

Research Article

Effects of packaging, packing condition and storage temperature on quality and shelf-life of seasoned tuna meat product

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This paper was originally presented at Food Innovation Asia, August 2009, Bangkok, Thailand.

Received 19 May 2009, Revised 27 August 2009, Accepted 28 August 2009.

Abstract

Effects of packaging, packing condition and storage temperature on quality of seasoned tuna meat product produced by one OTOP in Songkhla province was investigated. The seasoned tuna meat products were kept during storage in polypropylene (PP), nylon/aluminium foil/LLDPE (Laminate) and polyvinylidene chloride (PVDC) under the conditions of air, 90% nitrogen and air with oxygen absorber at the temperature of 30, 37 and 40°C. The samples were periodically monitored for quality. Aw and TBARS content of the seasoned tuna meat products were significantly affected by different packaging, packing condition and temperature of storage. The product packed under 90% nitrogen and air with oxygen absorber had water activity and TBARS content less than other conditions ($p < 0.05$). The microbiological quality of the product stored under different packaging, packing condition and temperature did not significantly change yeast and mould counts, but total viable counts were significantly increased ($p < 0.05$) as the storage time increased. The different packaging, packing condition and storage temperature significantly affected the overall acceptance score. If yeast and mould count, TBARS content and overall acceptance score were used as quality and food safety indicators, the seasoned tuna meat product packed in polyvinylidene chloride (PVDC) under air with oxygen absorber was the most suitable and could be stored at 30, 37 and 40°C for 28, 28 and 21 days, respectively. On the other hand the predicted shelf life of seasoned tuna meat product packed in polyvinylidene chloride (PVDC) under air with oxygen absorber by Q_{10} calculation was only 23 days at 37°C.

Keywords: seafood, PVDC, TBARS, shelf-life, dried product, Thailand

Introduction

Seasoned tuna meat is a traditional fish product popularly consumed amongst the muslim population in the south of Thailand and conventionally made from fresh tuna meat at the community scale. Seasoned tuna meat is a dried product (water activity ≤ 0.6) accomplished by deep fat frying. Seasoned tuna meat may suffer biological, chemical and physical deterioration during storage and distribution probably due to the chemical reaction i.e. oxidation, exposure to light as well as microbial growth during abused storage. The most common quality loss of packaged food is caused by oxygen [1]. Oxidative rancidity is a major problem in fried food and also a major cause of food deterioration leading to development of off-flavour, as well as reduced shelf stability and acceptability [2] and this makes its shelf-life short.

The sensory parameters such as texture, appearance, flavour and taste of any food products depend on the extent of oxidation of fats and oils forming peroxides, aldehydes and ketones [3]. The rate of oxidation is independent of oxygen concentration at very high oxygen partial pressures, while it is proportional to oxygen concentration at low oxygen partial pressures [4]. The availability of oxygen in a package can, to a certain extent, be controlled by the oxygen permeability of the packaging material [5]. Oxygen-barrier layers in food packaging materials typically consist of expensive synthetic barrier polymers including polyvinylidene chloride (PVDC), polyethyleneterephthalate (PET) and polyamide-6 (nylon), which are commonly used in the form of coextruded or laminated films and coatings. Alternatively, excellent barrier properties may be obtained by disposition of aluminum vapour [6, 7, 8]. Polyethylene (PE) and polypropylene (PP) have been widely used in diverse packaging applications due to abundant supply, low cost, good processability, low energy demand for processing and resistance to chemicals and harsh environments. Common polyolefin films such as PE and PP are also excellent moisture barriers, but they must be coated or laminated with previously mentioned synthetic polymer layers including laminate film, PVDC and nylon to provide an oxygen barrier [7] for extended shelf life.

Storage temperature can have a dramatic effect on oxidation rate, which in turn affects off-flavour formation. Several studies have focused on the influence of storage conditions on pistachio, almond, peanut and walnut at high temperatures such as 30, 36, and 40°C. Results showed nuts to be dramatically more rancid as compared to those stored at 8, 10, 20 or 25°C for the same period of time [9, 10, 11, 12, 13].

Therefore, the specific objective of the present study was to investigate the effect of (1) packaging material barrier to water vapour and oxygen, (2) condition of packing and (3) storage temperature on quality retention of seasoned tuna meat product. The shelf-life of the product under the optimum conditions was also predicted.

Materials and Methods

Sample preparation

Seasoned tuna meat product produced by an Agricultural Housewife Group under OTOP in Songkhla province (after HACCP was introduced and applied) was obtained direct from the producers. The product (50 g) was placed on a Polyethylene Terephthalate (PET) tray and packed in a polypropylene (PP: 80 μm in thickness; Water vapour permeability of 0.2271 g.mm/m² day atm and oxygen transmission rate (OTR) of 10.15 cm³/m² day atm at 0%RH 23°C), Nylon/Aluminium foil/LLDPE (Laminate: 80 μm in thickness; Water vapour permeability of 0.1773 g.mm/m² day atm and oxygen transmission rate (OTR) of 0.30 cm³/m²

day atm at 0%RH 23°C) and polyvinylidene chloride (PVDC: 80 µm in thickness; Water vapour permeability of 0.2007 g.mm/m² day atm and oxygen transmission rate (OTR) of 5.34 cm³/m² day atm at 0% RH 23°C) under the condition of air, 90% nitrogen and air with oxygen absorber using controlled storage chambers at the temperatures of 30, 37 and 40°C. Since the RH of these chambers could not be fully controlled, readings were only recorded. Triplicate samples from each treatment were randomly taken at 7 day intervals for analysis of quality and storage life.

Chemical analysis

Water activity was determined using Aw meter (Novasina, TH-500, Switzerland).

TBAR content was determined according to the method of Pearson [14] and expressed as mg malonaldehyde/kg sample.

Microbiological analysis

A sample (25 g) was removed aseptically and transferred to 225 ml of sterile 0.1% Butterfield's phosphate-buffer. The sample was homogenized for 30 seconds. A 10-fold dilution was made from the Butterfield's phosphate-buffer as needed for plating. For microbial enumeration, 0.1 ml samples of serial dilution were spread on the surface of plate count agar (Merck, Germany) and incubated at 35±2°C for 1-2 days for total plate count (TVC). Yeasts and moulds were enumerated using dichloran 18% glycerol (DG18) agar (Merck, Germany) after incubating at 30°C for 5 days [15].

Sensory evaluation

The sensory qualities of seasoned tuna meat during storage were evaluated every 7 days until the yeast and mould count exceeded acceptable levels (28, 28 and 21 days for products stored at 30, 37 and 40°C) by 30 panelists. Panelists were asked to evaluate the samples in terms of overall acceptance (1 = Dislike extremely 9 = Like extremely). The score of 5.0 was taken as the lowest limit of acceptability.

Statistical analysis

Data presented as mean values with standard deviations and subjected to statistical analysis with ANOVA and Duncan's multiple range test for the significant differences between the mean values of treatments ($\alpha = 0.05$) [16].

Shelf-life prediction by Q₁₀ calculation

The sample of the most suitable package and packing condition (from above) was selected to study the shelf-life prediction by Q₁₀ calculation according to Labuza's method [17]. The main quality criteria to terminate the shelf-life of the product consisted of yeast and mould count, TBARS and overall acceptance score.

Results and Discussion

Water activity

Changes in water activity of the seasoned tuna meat product were significantly affected by different packaging, packing condition and temperature of storage ($p < 0.05$) (Figure 1). Seasoned tuna meat packed in a laminate plastic bag and PVDC plastic bag had lower Aw than those packed in PP plastic bags because water vapour permeability of laminate plastic bags (0.1773 g.mm/m² day atm.) and PVDC plastic bags (0.2007g.mm/m² day atm.) were lower than those of PP plastic bags (0.2771g.mm/m² day atm). This result agrees with the theoretical considerations, wherein it can be expected that the best moisture barrier will be obtained from

packaging material having the lowest WVP [1, 7]. Therefore, the significant effect of packaging material could be observed at 30°C, 90% RH. On the other hand, the storage conditions at the elevated temperatures (37°C, 70% RH and 40°C, 65% RH) showed the most significant effect on the A_w compared to packages and packing conditions. In addition, the A_w of samples kept at these elevated temperatures tended to decrease over time particularly at 37°C, 70% RH wherein the A_w rapidly declined. It seems likely that the residual moisture was gradually released from the samples kept at this elevated temperature during storage [18]. Since the packaging materials tested provided a good moisture barrier, the balloon effect was also observed in some packages. However, the samples kept at 40°C, 65% RH had a lower decreasing rate of A_w compared to the storage conditions at 37°C, 70% RH. This probably occurs due to the oxidation of unsaturated fatty acids and decomposition of sugars and other compounds in the samples due to storage at the high temperature

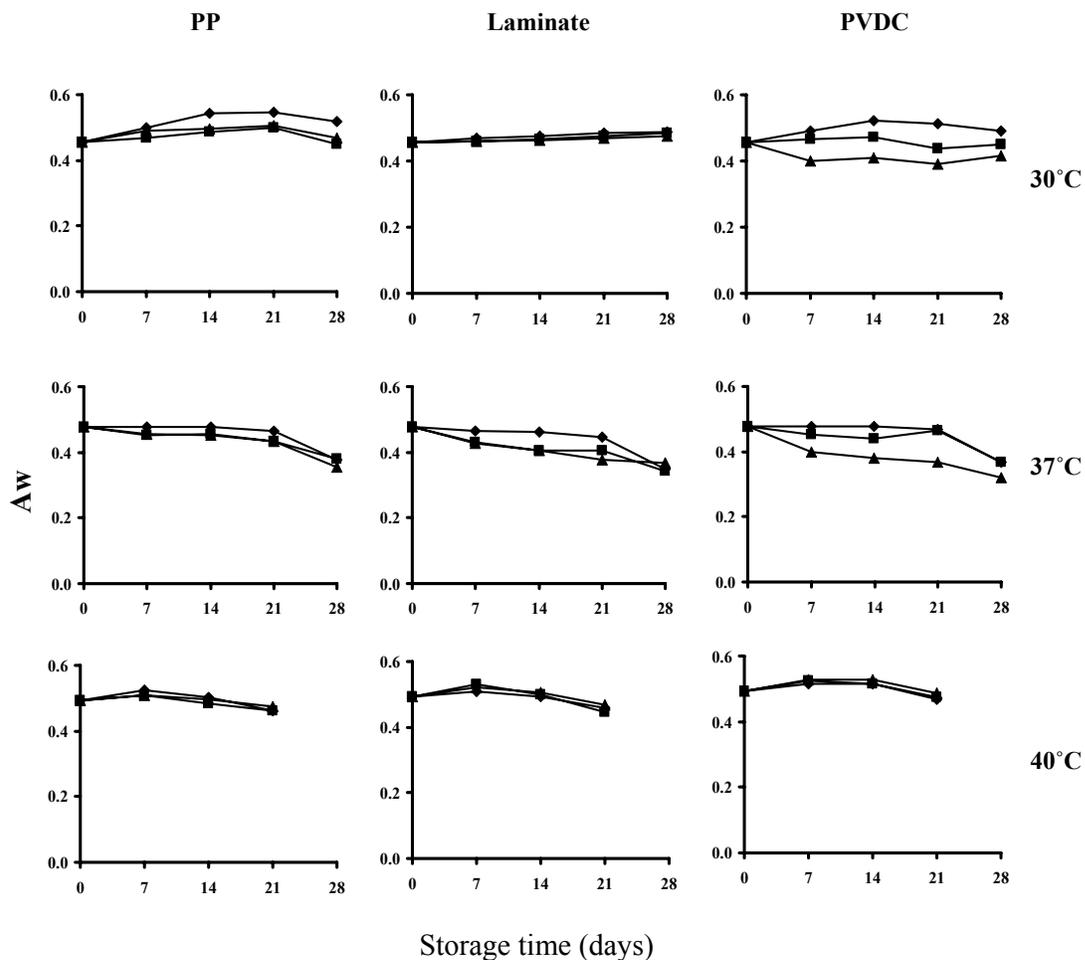


Figure 1. A_w values of seasoned tuna meat product packed in PP bag, laminate bag and PVDC bag under different packing condition during storage at 30, 37 and 40°C.

(—◆— Air, —■— 90% N₂, —▲— Air+O₂absorber)

Thiobarbituric acid reactive substances (TBARS) content

Changes in TBARS content of the seasoned tuna meat product were significantly affected by different packaging, packing condition and temperature of storage ($p < 0.05$) (Figure 2). Seasoned

tuna meat packed in PP plastic bags had higher TBARS content than the products packed in laminated plastic bags and PVDC plastic bags because water vapour permeability and oxygen transmission rate of PP plastic bags (0.2271 g.mm/m² day atm and 10.15 cm³/m² day atm at 0%RH 23°C) were more than that of laminated plastic bags (0.1773 g.mm/m² day atm and 0.30 cm³/m² day atm at 0%RH 23°C) and PVDC plastic bags (0.2007 g.mm/m² day atm and 5.34 cm³/m² day atm at 0%RH 23°C). These conditions might affect the transfer of moisture and oxygen from the environment to the product in PP plastic bags more so than the products packed in laminated plastic bags and PVDC plastic bags. TBARS content of seasoned tuna meat product under the three packing conditions tended to increase (p<0.05). Seasoned tuna meat packed under the condition of air with oxygen absorber had lower TBARS content than the products packed under the conditions of 90% nitrogen and air due to the effect of oxygen absorber on the oxygen content [19], which might slow down auto-oxidation of the product. TBARS content of the seasoned tuna meat at different storage temperatures tended to increase (p<0.05) throughout the storage period because the high temperature could activate lipid oxidation [20, 21]. TBARS content of seasoned tuna meat at the end of storage at 30, 37 and 40°C changed from 3.83 to 20.77 and 4.08 to 20.57 and 3.99 to 19.74 respectively. TBARS content at the most feasible level might cause undesirable flavours and malonaldehyde which is a breakdown product of unsaturated fatty acid and has been shown to be a carcinogenic initiator and mutagen, therefore there was a deliberate attempt to avoid exposure to those compounds [22, 23].

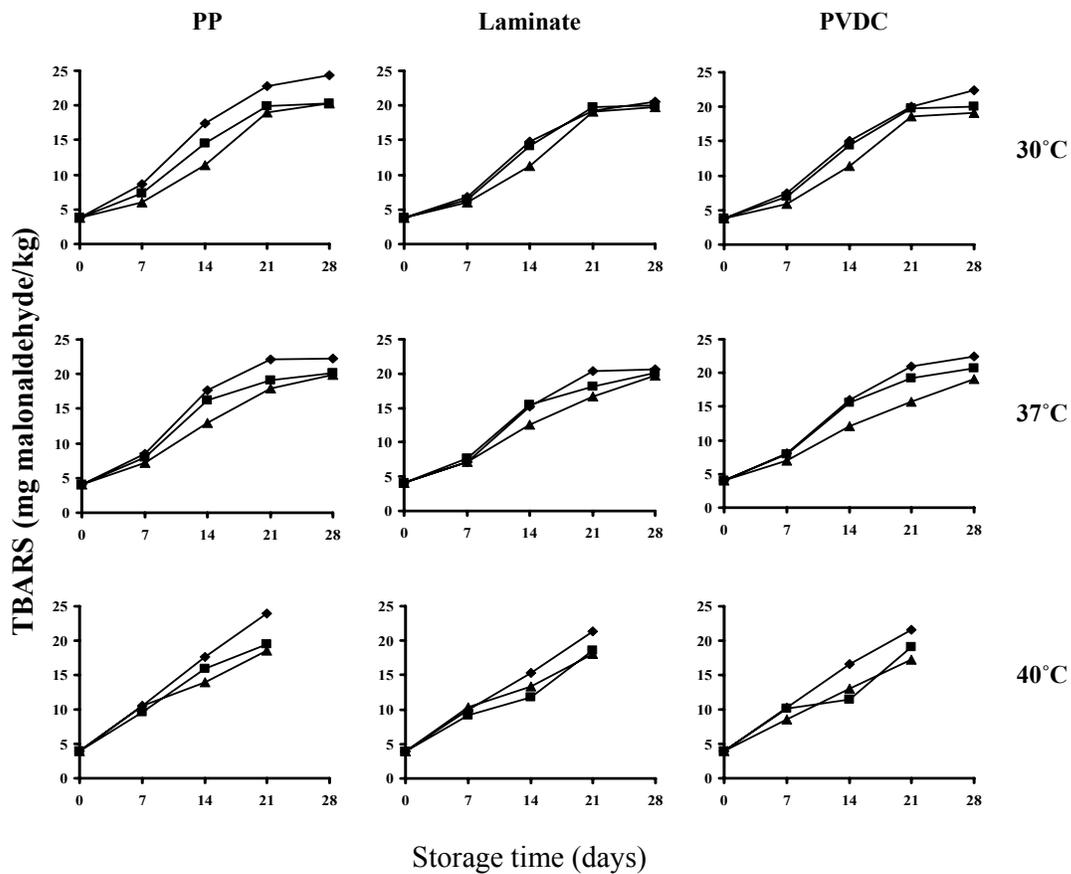


Figure 2. TBARS content of seasoned tuna meat packed in PP bag, laminated bag and PVDC bag under different packing conditions during storage at 30, 37 and 40°C.

(◆ Air, ■ 90% N₂, ▲ Air+O₂absorber)

Total viable count (TVC)

Changes in total viable count (TVC) of the seasoned tuna meat product were not significantly affected by different packaging ($p>0.05$). However, TVC tended to increase at 30°C throughout the storage and at the end of storage, TVC content changed from 40 cfu/g to 300 cfu/g (Figure 3) while they tended to decrease at storage temperatures of 37 and 40°C and at the end of storage, they changed from 53 cfu/g to 278 cfu/g and 37 cfu/g to 201 cfu/g. This was because the packing conditions had A_w less than 0.60 which was inappropriate for microbiological growth. Changes in TVC content of the seasoned tuna meat were significantly affected by different packing conditions ($p<0.05$) (Figure 3). Seasoned tuna meat packed under the conditions of air with oxygen absorber had lower TVC content than the products packed under the conditions of 90% nitrogen and air due to the effect of oxygen absorber on the oxygen content, resulting in unsuitable conditions for microbiological growth [19].

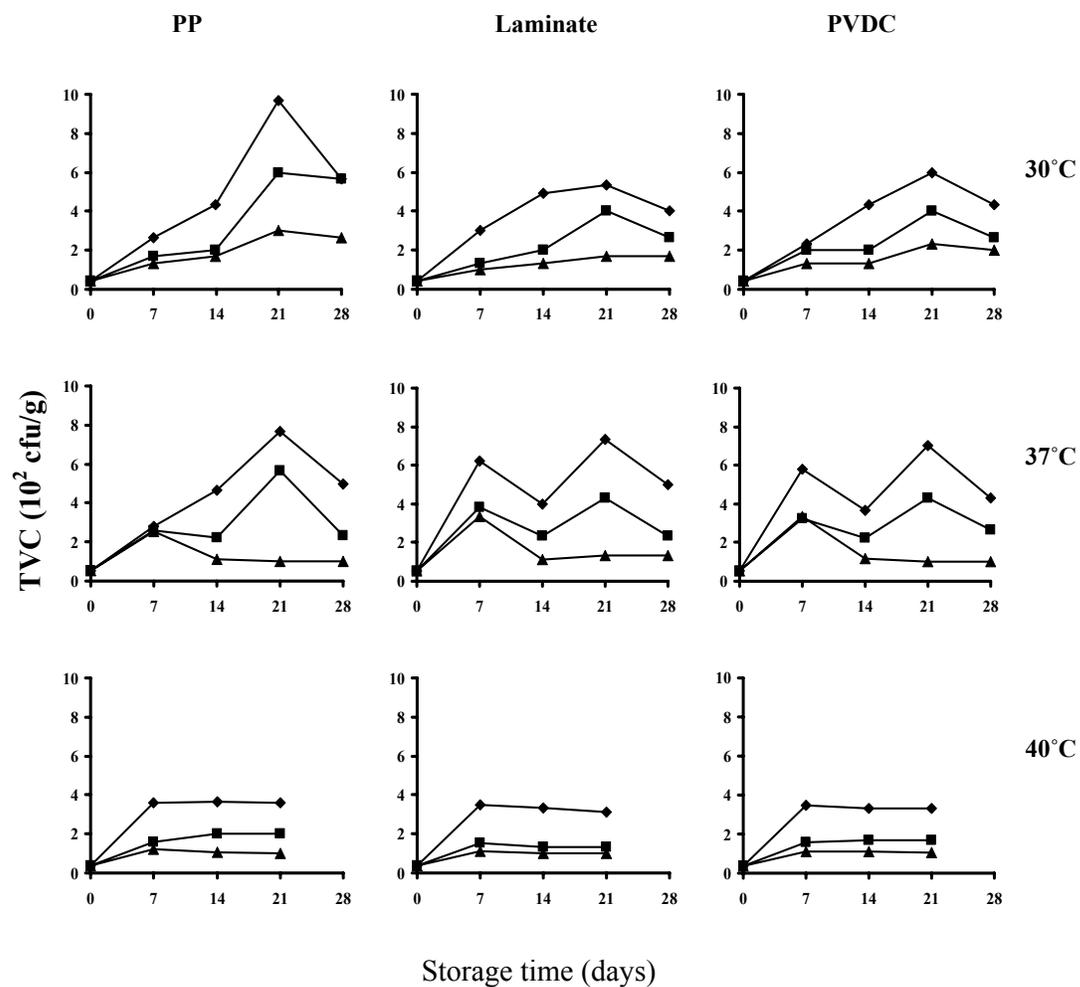


Figure 3. Total Viable Count of seasoned tuna meat packed in PP bag, laminated bag and PVDC bag under different packing conditions during storage at 30, 37 and 40°C.

(◆ Air, ■ 90% N₂, ▲ Air+O₂absorber)

Yeast and mould count

The different package, packing condition and storage temperature did not significantly affect the yeast and mould count of the product ($p>0.05$). However, as the storage time proceeded, they increased (Table 1) until exceeding the standard level of Thailand Community Standard NO.301/2004 (TISI, 2004) for seasoned tuna meat product (less than 100 cfu/g.) [24].

Table1. Yeast and mould count (x100 cfu/g) of seasoned tuna meat during storage.

Storage Temperature (°C)	Packaging material	Packing condition	Storage time (days)			
			0	14	21	28
30	PP	Air	0±0.00	0±0.00	1.33±0.58	2.46±0.15
		90%N ₂	0±0.00	0±0.00	1.00±0.00	2.00±0.00
		O ₂ Absorber	0±0.00	0±0.00	0.97±0.58	1.93±0.03
	Laminated	Air	0±0.00	0±0.00	1.33±0.58	2.48±0.00
		90%N ₂	0±0.00	0±0.00	0.97±0.58	2.08±0.19
		O ₂ Absorber	0±0.00	0±0.00	0.90±0.00	1.90±0.00
	PVDC	Air	0±0.00	0±0.00	1.00±0.00	2.42±0.10
		90%N ₂	0±0.00	0±0.00	1.00±0.00	2.00±0.00
		O ₂ Absorber	0±0.00	0±0.00	0.97±0.58	1.92±0.03
37	PP	Air	0±0.00	0±0.00	0.77±0.12	4.33±2.31
		90%N ₂	0±0.00	0±0.00	0.50±0.00	2.33±1.15
		O ₂ Absorber	0±0.00	0±0.00	0.43±0.15	5.50±0.71
	Laminated	Air	0±0.00	0±0.00	0.70±0.10	4.67±2.89
		90%N ₂	0±0.00	0±0.00	0.50±0.40	3.00±1.73
		O ₂ Absorber	0±0.00	0±0.00	0.40±0.00	4.50±0.71
	PVDC	Air	0±0.00	0±0.00	0.73±0.12	5.00±4.00
		90%N ₂	0±0.00	0±0.00	0.53±0.15	2.67±1.53
		O ₂ Absorber	0±0.00	0±0.00	0.50±0.10	5.00±1.41
40	PP	Air	0±0.00	0±0.00	2.33±0.58	-
		90%N ₂	0±0.00	0±0.00	1.00±1.00	-
		O ₂ Absorber	0±0.00	0±0.00	1.00±1.00	-
	Laminated	Air	0±0.00	0±0.00	2.00±0.00	-
		90%N ₂	0±0.00	0±0.00	1.00±0.00	-
		O ₂ Absorber	0±0.00	0±0.00	1.00±1.00	-
	PVDC	Air	0±0.00	0±0.00	2.33±0.58	-
		90%N ₂	0±0.00	0±0.00	1.03±1.53	-
		O ₂ Absorber	0±0.00	0±0.00	1.00±0.00	-

Mean ± standard deviation from 3 replicates

Sensory evaluation

Changes in sensory score for overall acceptance of the seasoned tuna meat product were significantly affected by different packaging, packing condition and temperature of storage ($p<0.05$) (Figure 4). The products stored at temperature 30, 37 and 40°C had overall acceptance score decrease from 7.51 to 5.58; 7.37 to 5.82 and 7.10 to 4.89, respectively, at the end of storage.

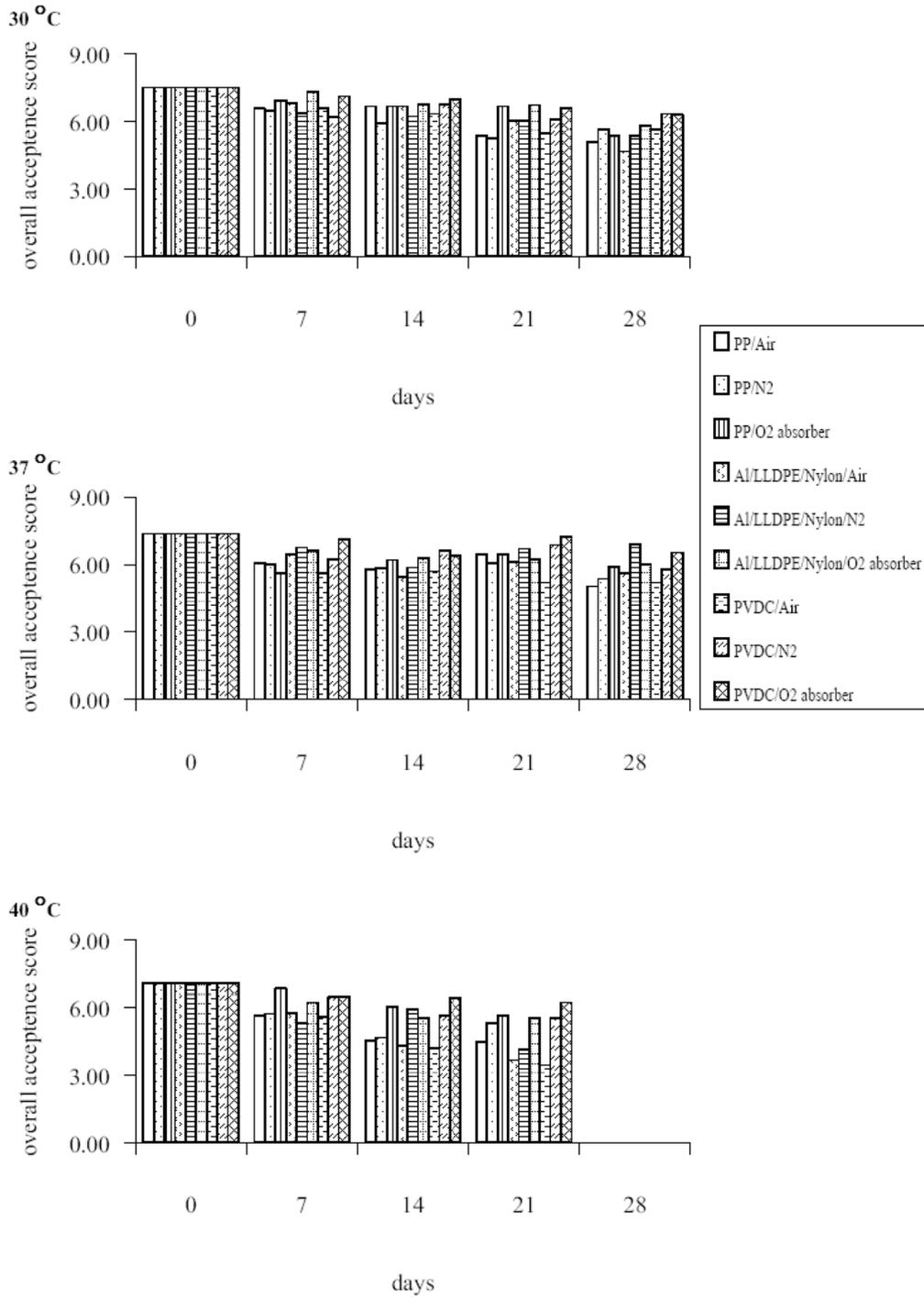


Figure 4. Sensory score for overall acceptance of seasoned tuna meat product packed in PP bag, laminated bag and PVDC bag under different packing conditions during storage at 30, 37 and 40°C.

Shelf life prediction by Q_{10} calculation

The different package, packing condition and storage temperature significantly affected the sensory score for overall acceptability. If yeast and mould count, TBARS content and overall acceptance score were used as quality and food safety indicators, the seasoned tuna meat product packed in polyvinylidene chloride (PVDC) under air with oxygen absorber was the most suitable and could be stored at 30, 37 and 40°C for 28, 28 and 21 days, respectively. On the other hand, the predicted shelf life of seasoned tuna meat in polyvinylidene chloride (PVDC) under air with oxygen absorber at 37°C by Q_{10} calculation was only 23 days.

Conclusions

Aw and TBARS content of the seasoned tuna meat product were significantly affected by different packaging, packing condition and temperature of storage ($p < 0.05$). The microbiological quality of the product stored under different packaging, packing condition and temperature did not significantly change in yeast and mould count, but total viable counts significantly increased ($p < 0.05$) as the storage time increased. The different packaging, packing condition and storage temperature significantly affected the sensory score for overall acceptability. If yeast and mould count, TBARS content and overall acceptance score were used as quality and food safety indicators, the seasoned tuna meat product packed in polyvinylidene chloride (PVDC) under air with oxygen absorber was the most suitable and could be stored at 30, 37 and 40°C for 28, 28 and 21 days, respectively. The predicted shelf life of seasoned tuna meat packed in polyvinylidene chloride (PVDC) under air with oxygen absorber at 37°C by Q_{10} calculation was only 23 days.

Acknowledgements

The authors would like to thank the Prince of Songkla University and the Thailand Research Fund for providing an annual budget to carry out this research work.

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