorial, nutritional, and functional attributes to the consumer.

INTRODUCTION

Luncheon is considered one of the most favorite foods of most Egyptian people. It is a quick and ready-to-eat food that does not require cooking before consumption. It is usually made from minced meat or poultry and has not yet been processed from fish on a commercial scale. Semi-dry luncheon meat and canned luncheon meat are the most common luncheon products in Egypt **(Abu-Salem *et al*., 2011; Mohamed *et al*., 2016)**. Due to the high consumption and over prices of meat, adulteration of meat products has

become a common practice in numerous countries via using unauthorized species in processing of meat products to increase quantity and reduce production costs **(Migaldi *et al*., 2016)**. Food innovation process is considered one of the most sources of competitive advantage and the main contributor to sector evolution, but is scarcely adopted in fish sector due to the complexity of an innovation process and high uncertainty of its success on the market **(Rumelt, 1987; Grunert *et al*., 2004)**.

Fish products are considered among the best healthiest foods, owing to their higher nutritional value, however they are quickly perishable, which neccessitates some innovative solutions to ensure their quality and safety. Smoking is considered one of the oldest methods of preserving fish. Its main purpose is the deposition of antimicrobial substances (phenols, carbonyls, and low molecular weight organic acids) as a result of surface drying of the product, which subsequently increases the shelf- life of fish products **(Mohanty *et al*., 2019; ISMEA, 2021)**. Hot smoking of fish products has a especial appeal to the consumer due to its uniqueness sensorial properties. The sensory quality of the fish product is evidently, significantly enhanced by the use of various sawdust materials of plant origin during smoking. This process preserves a rich source of volatile compounds, among which phenols play a predominant role in developing color and aroma in the food materials **(Dillon *et al*., 1994; Küçükgülmez *et al*., 2010)**. Fish smoking involves the control of physicochemical parameters such as pH- value, TVB-N, TMA-N, TBARS contents, fatty acid composition, and texture properties. This process aims to improve sensorial qualities, ultimately ensuring high quality final fish products aligned with the extended shelf-life **(Huang *et al*., 2019)**.

Although other studies have been performed on smoked fishery products **(Talab, 2006; Talab, 2011; Shehata *et al*., 2018a; Shehata *et al*., 2018b; Abbas *et al*., 2022)**, to the best of our knowledge, this is the first study performed on the production and quality evaluation of hot smoked fish luncheon. On the other hand, few recent studies were conducted on the production of cooked fish luncheon. **Talab (2011)** produced fish luncheon from common carp using natural antioxidants and stored the samples at cold temperatures. Moreover, **Ali *et al*. (2017)** produced canned tilapia fish luncheon and stored it at room temperature. Fish luncheon was produced from red tuna using various amounts of chickpea flour and beef fat **(Farag, 2023)**. In this context, the objective of this study was to optimize the production of an innovative smoked fish luncheon product from common carp and little tuna fish using a high smoking temperture. The present study was designed to adapt the hot smoke processing technique for improving the sensorial, physicochemical, and microbial qualities of common carp and little tuna fish luncheon as innovative fish products with an extended shelf life.

MATERIALS AND METHODS

Materials

Fish samples collection and preparation

Fifty kg of fresh common carp (*Cyprinus carpio*) with 44± 6.11cm total lengths and 4.45± 0.51kg weights were obtained from Manzala aquatic farm belonging to GAFAD, Egypt, during December 2019. Moreover, fifty kg of little tuna (*Euthynnus alletteratus*) with 49± 4.01cm total lengths and 6.50± 0.48kg total weights were purchased from Alexandria fish market, Egypt, in December 2019. Fish samples were transported immediately using ice box within three hours to the Fish Processing and Technology Laboratory, El-Kanater El-Khairia, Fish Research Station, National Institute of Oceanography and Fisheries. Fish samples were washed well with tap water, beheaded, gutted, filleted after removing of scales, fins, skin, and large bones, then rewashed carefully and drained.

Ingredients

Fat, starch, wheat flour, sodium chloride, onion powder, garlic powder and spices (black pepper, red pepper, cumin, cardamom, cloves, coriander, cubeb and clove) were purchased from a local market (Cairo, Egypt). Soybean flour was obtained from the Food Technology Research Institute, Agriculture Research Center, Giza, Egypt.

Processing of fish luncheon

Common carp and little tuna fish luncheon was processed according to the method described by **Ghoneim (1978)** using the recipes presented in Table (1) as follows: Fish fillets were minced, pressed in cheese cloth to remove excess water and used for luncheon preparation. The ingredients were mixed thoroughly, subjected to final grinding (4mm plate) and stuffed (in low-density polyethylene casing).

Table 1. Common carp and little tuna fish luncheon recipes

Ingredient	Control (starch)	Wheat flour	Soybean flour
Minced fish	62.92	62.92	62.92
Fat	20.97	20.97	20.97
Salt	2.52	2.52	2.52
Sugar	1.2585	1.2585	1.2585
Onions	1.8877	1.8877	1.8877
Garlic	1.8877	1.8877	1.8877
Black pepper	1.3461	1.3461	1.3461
Red pepper	0.3335	0.3335	0.3335
Cardamom	0.0357	0.0357	0.0357
Cumin	0.1049	0.1049	0.1049
Cloves	0.0210	0.0210	0.0210
Coriander	0.1049	0.1049	0.1049
Cubeb	0.0629	0.0629	0.0629
Starch	7.3411	3.67	3.67
Wheat flour	0.00	3.67	0.00
Soy bean flour	0.00	0.00	3.67

Fig. 1. Smoked little tuna fish luncheon

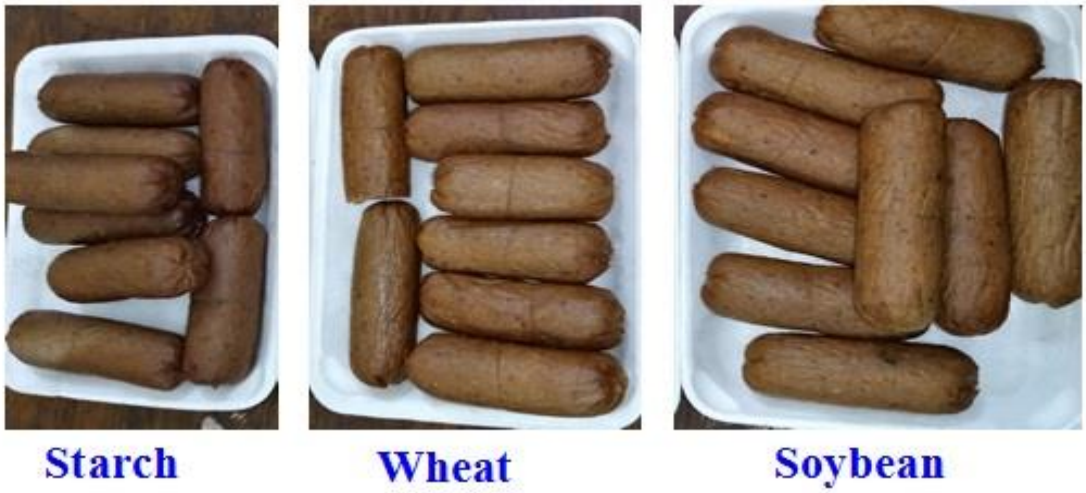

Fig. 2. Smoked common carp fish luncheon

Three batches of fish luncheon were prepared i.e., the first trial: formulated to contain 35% (7.3411) starch as control sample (L1); the second trial: formulated with replacing 50% of the added starch with wheat flour (L2) i.e., containing starch and wheat flour at a ratio of 1:1; the third trial: formulated with substituting 50% of the added starch with soybean flour (L3) i.e., containing starch and soy bean flour at a ratio of 1:1. Both luncheon treatments were smoked in a laboratory smokehouse using citrus sawdust as follows: CCFL and LTFL fish luncheon samples were partially air dried (20- 23ºC) for about two hours before the smoking process and then subjected to hot smoking, and then samples were hooked above the smoke source by about 250cm. Hot smoking extended for 5- 6 hours at 40- 90°C (2 hours at 40- 50°C, 2 hours at 60- 80°C and the remained period at 90°C). After the smoking process, fish luncheon samples were cooled at an ambient temperature, packed in polyethylene bags then divided into two halves; one half

was stored in a refrigerator at 4± 1°C, while the other half was stored at room temperature (20± 1°C) (Figs. 1, 2). Fish luncheon samples were analyzed immediately (at zero time of storage) and periodically every 6 days until spoilage.

Analytical methods

Moisture, crude protein, lipid, and ash were determined according to **AOAC (2012)**. Carbohydrates were calculated by the difference in the sum of the values of fat, ash, moisture, and protein content. The pH value was measured as described by **Egbert *et al.* (1992)**. Total volatile basic nitrogen (TVB-N) contents were determined according to the guidelines of **AOAC (2012)**. Additionally, the trimethylamine nitrogen (TMA-N) contents were determined as mentioned by **Pearson (1976)**, and thiobarbituric acid (TBA) values were determined according to **Siu and Draper (1978)**. Total mesophilic bacterial count (TMBC) and total psychrophilic bacterial count (TPBC) were determined according to the method described in **APHA (2001)**. The total plate count (TPC) was determined according to **ISO (2003)** by using nutrient agar medium as described by **(Oxoid, 2006)**. Yeast and mold counts (YMC) were determined in accordance with **ISO (2008)**. Sensory evaluation was assessed according to the procedure of **Teeny and Miyaauchi (1972)**.

Statistical analysis

Data were expressed as the mean values of three replicates, and standard deviations were statistically analyzed by performing the analysis of variance technique (ANOVA) using the statistical analysis system according to **SAS (2008)**. Differences among means were compared using Duncan's multiple range test (1955) at a significant level of 95% ($P \leq 0.05$).

RESULTS AND DISCUSSION

It is evident that the quality attributes of smoked fishery product are determined by various analysis methods including sensory evaluation (color, texture, odor, flavor, and overall acceptance), physicochemical assessment (i.e., pH level, VBN level, TBARS level, TMAO, and fatty acid content), and microbial growth quantification **(Mohibbullah *et al.*, 2018)**.

Effect of hot smoking on biochemical composition of fish luncheon

The chemical composition of fishery products varies greatly in relation to age, sex, environment, season, and even among the same species **(Baten *et al.*, 2020)**. The moisture content of hot smoked little tuna and common carp fish luncheon, formulated using starch, wheat and soybean flour, stored at cold and ambient temperatures, is illustrated in Fig. (2). The results showed that there were significant differences ($P \leq 0.05$) in moisture content between control hot smoked fish luncheon compared with other treatments and during different storage conditions as prolonged shelf-life. Moisture content of control, wheat and soybean flour of hot smoked little tuna fish luncheon at zero time was 51.04, 50.72, 50.33%. and it significantly decreased ($P \leq 0.05$) at the end of

cold and ambient storage period to 42.22, 42.45, 42.84%, and to 39.18, 39.25, 38.96%, respectively.

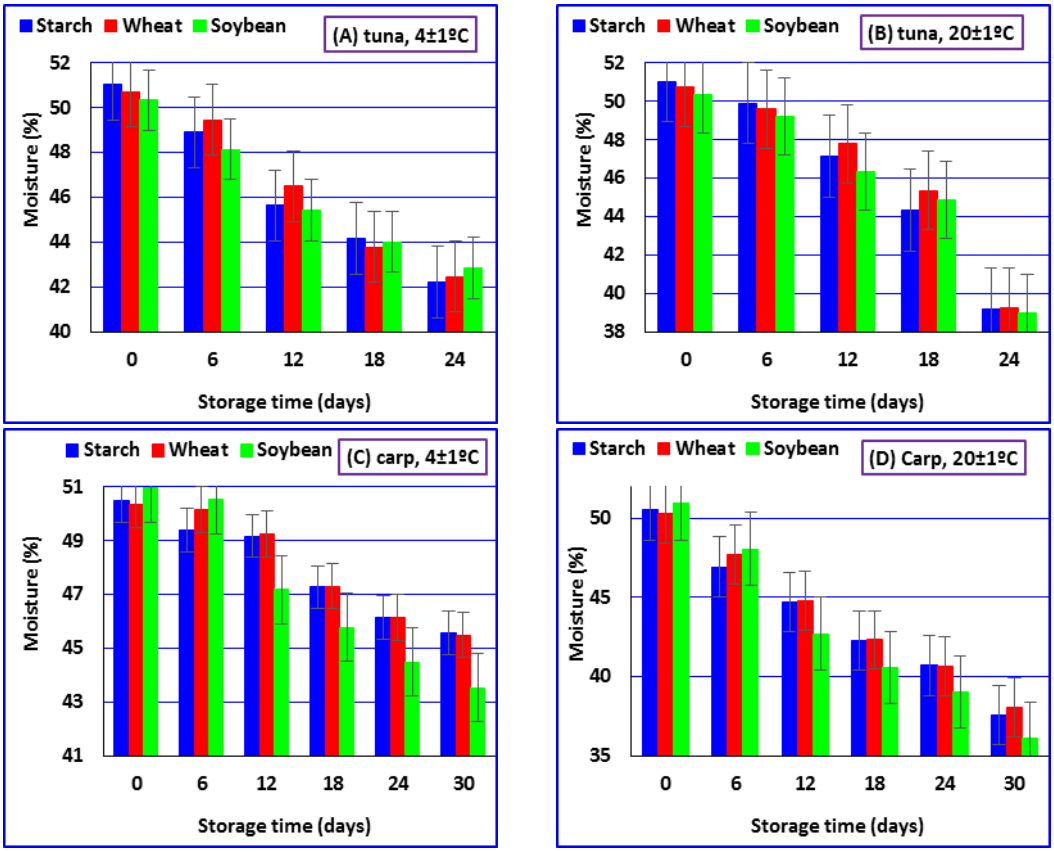

Fig. 2. Moisture content (%) of hot smoked little tuna and common carp fish luncheon stored at cold and ambient temperatures

However, moisture content of control, wheat and soybean flour of hot smoked common carp fish luncheon at zero time was 50.50, 50.34, 50.95%, and it significantly decreased ($P \leq 0.05$) at the end of cold and ambient storage period to 40.10, 40.42, 41.33%, and to 37.58, 38.04, 36.07%, respectively. Moisture content was varied in hot smoked fish luncheon samples due to addition of water or sodium chloride during processing steps and thermal processing temperatures. While, the decrease in moisture content during the frozen storage may be ascribed to the loss of water by evaporation or due to protein denaturation **(Talab, 2006; Talab, 2011; Kilic & Oztan, 2013; Tenyang *et al.*, 2022)**.

Protein content of hot smoked little tuna and common carp fish luncheon, formulated using starch, wheat and soybean flour, stored at cold and ambient temperatures, is illustrated in Fig. (3). The results showed that there were significant differences ($P \leq 0.05$) in protein content between control hot smoked fish luncheon compared with other treatments and during different storage conditions as prolonged shelf-life.

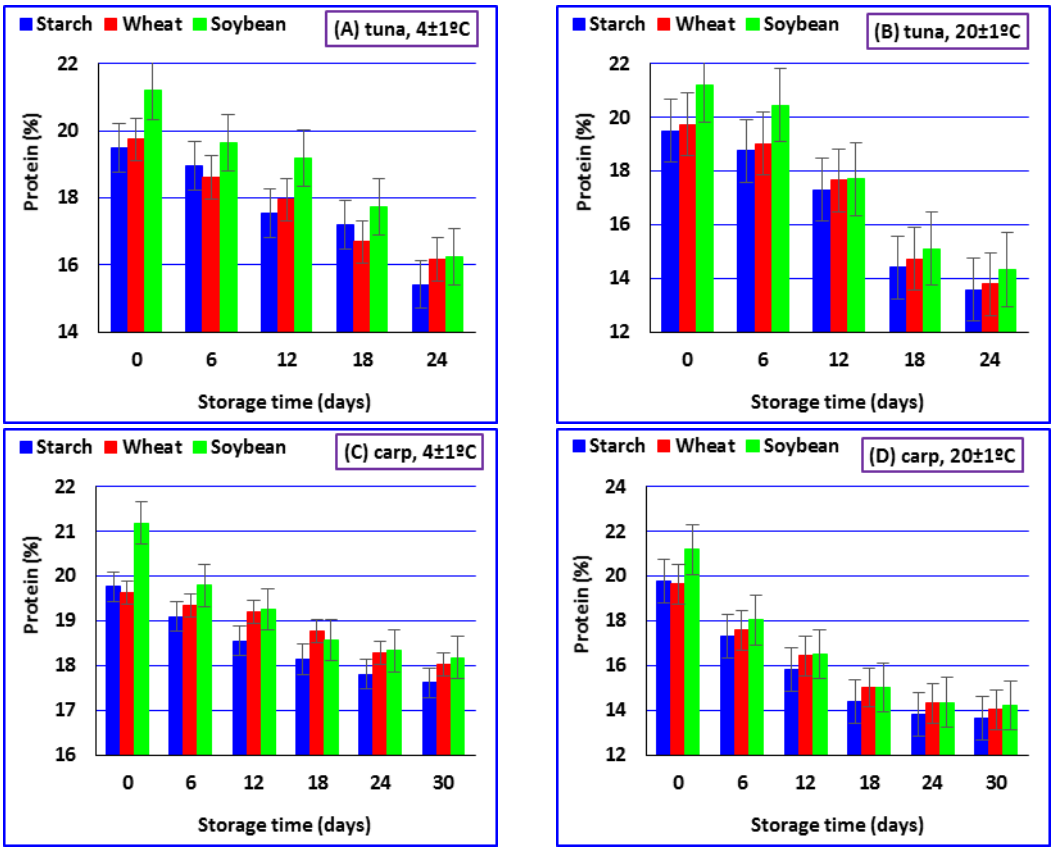

Fig. 3. Protein content (%) of hot smoked little tuna and common carp fish luncheon stored at cold and ambient temperatures

Protein content of control, wheat and soybean flour of hot smoked little tuna fish luncheon at zero time was 19.49, 19.74, 21.19%, and it significantly decreased ($P \leq 0.05$) at the end of cold and ambient storage period to 15.41, 16.17, 16.24%, and to 13.56, 13.78, 14.33%, respectively. However, protein content of control, wheat and soybean flour of hot smoked common carp fish luncheon at zero time was 19.76, 19.64, 21.19%, and it significantly decreased ($P \leq 0.05$) at the end of cold and ambient storage period to 17.61, 18.01, 18.18%, and to 13.63, 14.03, 14.20%, respectively. The decrease in protein content during frozen storage to protein hydrolysis by enzymatic proteolysis, resulting in the formation of small nitrogenous compounds (**Talab *et al*., 2022**). The obtained results agree with **Talab (2006)**, **Talab (2011)** and **Tenyang *et al*. (2022)**.

Fig. (4) represents lipid content of hot smoked little tuna and common carp fish luncheon formulated using starch, wheat and soybean flour, stored at cold and ambient temperatures. The results showed that there were significant differences ($P \leq 0.05$) in lipid content between control hot smoked fish luncheon compared with other treatments and during different storage conditions as prolonged shelf-life.

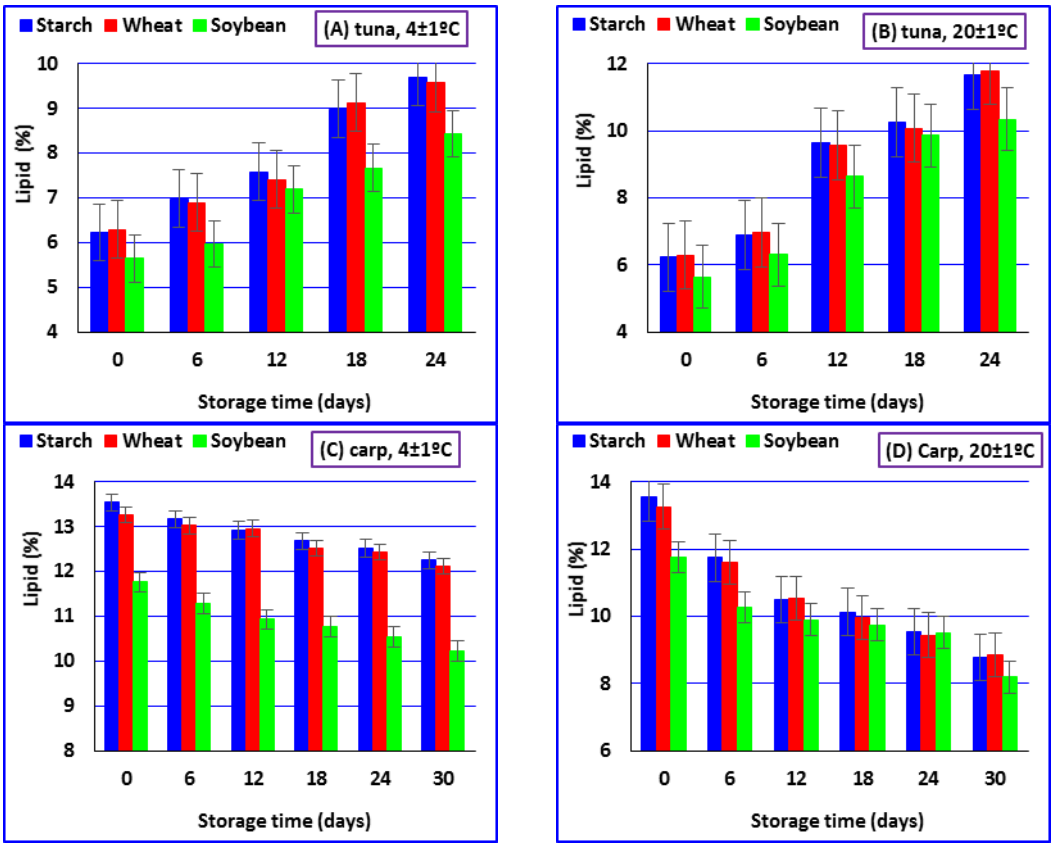

Fig. 4. Lipid content (%) of hot smoked little tuna and common carp fish luncheon stored at cold and ambient temperatures

Lipid content of control, wheat and soybean flour of hot smoked little tuna fish luncheon at zero time was 6.22, 6.29, 5.64%, and it significantly increased ($P \leq 0.05$) at the end of cold and ambient storage period to 9.70, 9.57, 8.43%, and to 11.66, 11.80, 10.34%, respectively. However, lipid content of control, wheat and soybean flour of hot smoked common carp fish luncheon at zero time was 13.54, 13.26, 11.76%, and it significantly decreased ($P \leq 0.05$) at the end of cold and ambient storage period to 12.25, 12.12, 10.22%, and to 8.77, 8.84, 8.19%, respectively. The decrement in lipid content during different storage conditions may be due to the lipid hydrolysis and formation of some volatile compounds **(Talab *et al.*, 2022)**. Our results are in accordance with the findings of **Talab (2006)**, **Talab (2011)** and **Tenyang *et al.* (2022)**.

Ash content of hot smoked little tuna and common carp fish luncheon formulated using starch, wheat and soybean flour, stored at cold and ambient temperatures, is given in Fig. (5). The results showed that there were significant differences ($P \leq 0.05$) in ash content between control hot smoked fish luncheon compared with other treatments and during different storage conditions as prolonged shelf-life.

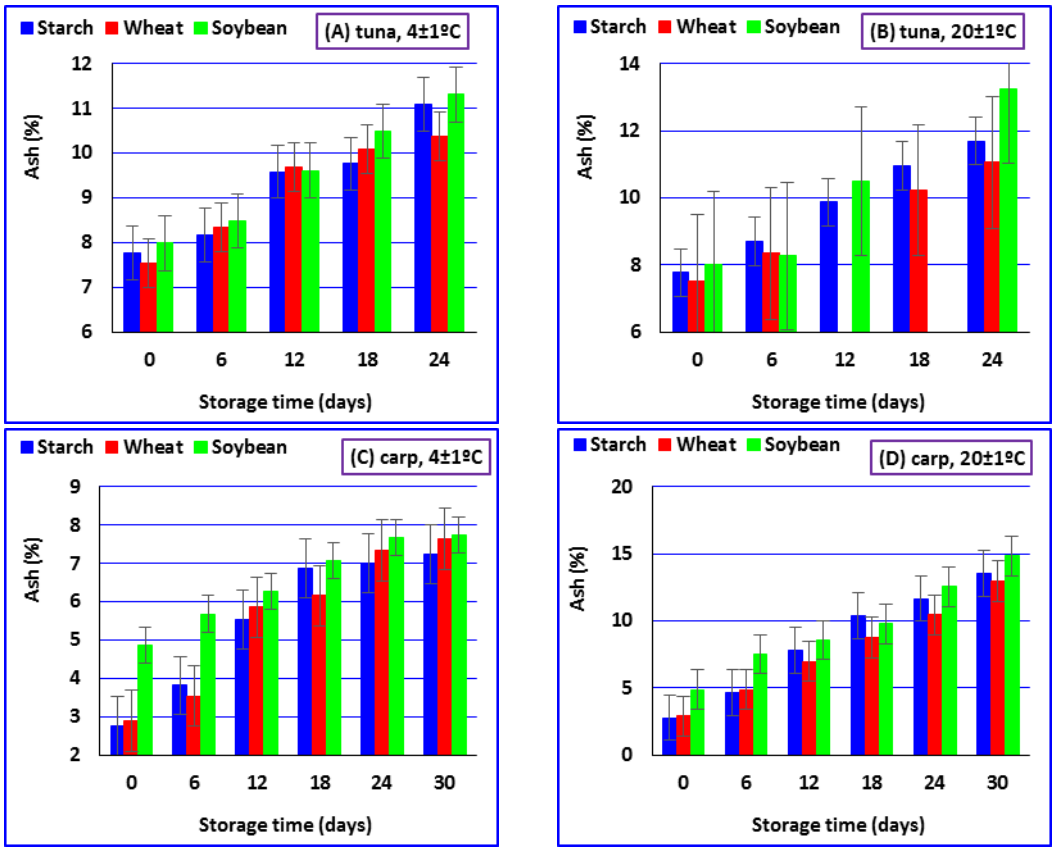

Fig. 5. Ash content (%) of hot smoked little tuna and common carp fish luncheon stored at cold and ambient temperatures

Ash content of control, wheat and soybean flour of hot smoked little tuna fish luncheon at zero time was 7.77, 7.53, 7.99%, and it significantly increased ($P \leq 0.05$) at the end of cold and ambient storage period to 11.09, 10.38, 11.31%, and to 11.69, 11.05, 13.26%, respectively. However, ash content of control, wheat and soybean flour of hot smoked common carp fish luncheon at zero time was 2.76, 2.88, 4.87%, and it significantly increased ($P \leq 0.05$) at the end of cold and ambient storage period to 7.23, 7.65, 7.75%, and to 13.54, 12.98, 14.84%, respectively. Similar results were reported by **Talab (2006)**, **Talab (2011)** and **Tenyang *et al*. (2022)**.

Carbohydrate content of hot smoked little tuna and common carp fish luncheon formulated using starch, wheat and soybean flour, stored at cold and ambient temperatures, is represented in Fig (6). The results showed that there were significant differences ($P \leq 0.05$) in carbohydrate content between control hot smoked fish luncheon compared with other treatments and during different storage conditions as prolonged shelf-life.

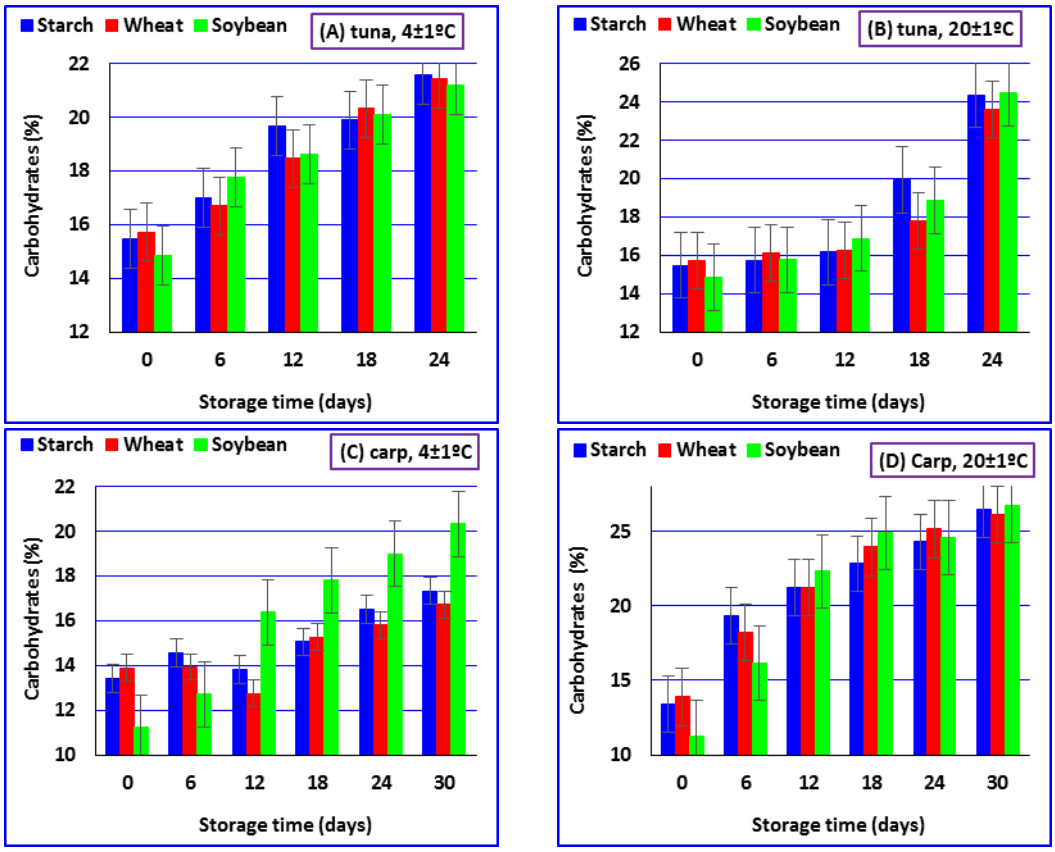

Fig. 6. Carbohydrate content (%) of hot smoked little tuna and common carp fish luncheon stored at cold and ambient temperatures

Carbohydrate content of control, wheat and soybean flour of hot smoked little tuna fish luncheon at zero time was 15.48, 15.72, 14.85%, and it significantly increased ($P \leq 0.05$) at the end of cold and ambient storage period to 21.58, 21.43, 21.18%, and to 24.36, 23.60, 24.46%, respectively. However, carbohydrate content of control, wheat and soybean flour of hot smoked common carp fish luncheon at zero time was 13.41, 13.88, 11.23%, and it significantly increased ($P \leq 0.05$) at the end of cold and ambient storage period to 17.34, 16.73, 20.33%, and to 26.48, 26.11, 26.70%, respectively. Similar results were found by **Talab (2006)**, **Talab (2011)** and **Tenyang *et al*. (2022)**.

Effect of hot smoking on physicochemical quality of fish luncheon

The pH value of hot smoked little tuna and common carp fish luncheon formulated using starch, wheat and soybean flour, stored at cold and ambient temperatures, is represented in Fig. (7). The results showed that there were significant differences ($P \leq 0.05$) in pH value between control hot smoked fish luncheon compared with other treatments and during different storage conditions as prolonged shelf-life. Moreover, it can be noticed that, there is non-significant differences between the two kinds of smoked fish luncheon. The pH value of control, wheat and soybean flour of both hot smoked little tuna and common carp fish luncheon at zero time was 5.62, 5.60, 5.57, and it

significantly increased ($P \leq 0.05$) at the end of cold and ambient storage period to 6.32, 6.28, 6.11, and to 6.14, 6.20, 6.09, respectively.

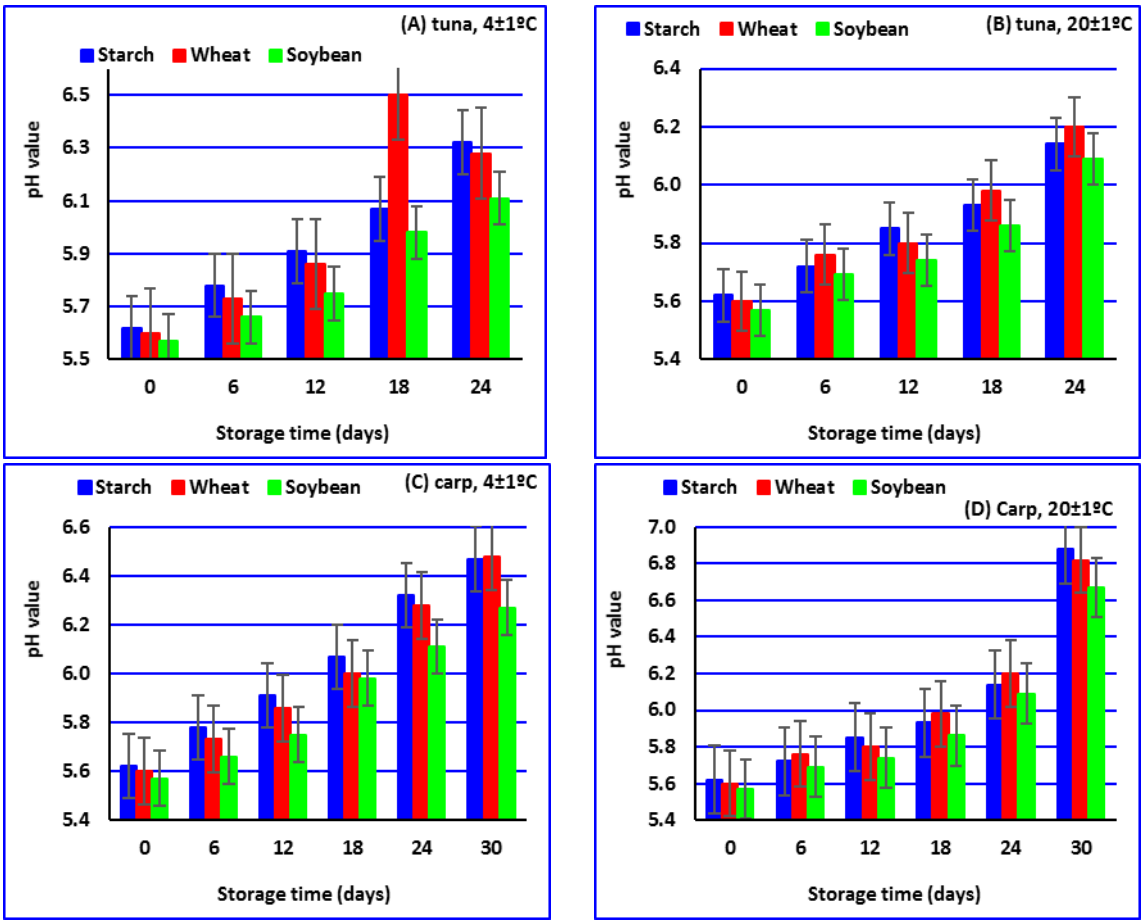

Fig. 7. The pH value of hot smoked little tuna and common carp fish luncheon stored at cold and ambient temperatures

During storage, pH of fish sausage increased throughout the storage time, presumably due to the production of basic amines **(Debevere & Boskou, 1996)**. Similar results were found by **Talab (2006)**, **Talab (2011)**, **Özpolat and Guran (2017)** and **Baten *et al*. (2020)**.

Total volatile basic nitrogen (TVB-N) content of hot smoked little tuna and common carp fish luncheon formulated using starch, wheat and soybean flour, stored at cold and ambient temperatures, is represented in Fig. (8). The results showed that there were significant differences ($P \leq 0.05$) in TVB-N content between control hot smoked fish luncheon compared with other treatments and during different storage conditions as prolonged shelf-life. Moreover, it can be noticed that, there is non-significant differences between the two kinds of smoked fish luncheon. TVB-N content of control, wheat and soybean flour of both hot smoked little tuna and common carp fish luncheon at zero time was 18.66, 18.96, 19.37mg/ 100g, ww, and it significantly increased ($P \leq 0.05$) at the end

of cold and ambient storage period to 25.77, 25.92, 28.08mg/ 100g, ww, and to 26.57, 25.89, 26.87mg/ 100g, ww, respectively. Our results concur with the findings of **Talab (2006)**, **Talab (2011)**, **Özpolat and Guran (2017)** and **Baten *et al*. (2020)**.

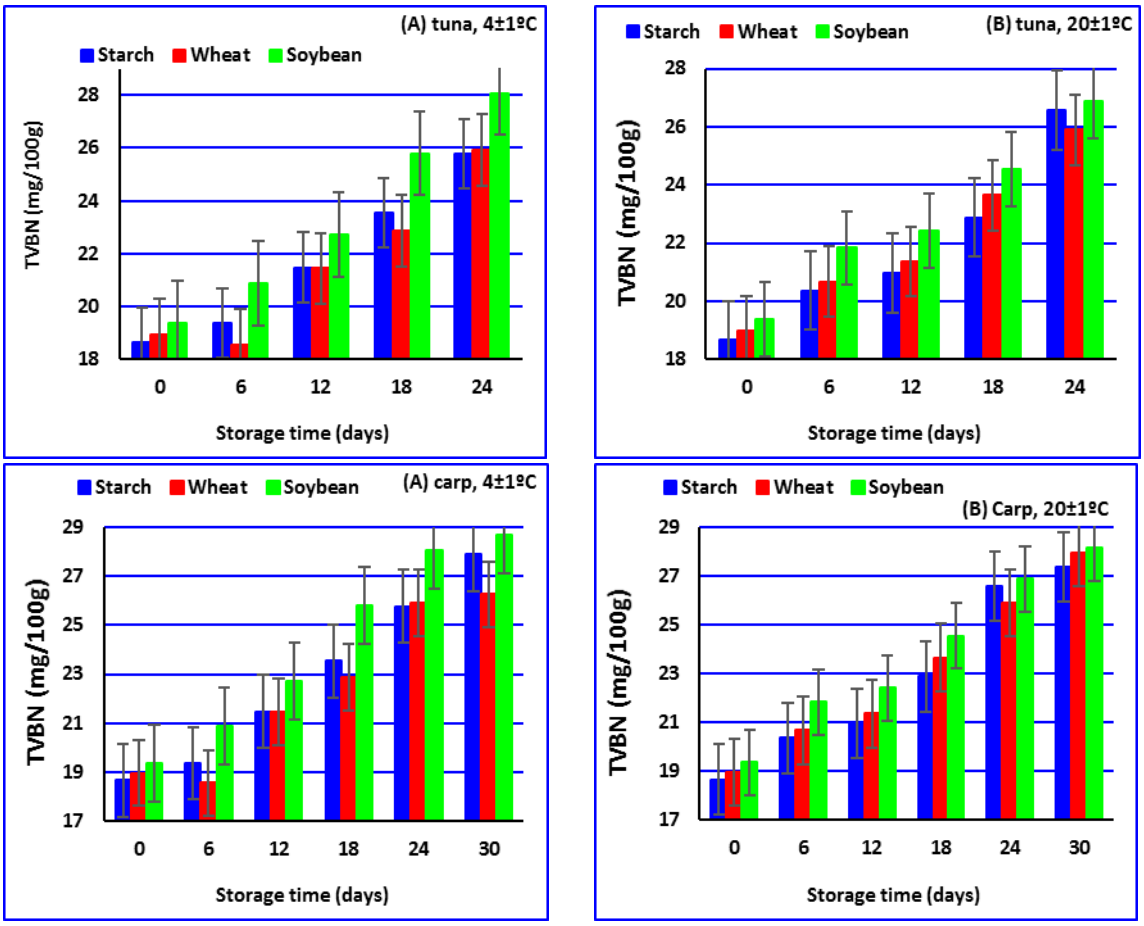

Fig. 8. Total volatile basic nitrogen (TVB-N) of hot smoked little tuna and common carp fish luncheon stored at cold and ambient temperatures

Trimethylamine nitrogen (TMA-N) content of hot smoked little tuna and common carp fish luncheon formulated using starch, wheat and soybean flour, stored at cold and ambient temperatures, is displayed in Fig. (9). The results showed that there were significant differences ($P \leq 0.05$) in TMA-N content between control hot smoked fish luncheon compared with other treatments and during different storage conditions as prolonged shelf-life. TMA-N content of control, wheat and soybean flour of hot smoked little tuna fish luncheon at zero time was 4.20, 4.36, 4.98%, and it significantly increased ($P \leq 0.05$) at the end of cold and ambient storage period to 7.53, 7.30, 8.05%, and to 8.96, 8.89, 9.67%, respectively. However, TMA-N content of control, wheat and soybean flour of hot smoked common carp fish luncheon at zero time was 2.80, 2.47, 2.86%, and it significantly increased ($P \leq 0.05$) at the end of cold and ambient storage period to 6.67, 5.50, 7.99%, and to 8.67, 8.20, 8.79%, respectively. The obtained results agree with the

findings of **Talab (2006)**, **Talab (2011)**, **Özpolat and Guran (2017)** and **Baten *et al.* (2020)**. The maximum permissible limit of 10 to 12mg/ 100g of fish muscle have been established by the **EU (1995)** for fish muscle freshness.

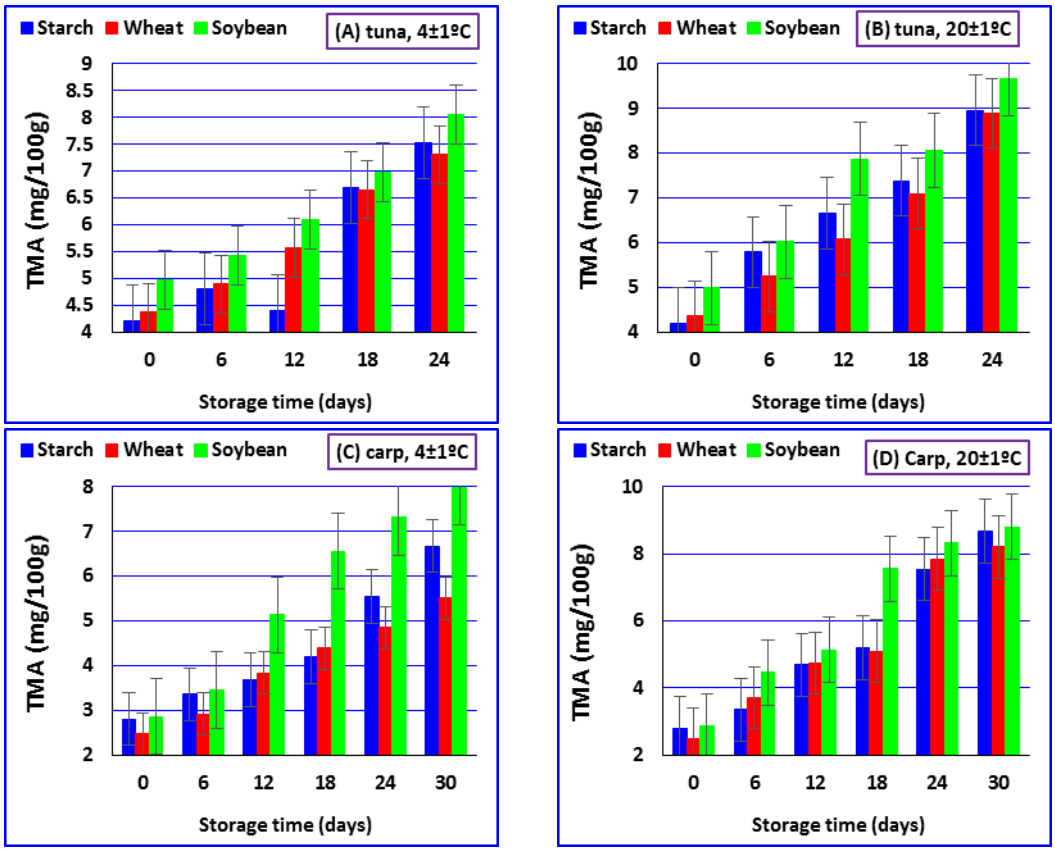

Fig. 9. TMA-N (mg/ 100g) of hot smoked little tuna and common carp fish luncheon stored at cold and ambient temperatures

Thiobarbituric acid (TBA) value of hot smoked little tuna and common carp fish luncheon formulated using starch, wheat and soybean flour, stored at cold and ambient temperatures, is provided in Fig. (10). The results showed that, there were significant differences ($P \leq 0.05$) in TBA value between control hot smoked fish luncheon compared with other treatments and during different storage conditions as prolonged shelf-life.

Thiobarbituric acid (TBA) value of control, wheat and soybean flour of hot smoked little tuna fish luncheon at zero time was 1.36, 1.48, 1.25mg malonaldhyde/ kg, ww, and it significantly increased ($P \leq 0.05$) at the end of cold and ambient storage period to 3.76, 3.42, 3.39mg malonaldhyde/ kg, ww, and to 3.99, 3.90, 3.84mg malonaldhyde/ kg, ww, respectively. However, TBA value of control, wheat and soybean flour of hot smoked common carp fish luncheon at zero time was 1.27, 1.23, 1.18mg malonaldhyde/ kg, ww, and it sgnificantly increased ($P \leq 0.05$) at the end of cold and ambient storage period to 3.59, 2.97, 3.77mg malonaldhyde/ kg, ww, and to 3.06, 2.68, 2.95mg malonaldhyde/ kg,

ww, respectively. Similar results were found by **Talab (2006)**, **Talab (2011)**, **Özpolat and Guran (2017)** and **Baten *et al*. (2020)**.

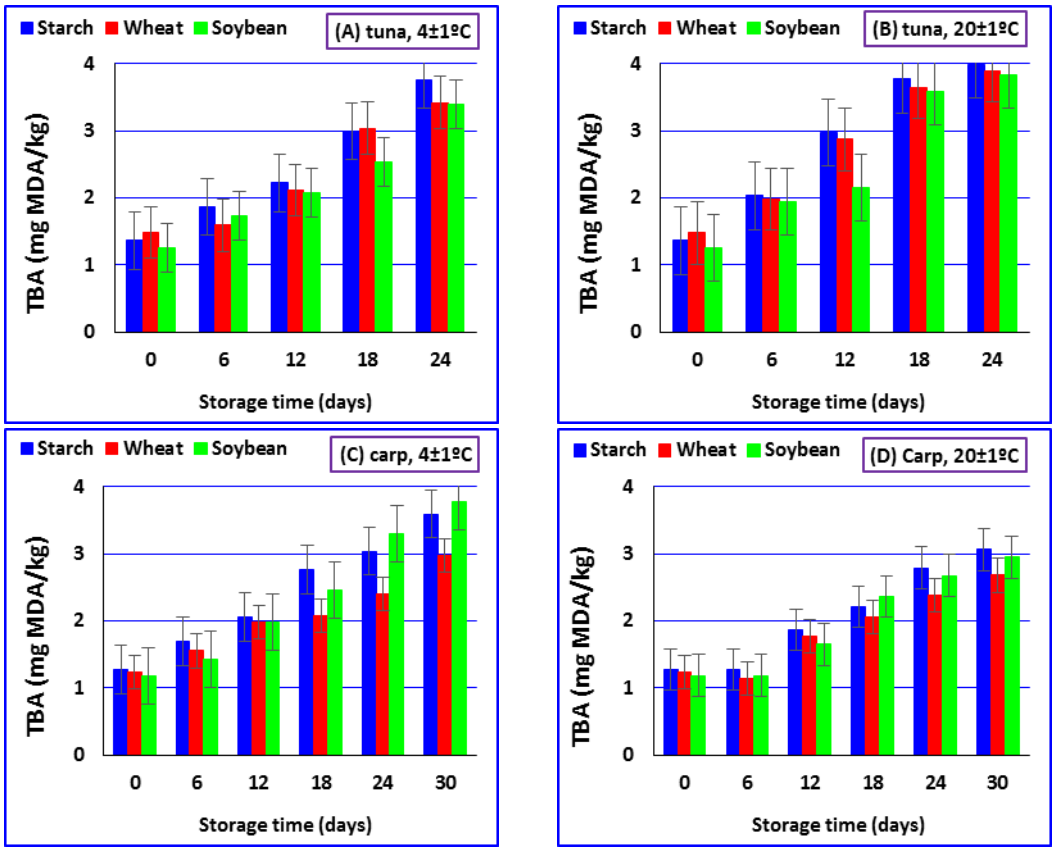

Fig. 10. TBA (mg malonaldhyde/ kg, ww) of hot smoked little tuna and common carp fish luncheon stored at cold and ambient temperatures

Effect of hot smoking on microbiological quality of fish luncheon

Total mesophilic bacterial and total psychrophilic bacterial count

Total mesophilic bacterial count (TMBC) and total psychrophilic bacterial count (TPBC) of hot smoked little tuna and common carp fish luncheon formulated using starch, wheat and soybean flour, stored at cold and ambient temperatures, are provided in Fig. (11). The results showed that there were significant differences ($P \leq 0.05$) in TMBC and TPBC values between control hot smoked fish luncheon compared with other treatments and during different storage conditions as prolonged shelf-life. TMBC of control, wheat and soybean flour of hot smoked little tuna fish luncheon at zero time was 2.21, 2.15, 2.22 log cfu/ g, and it significantly increased ($P \leq 0.05$) at the end of cold storage period to 3.18, 3.02, 3.44 log cfu/ g.

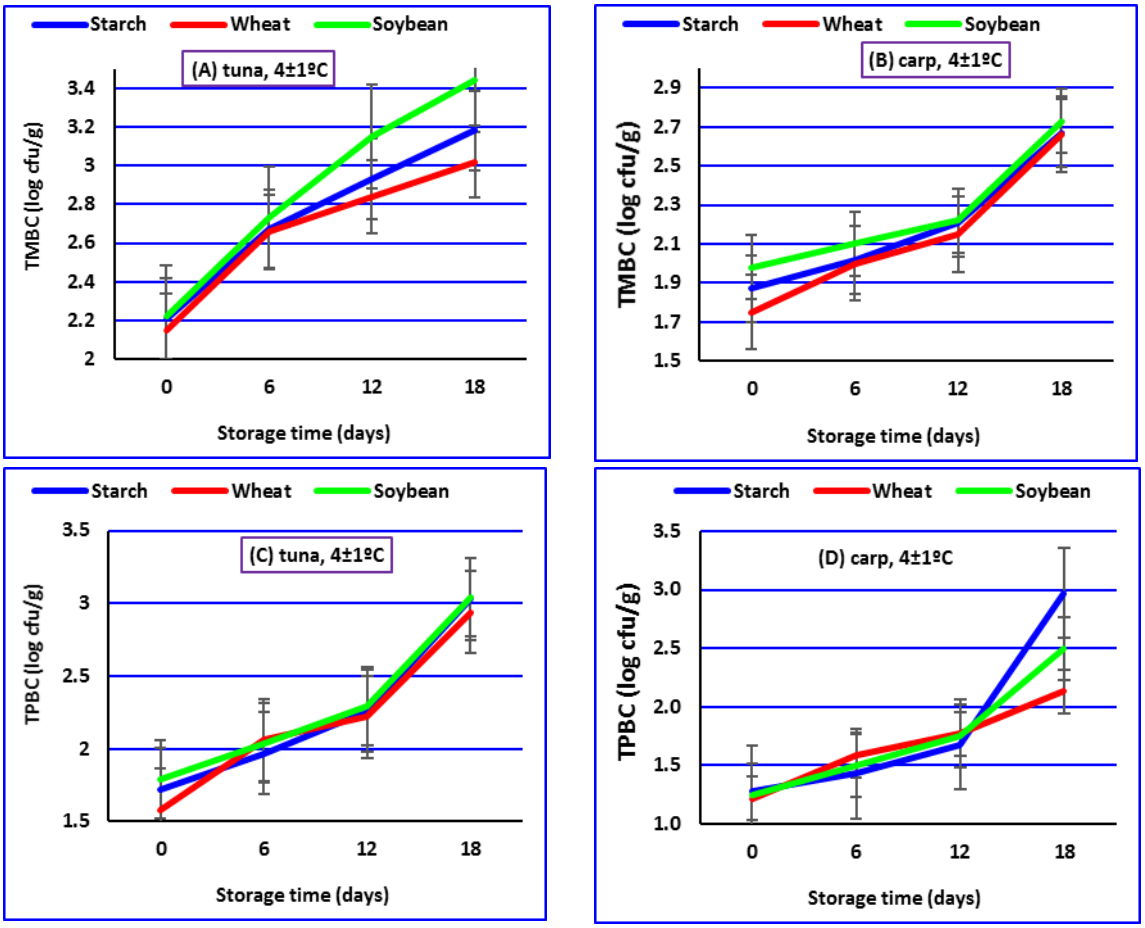

Table 11. Mesophilic bacterial count (TMBC) and total psychrophilic bacterial count (TPBC) as log cfu/ g of hot smoked little tuna and common carp fish luncheon stored at cold temperatures

TMBC of control, wheat and soybean flour of hot smoked common carp fish luncheon at zero time was 1.87, 1.75, 1.98 log cfu/ g, and it significantly increased ($P \leq 0.05$) at the end of cold storage period to 2.67, 2.66, 2.73 log cfu/ g. TPBC of control, wheat and soybean flour of hot smoked little tuna fish luncheon at zero time was 1.72, 1.58, 1.79 log cfu/ g, and it significantly increased ($P \leq 0.05$) at the end of cold storage period to 3.03, 2.94, 3.04 log cfu/ g. TPBC of control, wheat and soybean flour of hot smoked common carp fish luncheon at zero time was 1.28, 1.22, 1.25 log cfu/ g, and it significantly increased ($P \leq 0.05$) at the end of cold storage period to 2.97, 2.13, 2.50 log cfu/ g.

Total plate count (TPC) of hot smoked little tuna and common carp fish luncheon formulated using starch, wheat and soybean flour, stored at cold and ambient temperatures, is presented in Fig. (11). The results showed that there were significant differences ($P \leq 0.05$) in TPC values between control hot smoked fish luncheon compared with other treatments and during different storage conditions as prolonged shelf-life. TPC of control, wheat and soybean flour of hot smoked little tuna fish luncheon at zero time

was 2.86, 2.86, 2.86 log cfu/ g, and it significantly increased ($P \leq 0.05$) at the end of ambient storage period to 5.75, 5.75, 5.75 log cfu/ g. TPC of control, wheat and soybean flour of hot smoked common carp fish luncheon at zero time was 3.38, 3.24, 3.39 log cfu/ g, and it significantly increased ($P \leq 0.05$) at the end of ambient storage period to 5.93, 5.69, 5.86 log cfu/ g.

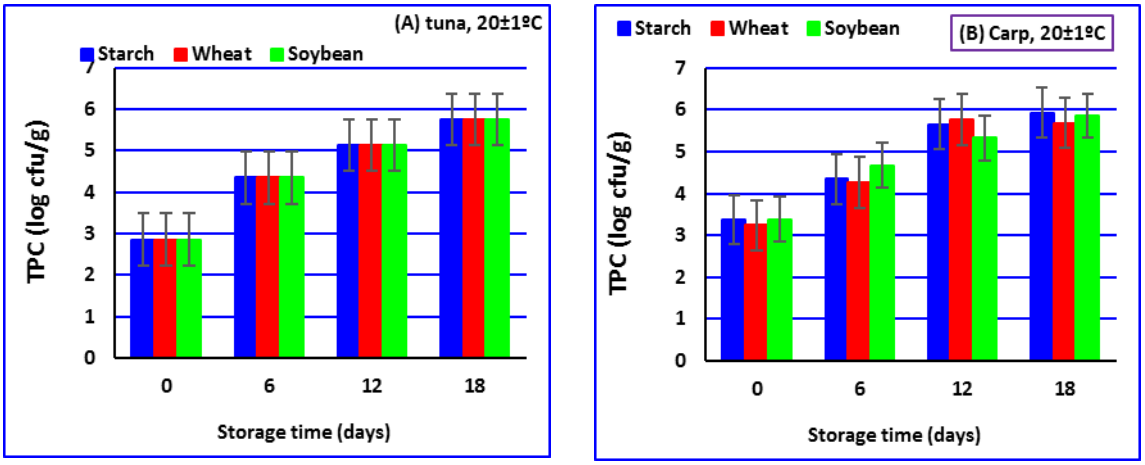

Table 12. Total plate count (TPC) (log cfu/g) of hot smoked little tuna and common carp fish luncheon stored at cold temperatures

Yeast and mold counts (YMC) of hot smoked little tuna and common carp fish luncheon, formulated using starch, wheat and soybean flour and stored at cold and ambient temperatures, are provided in Fig. (13). The results showed that there were significant differences ($P \leq 0.05$) in YMC values between control hot smoked fish luncheon compared with other treatments and during different storage conditions as prolonged shelf-life. YMC of control, wheat and soybean flour of hot smoked little tuna fish luncheon at zero time was 1.83, 1.85, 1.89 log cfu/ g, and it significantly increased ($P \leq 0.05$) at the end of cold and ambient storage period to 2.78, 2.69, 3.26 log cfu/g, and to 3.88, 3.61, 4.09 log cfu/ g. YMC of control, wheat and soybean flour of hot smoked common carp fish luncheon at zero time was 1.01, 1.05, 1.08 log cfu/g, and it significantly increased ($P \leq 0.05$) at the end of cold and ambient storage period to 3.22, 3.87, 3.96 log cfu/ g, and to 4.29, 3.90, 4.77 log cfu/g. All hot smoked fish luncheon samples did not exceed the maximum permissible limit set by **Connell (1990)**, the **EU (1995)** and Egyptian Standard Specificatiom **(ESS, 2005)** for luncheon meat. Similar results were found by **Talab (2006)**, **Talab (2011)**, **Kilic and Oztan (2013)**, **Özpolat and Guran (2017)** and **Baten *et al*. (2020)**.

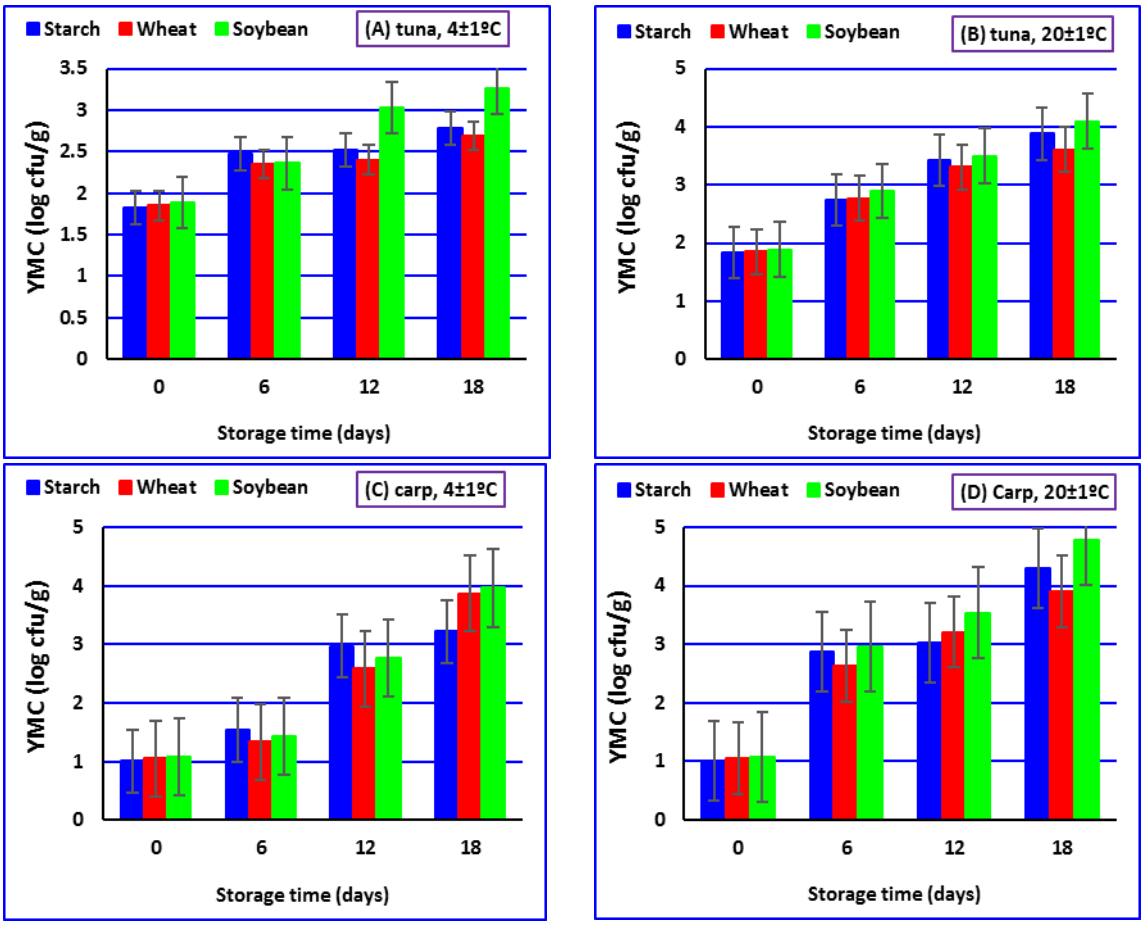

Table 13. Yeast and mold counts (YMC) as log cfu/ g of hot smoked little tuna and common carp fish luncheon stored at cold and ambient temperatures

The overall preferences of hot smoked little tuna and common carp fish luncheon formulated using starch, wheat and soybean flour, stored at cold and ambient temperatures, are provided in Fig. (14). The results showed that there were significant differences ($P \leq 0.05$) in overall preferences values between control hot smoked fish luncheon compared with other treatments and during different storage conditions as prolonged shelf-life. Moreover, sensory properties of fish luncheon were reduced ($P \leq 0.05$) by storage time. Overall preferences of control, wheat and soybean flour of hot smoked little tuna fish luncheon at zero time was 8.13, 8.25, 8.00, and it significantly decreased ($P \leq 0.05$) at the end of cold and ambient storage period to 6.00, 6.74, 5.66, and to 5.41, 6.54, 4.93, respectively. Overall acceptability of control, wheat and soybean flour of hot smoked common carp fish luncheon at zero time was 9.57, 9.69, 9.44, and it significantly decreased ($P \leq 0.05$) to 7.94, 8.18, 7.10, and to 6.85, 7.98, 6.37 at the end of cold and ambient storage period, respectively. Hot smoked little tuna and common carp fish luncheon formulated with wheat flour recorded the best sensorial values, followed by soybean trial, then the starch. Similar results were found by **Talab (2006)**, **Talab (2011)**, **Kilic and Oztan (2013)**, **Özpolat and Guran (2017)** and **Baten *et al*. (2020)**.

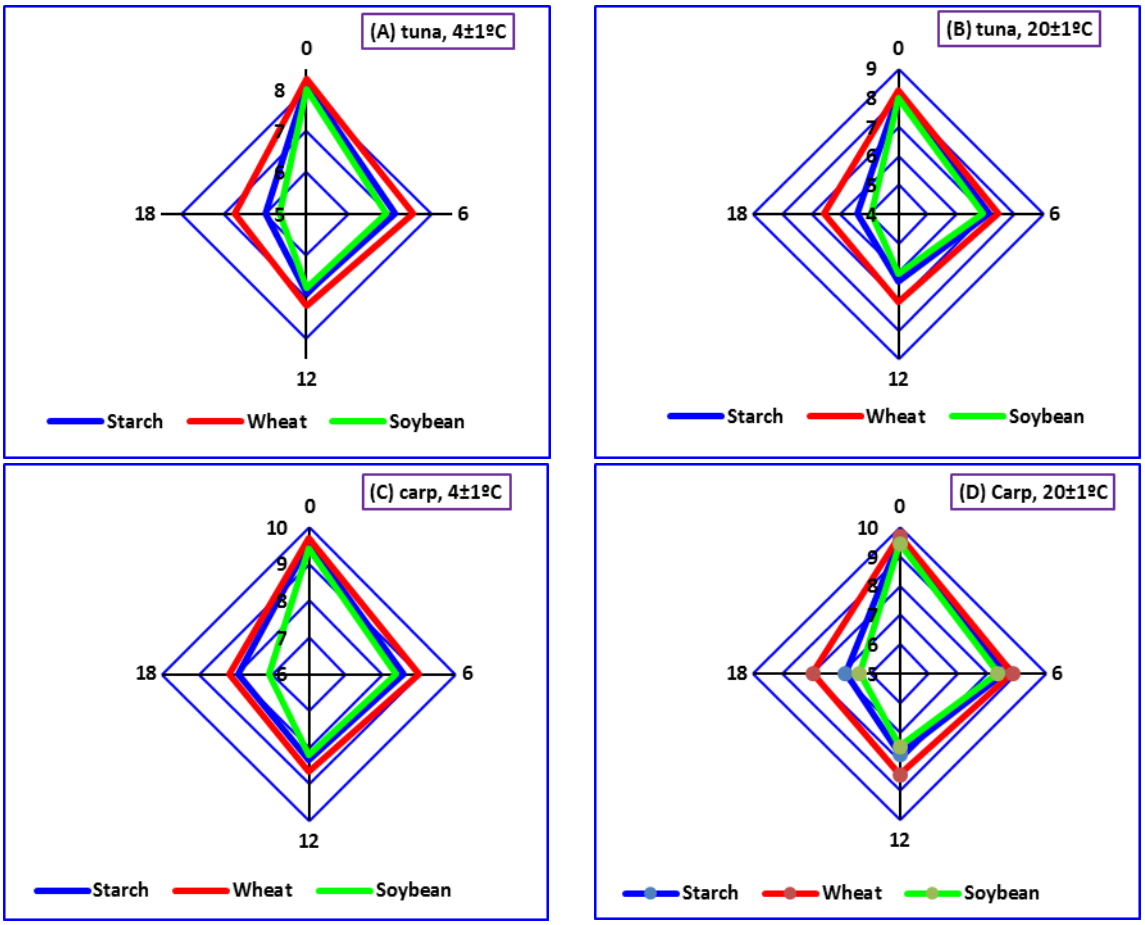

Table 14. Overall preferences of hot smoked little tuna and common carp fish luncheon stored at cold and ambient temperatures

CONCLUSION

Hot-smoked (90°C) of little tuna and common carp fish luncheon using citrus sawdust improved its physicochemical, microbiological, and sensorial attributes. In addition, the shelf-life of fish luncheon was extended. According to the sensory evaluation, it could be noticed that wheat flour treatment was the best compared to starch and soybean flour. Moreover, hot smoked little tuna and common carp fish luncheon stored at cold and ambient temperatures did not exceed the maximum permissible limits set by the national and international standard specification, indicating the product's safety for human consumption.

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