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Research Article

INFLUENCE OF PACKAGING MATERIAL AND DILL LEAF ENRICHMENT ON THE FATTY ACID PROFILES OF TUNA PATE DURING REFRIGERATED STORAGE

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ABSTRACT. Tuna species are most commonly consumed fish species globally. Due to high rate of generated by products during canning process, the valorization of these by-product has gained importance over the last years. Tuna pate is an alternative for valorization of tuna by products. Packaging material is one of the key factor for the quality of food products through shelf life. Utilization of plant material into several food products has become popular owing to its antioxidant property. The two aims of the study were to investigate the proximate composition and fatty acid profile of tuna pates enriched with dill leaf and the effect of packaging materials on relevant quality parameters. For these two approaches, two tuna pates produced from tuna flake with without or dill leaf enrichment and DE, respectively. Then each pate group was separated into three sub-groups; which were stored in flint glass (F), amber glass (A) and plastic container (P).All sub-groups stored in refrigerator at 4±2 °C within for 24 weeks. The differences in terms of proximate composition determined following to tuna pate production stage. The variation of fatty acid profile among tuna pate groups during the storage. The results showed that dill leaf enrichment retarded the lipid oxidation and fatty acid oxidation during the shelf life. Similar impact was determined in stored in amber glass groups (CA and DEA) when compared with other packaging material groups ($P<0.05$). These findings revealed that, statistically significant differences observed in terms of PUFA, SFA and MUFA among the groups. Enriching with dill leaf and storing in amber glass jar prolonged the shelf life of tuna pate.

Keywords: *Fatty acid profile, tuna, pate, refrigerated storage, proximate composition, dill leaf*

INTRODUCTION

Pâté is classified as an emulsified meat product prepared from offal, such as liver, fatty meat and other ingredients. This product commonly consumed around the world owing to its rich and smooth texture [1]. Historically, the first pate was prepared from goose liver which is known "foie-grass", thereafter liver from several animals such as pork [2] and chicken [3] were used for pate production. With better understanding of seafood importance, fish pate is becoming popular which allows new sensorial properties and nutritional benefits [4].

Generally, fatty fish species and by-products of them are used for pate production due to their desirable taste and superior emulsifier capacity. By-products from seafood processing industry are obtain after different methods, generate up to 60% containing skin, trimmings and chunks [5]. Valorisation of these compounds into highly-profit products has offered an environmental and economic solution [6]. Among the seafood by-products, canned tuna chunk considered as an important compound as the tuna canning industry is world's second-largest international seafood trade. Similar to other seafood, pâté products are also highly susceptible to oxidation and microbial deterioration. Due to these reasons, the storage conditions, whether the addition of any antioxidant or not and packaging material are important for quality and shelf life of these products. Thus, the objective of the present study was conducted to elucidate the effects of dill leaf addition as a natural antioxidant and antimicrobial on the oxidative stability of tuna pate in different packaging material. Furthermore, the effect of packaging material (jar and plastics) and colour of packaging material (flint or amber glass jar) on quality of tuna pate during the refrigerated storage at 2 ± 1 ºC were assessed by proximate composition and fatty acid composition.

MATERIALS AND METHODS

Materials

Pre-cooked and non-used skipjack tuna (*Katsuwonus pelamis*) chunks for canning process were considered as by-product. Tuna chunks were obtained in the frozen state from seafood processing plant (Sasu Ltd., Adana, Turkey) the other ingredients (potato, starch, lemon juice, salt, milk powder) were obtained from local market located in Adana, Turkey. Tuna chunks samples were packed in ice and transported to the laboratory on the same day, then stored at -80ºC up to tuna pate production. Dill leaves (*Anethum graveolens*) were also obtained from the local market as fresh form and then washed, dried and grinded. All reagents used were of analytical grade and obtained from Sigma-Aldrich, Inc. (St. Louis, MO, USA) and Merck (Darmstadt, Germany).

Tuna Pate Preparation and Storage

For the production of the tuna pâté, tuna chunks and other indigents were mixed in two different formulations. The recipes of main pâté groups (g/100 g) are shown in Table 1. Thawed tuna chunks were used for each batch and manufactured as follows: first, tuna chunks were chopped and mixed in a dough mixer (AHE.PM.5, Alveo, Turkey) at 4 °C until obtaining a homogeneous meat dough (10 min). During this process, mush potato, cold water, milk powder, salt, starch, and sunflower oil were added gradually. The total pate dough was divided into 2 group: Control group (C) was stored without any other ingredient addition, for dill leaf enriched (DE) group, dried dill leaves and lemon juice were added to control groups while mixing slowly. Then, each pate group was divided into three sub-groups based on packaging material (F: flint glass jar, A: amber glass jar and P: plastic container).Different tuna pate groups (C and DE) in different packaging materials classified as CF,CA,CP,DEF,DEA,DEP. The pâtés were manually full filled (~100 g) into packaging materials and closed. Then, thermal treatment (80 °C/45 min) was applied in a laboratory-type oven (Tefal model; 18L; Tefal, Barcelona, Spain). Pâté groups were stored under refrigerated conditions at 2±1 °C during 24 weeks. For each groups, stored tuna pate were selected by randomly and all analysis were carried out in triplicates on week 0, 7, 12, 16,20,22 and 24 of storage.

Determination of Proximate Composition

For determination of the proximate composition of tuna pate groups, protein, lipid, moisture and ash content were quantified. The crude protein was measured by a Kjeldahl technique (Association of Official Agricultural Chemists [7]. Lipid content was analysed according to the Bligh & Dyer [8] technique. Tuna pate samples were analyzed for moisture by oven drying of 5 g of sample at 105 °C and the ash content was estimated by the method. Both moisture and ash content was carried out according to AOAC Method [9].

Fatty Acid Analysis

In order to determinate the fatty acid profile, the extracted tuna pate oil was methyl esterified by using the method of Ichihara et al.,[10]. 10 mg of extracted oil sample was dissolved in heptane (2 ml) and then mixed with 2 M methanolic KOH (4 ml) and then centrifuged at 4000 rpm for 10 min, and heptane layer was collected for gas chromatography (GC) analyses. The fatty acid profile determination was carried out by using a capillary GC (Clarus 500 Perkin Elmer, Shelton, CT, USA) which was equipped with a fused silica capillary column and flame ionisation detector. Investigation of the fatty acid profile, each fatty acid peaks were characterized by comparing the retention times of FAME with the standard 37-component FAME mixture (Sigma-Aldrich Chemie GmbH, Munich, Germany). Three replicate samples were run and data was indicated as mean value ± standard deviation, which expressed in GC area %.

Fatty acid methyl ester analyses (FAME) Extracted lipids were derivatized to fatty acid methyl esters (FAME) according to the method of Ichihara et al. (1996) with minor modifications. Briefly, 25 mg of extracted lipid sample was dissolved in 2 ml of n-heptane followed by 4 ml of 2 M KOH. The mixture was shaken in a vortex for 2 min at room temperature and centrifuged at 4000 RPM for 10 min, and the nheptane layer containing the FAME was collected to be analysed by gas chromatography (GC). Gas chromatographic condition The determination of fatty acid composition was evaluated by gas chromatography (GC) Clarus 500 device (Perkin–Elmer, USA), equipped with a flame ionization detector and a fused silica capillary SGE column (60 m × 0.32 mm ID BPX70 × 0.25 μm, USA or Australia). The oven temperature was 140 °C held for 8 min and raised to 220 °C at a rate of 4 °C/min and then to 230 °C at a rate of 1 °C/min, while the injector and detector temperatures were maintained at 260 and 230 °C, respectively. Helium was used as a carrier gas and had a flow of 40 ml/min (1:40), with a constant pressure of 16 ps. During the analysis, 1 μl of the sample was injected. Fatty acids were identified by comparison of their retention index with that of a mixture of external standard methyl esters (Supelco 37 F.A.M.E. Mix C4-C24 Component, Catalogue No. 18919).

Statistical Analysis

All measurements were carried out in triplicate and the results are given as the mean and standard deviation. A general linear model, one-way variance analysis (ANOVA) was used to determine the statistically significant differences ($P<0.05$) among different formulation tuna pates stored in different packaging material applied by using the software SPSS version 19 (Chicago, Illinois, USA).

RESULTS AND DISCUSSION

Proximate Composition of Raw Material and Tuna Pate Groups

Proximate composition of tuna chunk were determined as 24. 78% (crude protein), 18.56% (lipid), 56.24% (moisture), and 1.96% (ash), respectively (Table 2). These values are in agreement with previous research which stated that protein content of skipjack tuna changed between 14.60 and 26.50% Nakamura et al.,[11] and Peng et al.,[12]. Similar lipid content of tuna was reported by Mahaliyana et al.,[13].They highlighted that the lipid content of tuna species differ from 8.0-39.2 % depend on the various factors such as age, environmental conditions and diet. Proximate composition of tuna pates is shown in Table 2. The protein content of C and DE group was found 13.68 % and 12.51 %., respectively. Lipid rate of control group (29.84 %) determined higher than dill leaf enriched group (28.15%). It is known that high lipid content of pate products caused by used fatty fish material or viscera and external oil addition during pate production [14]. In terms of proximate composition, the main difference between two pate groups was found in moisture content, which can be explained by external lemon juice addition to DE group. (C: 53.85 and DE: 56.42 %, respectively). Xiong et al.[15] similarly determined moisture content of tuna pate changed between 51.96 and 52.36%. The ash content of pate formulation groups was found 1.75 and 2.05 % for C and DE group respectively.

Differentiation of Fatty Acid Profile during Refrigerated Storage

The impact of dill leaf enrichment and stored in different packaging material on fatty acid profile of tuna pate during refrigerated storage are given in Table 3. The lipids presented 19.99 and 19.69% of saturated fatty acids (SFA) for C and DE group, respectively which was dominated by palmitic acid (C16:0) followed by Stearic acid (C18:0) in the two group. The dominant acids of the monounsaturated fatty acids (MUFA) fraction were palmitoleic acid (C16:1), oleic acid (C18:1*n*-9) in total 34.49 % and 35.74 % MUFA for C and DE group, respectively. Total MUFA contents of tuna pate groups are in agreement with the results reported by Peng et al. [12]who reported that the MUFA content of tuna species was changed between 26.66 and 38.08 %. The sum of polyunsaturated fatty acids (PUFA) was found 36.16 % for C and 37.58 % for DE group with highest level of docosahexaenoic acid (C22:6*n*-3, DHA) linoleic acid (C18:2n6) and eicosapentaenoic acid (C20:5*n*-3, EPA) (Table 3). The PUFA content of tuna pates groups (C:36.16, DE:37.58) also consisted with the findings of Mahaliyana et al., [13] who found PUFA value for skipjack tuna 23.16-49.40%. Initial SFA content, 19.99%, for control group raised to 20.53, 20.53 and 20.64 % for CF, CA, CP group, respectively. Similar significant increases were observed in DE group, from 19.69 to 20.87, 20.63 and 20.71 for DEF, DEA and DEP group, respectively. MUFAs percent increased from 34.49 to 38.22-40.73 % for control groups, without dill leaf addition. For dill enriched groups, initial MUFA content (35.74%) increased to 39.99-44.49%. These changes are in agreement with previous study carried out by Siriamornpun, et al.,[16]. They demonstrated that SFA and MUFAs content of processed tuna products were increased during refrigerated storage. PUFAs level of stored tuna pates showed some fluctuations during the 16 weeks thereafter, significant decreases were observed in all groups at the end of storage (week 24). For control groups, initial PUFA value (36.16%) decreased to 34.16-36.17%. and for DE groups, initial PUFA value (37.58 %) was decreased by 35.5-

37.7%. In dill leave treated groups, the PUFA level less affected by storage period and protected well when compared with the control group.

Table 1. *The formulation of tuna pate groups*

Ingredients (%)	**Groups**	
	C	DE
Tuna chunk	52,91	50,99
Mush potato	29,39	28,33
Sunflower oil	6,17	5,95
Cold water	4,41	4,25
Milk powder	4,00	3,85
Starch	2,94	2,83
Salt	0,18	0,17
Dill leaf	-	2,41
Lemon sauce	-	1,22
TOTAL	100	100

Group: Control tuna pate, DEF: Dill leaf enriched tuna pate

Table 2. *Proximate analysis of different formulation of tuna pate*

	Raw material (Tuna chunks)	**Pate group**	
		Control	**DE**
Moisture	56.24±0.12	53.85±0.07^{b}	56.42±0.06^{a}
Protein	24.78±0.06	13.68±0.06^{a}	12.51±0.03^{a}
Lipid	18.56±0.14	29.84±0.12^{a}	28.15±0.05^{b}
Crude ash	1.96±0.08	1.75±0.03^{b}	2.05±0.13^{a}

$^{a-d}$ Values followed by different letters indicate significant differences (P<0.05)

Table 3. *Effect of dill leaf addition and stored in different packaging material on fatty acid profile changes of tuna pate during refrigerated storage*

Fatty Acid	Storage time (weeks)							Groups
	0	7	12	16	20	22	24	
C12:0	0.44±0.13	0.82±0.08^{c}	0.44±0.02^{c}	0.40±0.00^{bc}	0.52±0.02^{b}	0.80±0.02^{a}	0.82±0.02^{c}	CF
	-	0.73±0.01^{c}	0.40±0.02^{c}	0.38±0.00^{bc}	0.44±0.04^{bc}	0.74±0.02^{cd}	0.85±0.03^{c}	CA
	-	0.47±0.01^{d}	0.32±0.02^{d}	0.35±0.01^{bc}	0.40±0.02^{bc}	0.69±0.03^{cd}	0.88±0.02^{ab}	CP
	0.39±0.11	0.52±0.02^{c}	0.49±0.03^{c}	0.42±0.04^{c}	0.57±0.03^{cd}	0.76±0.04^{bc}	0.85±0.01^{a}	DEF
	-	0.55±0.01^{b}	0.68±0.06^{b}	0.76±0.16^{a}	0.65±0.03^{a}	0.79±0.03^{b}	0.90±0.00^{a}	DEA
	-	0.60±0.02^{a}	0.66±0.04^{a}	0.37±0.03^{b}	0.46±0.02^{d}	0.71±0.03^{de}	0.87±0.04^{b}	DEP
C14:0	2.50±0.07	2.75±0.05^{ab}	2.86±0.12^{a}	2.92±0.04^{bc}	2.99±0.07^{b}	3.01±0.01^{ab}	3.18±0.12^{a}	CF
	-	2.72±0.10^{ab}	2.79±0.03^{b}	2.85±0.11^{bc}	3,05±0.03^{a}	3.05±0.01^{a}	3.22±0.04^{d}	CA
	-	2.66±0.12^{ab}	2.76±0.08^{b}	2.91±0.03^{c}	2,95±0.01^{a}	2.99±0.03^{ab}	3.11±0.03^{ab}	CP
	2.45±0.01	2.81±0.07^{ab}	2.73±0.01^{b}	2.95±0.05^{a}	3.02±0.02^{a}	3.23±0.11^{a}	3.36±0.06^{bc}	DEF
	-	2.83±0.11^{a}	2.58±0.04^{b}	2.68±0.02^{abc}	3.06±0.02^{b}	3.02±0.18^{ab}	3.38±0.12^{ab}	DEA
	-	2.39±0.07^{ab}	2.46±0.12^{b}	2.64±0.12^{bc}	3.01±0.03^{a}	3.02±0.04^{ab}	3.14±0.06^{cd}	DEP
C16:0	13.54±0.16	13.71±0.03^{bc}	14.12±0.28^{bcd}	12.86±0.51	13.15±0.05^{e}	13.24±0.12^{bc}	12.89±0.11^{b}	CF
	-	13.24±0.12^{d}	14.93±0.11^{ab}	12.05±0.01	13.04±0.02^{c}	13.02±0.04^{bc}	13.06±0.12^{de}	CA
	-	13.38±0.04^{d}	14.99±0.03^{d}	12.99±0.01^{a}	12.89±0.21^{a}	12.86±0.51	13.15±0.05^{e}	CP
	13.04±0.02	13.03±0.04^{cd}	14.45±0.05^{bcd}	13.02±0.02^{cd}	12.98±0.04^{bc}	12.05±0.01	13.04±0.02^{c}	DEF
	-	14.45±1.13^{a}	15.53±0.03^{a}	12.89±0.11^{b}	12.68±0.02^{bc}	12.99±0.01^{a}	12.89±0.21^{a}	DEA
	-	14.94±0.22^{cd}	15.76±0.04^{bc}	13.06±0.12^{de}	13.06±0.02^{c}	13.02±0.02^{cd}	12.98±0.04^{bc}	DEP
C17:0	0.44±0.13	0.09±0.01^{a}	0.08±0.02^{a}	0.07±0.01^{a}	0.06±0.01^{b}	0.06±0.02^{a}	0.06±0.01^{a}	CF
	-	0.09±0.01^{a}	0.09±0.00^{c}	0.08±0.00^{a}	0.08±0.01^{ab}	0.07±0.01^{a}	0.07±0.01^{a}	CA
	-	0.08±0.01^{a}	0.07±0.00^{ab}	0.06±0.00^{a}	0.06±0.01^{b}	0.06±0.01^{a}	0.06±0.00^{a}	CP
	0.39±0.11	0.09±0.01^{a}	0.09±0.01^{ab}	0.08±0.01^{a}	0.08±0.01^{a}	0.06±0.01^{a}	0.07±0.01^{a}	DEF
	-	0.09±0.02^{a}	0.08±0.01^{ab}	0.08±0.01^{a}	0.09±0.00^{ab}	0.07±0.02^{a}	0.07±0.02^{a}	DEA
	-	0.08±0.01^{a}	0.08±0.01^{ab}	0.07±0.01^{a}	0.07±0.01^{ab}	0.06±0.02^{a}	0.06±0.00^{a}	DEP
C18:0	3.27±0.09	3.75±0.13^{a}	3.22±0.02^{cd}	3.45±0.11^{b}	3.45±0.11^{b}	3.05±0.07	3.31±0.12^{ab}	CF
	-	3.44±0.12^{a}	3.54±0.02^{a}	3.51±0.16^{b}	3.51±0.16^{b}	3.05±0.07	3.05±0.03^{b}	CA
	-	3.66±0.22^{ab}	3.50±0.16^{c}	3.54±0.14^{a}	3.54±0.14^{a}	3.14±0.02^{b}	3.19±0.07^{c}	CP
	3.62±0.02	3.88±0.02^{b}	3.45±0.11^{b}	3.45±0.11^{b}	3.15±0.07	3.16±0.08^{b}	3.26±0.08^{a}	DEF
	-	3.41±0.03^{ab}	3.51±0.16^{b}	3.51±0.16^{b}	3.14±0.02^{b}	2.93±0.03^{c}	3.01±0.04^{b}	DEA
	-	3.78±0.12^{ab}	3.54±0.14^{a}	3.54±0.14^{a}	3.26±0.08^{b}	3.22±0.04^{ab}	3.37±0.03^{a}	DEP
C20:0	0.15±0.00	0.17±0.01^{a}	0.19±0.03^{a}	0.18±0.02^{b}	0.20±0.02^{a}	0.24±0.02^{a}	0.27±0.03^{b}	CF
	-	0.18±0.02^{a}	0.21±0.01^{a}	0.19±0.00^{b}	0.22±0.02^{ab}	0.25±0.01^{ab}	0.28±0.02^{ab}	CA
	-	0.14±0.02^{a}	0.17±0.01^{a}	0.16±0.02^{b}	0.19±0.01^{b}	0.27±0.03^{ab}	0.25±0.01^{b}	CP
	0.12±0.02	0.18±0.01^{a}	0.21±0.01^{a}	0.19±0.01^{a}	0.23±0.01^{ab}	0.28±0.02^{b}	0.29±0.01^{a}	DEF
	-	0.22±0.01^{a}	0.23±0.01^{a}	0.20±0.00^{b}	0.24±0.02^{b}	0.29±0.03^{ab}	0.31±0.03^{b}	DEA
	-	0.15±0.01^{a}	0.19±0.02^{a}	0.18±0.01^{b}	0.22±0.02^{a}	0.26±0.02^{ab}	0.29±0.01^{ab}	DEP
∑ SFA	**19.99**	**21.29**	**20.91**	**19.88**	**20.37**	**20.40**	**20.53**	**CF**
	-	**20.40**	**21.96**	**19.06**	**20.34**	**20.18**	**20.53**	**CA**
	-	**20.39**	**21.81**	**20.01**	**20.03**	**20.01**	**20.64**	**CP**
	19.69	**20.51**	**21.42**	**20.11**	**20.03**	**19.54**	**20.87**	**DEF**
	-	**21.55**	**22.61**	**20.12**	**19.86**	**20.09**	**20.63**	**DEA**
	-	**21.94**	**22.69**	**19.86**	**20.08**	**20.29**	**20.71**	**DEP**

C14:1	0.07±0.00	0.08±0.01^{a}	0.09±0.01^{a}	0.10±0.02^{a}	0.13±0.01^{b}	0.14±0.02^{a}	0.16±0.02^{ab}	**CF**
	-	0.09±0.01^{a}	0.10±0.02^{ab}	0.12±0.04^{a}	0.15±0.03^{b}	0.17±0.03^{a}	0.19±0.05^{a}	**CA**
	-	0.07±0.00^{a}	0.09±0.01^{ab}	0.09±0.02^{a}	0.12±0.01^{ab}	0.11±0.01^{a}	0.13±0.03^{ab}	**CP**
	0.08±0.01	0.09±0.00^{a}	0.11±0.01^{ab}	0.12±0.02^{a}	0.15±0.02^{ab}	0.15±0.01^{a}	0.19±0.01^{a}	**DEF**
	-	0.09±0.02^{a}	0.12±0.02^{b}	0.14±0.02^{a}	0.16±0.02^{ab}	0.18±0.02^{a}	0.21±0.01^{a}	**DEA**
	-	0.08±0.01^{a}	0.09±0.01^{b}	0.10±0.02^{a}	0.12±0.02^{a}	0.10±0.02^{a}	0.16±0.02^{a}	**DEP**
C16:1	4.68±0.12	4.60±0.12^{a}	4.64±0.16^{c}	4.98±0.12^{d}	5.11±0.13^{d}	4.19±0.03^{c}	4.32±0.16^{ab}	**CF**
	-	4.75±0.05^{a}	4.82±0.12^{bc}	5.03±0.03^{b}	5.14±0.06^{b}	4.28±0.04^{a}	4.46±0.12^{ab}	**CA**
	-	4.56±0.02^{a}	4.55±0.11^{ab}	4.91±0.11^{b}	4.98±0.12^{cd}	4.16±0.14^{c}	4.24±0.02^{bc}	**CP**
	4.72±0.08	4.68±0.02^{a}	4.72±0.06^{c}	5.11±0.07^{a}	5.17±0.03^{bc}	4.23±0.07^{b}	4.54±0.08^{ab}	**DEF**
	-	4.77±0.03^{a}	4.89±0.11^{bc}	5.16±0.04^{c}	5.19±0.03^{c}	428±0.06^{b}	4.59±0.11^{c}	**DEA**
	-	4.65±0.15^{a}	4.67±0.13^{d}	5.02±0.02^{b}	5.01±0.23^{c}	4.18±0.09^{b}	4.41±0.13^{d}	**DEP**
C17:1	0.09±0.01	0.10±0.00^{a}	0.11±0.01^{a}	0.14±0.02^{a}	0.15±0.01^{b}	0.17±0.01^{a}	0.19±0.01^{a}	**CF**
	-	0.11±0.01^{a}	0.12±0.01^{a}	0.16±0.02^{a}	0.17±0.03^{ab}	0.19±0.01^{a}	0.20±0.02^{a}	**CA**
	-	0.09±0.01^{a}	0.10±0.00^{a}	0.11±0.01^{a}	0.12±0.02^{b}	0.14±0.02^{a}	0.21±0.01^{a}	**CP**
	0.10±0.01	0.09±0.01^{a}	0.13±0.01^{a}	0.14±0.02^{a}	0.18±0.02^{b}	0.20±0.02^{a}	0.22±0.02^{a}	**DEF**
	-	0.10±0.01^{a}	0.15±0.01^{a}	0.13±0.01^{a}	0.19±0.03^{ab}	0.21±0.03^{a}	0.24±0.06^{a}	**DEA**
	-	0.11±0.01^{a}	0.10±0.01^{a}	0.12±0.02^{a}	0.17±0.01^{ab}	0.19±0.01^{a}	0.16±0.02^{a}	**DEP**
C18:1n9	28.74±0.35	28.34±0.12^{b}	28.95±0.17^{c}	29.16±0.28^{de}	30.31±0.15^{cd}	31.48±0.04^{b}	32.42±0.14^{d}	**CF**
	-	29.10±0.03^{a}	29.44±0.08^{b}	30.04±0.06^{cd}	31.99±0.12^{cd}	30.05±0.12^{a}	33.15±0.13^{abc}	**CA**
	-	30.27±0.03^{a}	30.85±0.05^{a}	29.88±0.12^{a}	28.89±0.07^{ab}	29.45±0.07^{a}	31.05±0.16^{cd}	**CP**
	29.83±0.17	30.12±0.10^{a}	31.45±0.04^{a}	32.40±0.04^{bc}	33.82±0.04^{a}	34.14±0.06^{a}	35.14±0.02^{bc}	**DEF**
	-	30.19±0.03^{a}	30.24±0.04^{a}	32.99±0.06^{a}	34.06±0.12^{d}	35.44±0.12^{a}	36.51±0.17^{ab}	**DEA**
	-	30.03±0.21^{a}	29.77±0.16^{c}	30.19±0.14^{e}	30.34±0.10^{b}	31.22±0.06^{a}	32.59±0.13^{a}	**DEP**
C20:1	0.72±0.06	0.93±0.01^{a}	0.99±0.03^{cd}	1.05±0.03^{a}	1.15±0.03^{c}	1.20±0.02^{ab}	1.33±0.05^{ab}	**CF**
	-	0.98±0.12^{abc}	1.06±0.02^{bc}	1.17±0.03^{ab}	1.19±0.05^{ab}	1.22±0.04^{c}	1.39±0.07^{a}	**CA**
	-	0.85±0.03^{c}	0.93±0.03^{d}	0.99±0.03^{b}	1.05±0.03^{bc}	1.12±0.04^{ab}	1.28±0.12^{b}	**CP**
	0.79±0.05	1.02±0.12^{a}	1.12±0.02^{bc}	1.23±0.03^{ab}	1.34±0.02^{bc}	1.36±0.02^{bc}	1.45±0.07^{ab}	**DEF**
	-	0.99±0.11^{bc}	1.13±0.05^{bc}	1.25±0.03^{ab}	1.39±0.03^{ab}	1.40±0.05^{a}	1.52±0.14^{ab}	**DEA**
	-	0.88±0.04^{abc}	1.01±0.03^{a}	1.16±0.12^{ab}	1.22±0.04^{c}	1.28±0.06^{c}	1.36±0.04^{ab}	**DEP**
C22:1n9	0.19±0.03	0.20±0.02^{a}	0.24±0.02^{a}	0.38±0.02^{b}	0.27±0.01^{ab}	0.29±0.03^{bc}	0.32±0.04^{ab}	**CF**
	-	0.22±0.02^{a}	0.26±0.04^{ab}	0.21±0.05^{ab}	0.29±0.03^{c}	0.31±0.05^{d}	0.34±0.06^{a}	**CA**
	-	0.19±0.03^{a}	0.22±0.02^{ab}	0.27±0.01^{a}	0.24±0.02^{abc}	0.22±0.02^{cd}	0.31±0.01^{c}	**CP**
	0.22±0.04	0.22±0.02^{a}	0.23±0.03^{b}	0.25±0.03^{a}	0.28±0.02^{c}	0.29±0.03^{b}	0.39±0.07^{d}	**DEF**
	-	0.24±0.02^{b}	0.25±0.03^{b}	0.27±0.03^{a}	0.29±0.01^{ab}	0.32±0.02^{a}	0.42±0.04^{abc}	**DEA**
	-	0.21±0.01^{a}	0.19±0.02^{ab}	0.21±0.01^{b}	0.22±0.02^{bc}	0.24±0.02^{cd}	0.31±0.07^{bc}	**DEP**
∑ MUFA	**34.49**	**34.25**	**35.02**	**35.81**	**37.12**	**38.47**	**39.74**	**CF**
	-	**35.25**	**35.80**	**36.73**	**38.93**	**37.22**	**40.73**	**CA**
	-	**36.03**	**36.7**	**36.25**	**35.40**	**36.20**	**38.22**	**CP**
	35.7	**36.22**	**37.76**	**39.25**	**40.94**	**41.37**	**42.93**	**DEF**
	-	**36.38**	**36.78**	**39.94**	**41.28**	**42.83**	**44.49**	**DEA**
	-	**35.96**	**35.83**	**36.8**	**37.08**	**38.21**	**39.99**	**DEP**
C18:2 n6	14.12±0.06	15.04±0.08^{cd}	15.22±0.08^{b}	15.38±0.12^{b}	16.46±0.12^{b}	12.05±0.13^{b}	14.38±0.30^{c}	**CF**
	-	15.10±0.12^{d}	15.28±0.14^{b}	15.49±0.13^{b}	16.92±0.08^{b}	13.25±0.15^{ab}	13.49±0.13^{b}	**CA**
	-	14.93±0.11^{bc}	15.17±0.02^{b}	15.27±0.09^{b}	16.10±0.06^{b}	12.12±0.06^{ab}	14.36±0.06^{b}	**CP**
	15.11±0.07	15.28±0.12^{ab}	15.36±0.22^{a}	15.96±0.03^{a}	16.72±0.12^{a}	14.12±0.22^{ab}	15.84±0.14^{a}	**DEF**
	-	15.54±0.06^{a}	15.45±0.13^{b}	15.99±0.07^{a}	16.82±0.18^{a}	14.47±0.13^{ab}	15.59±0.17^{b}	**DEA**
	-	15.15±0.17^{ab}	15.28±0.12^{b}	15.52±0.12^{b}	16.66±0.22^{b}	14.09±0.03^{ab}	15.45±0.07^{b}	**DEP**

C18:3 n3	0.55±0.01	0.52±0.04^{ab}	0.54±0.06^{ab}	0.57±0.01^{a}	0.59±0.03^{ab}	0.61±0.03^{ab}	0.68±0.12^{b}	**CF**
	-	0.53±0.03^{a}	0.55±0.01^{ab}	0.59±0.01^{a}	0.52±0.02^{ab}	0.63±0.03^{ab}	0.74±0.02^{ab}	**CA**
	-	0.49±0.01^{ab}	0.51±0.01^{ab}	0.55±0.01^{a}	0.50±0.02^{ab}	0.55±0.01^{ab}	0.64±0.12^{ab}	**CP**
	0.63±0.03	0.56±0.04^{b}	0.56±0.02^{ab}	0.58±0.12^{a}	0.65±0.13^{b}	0.73±0.11^{b}	0.81±0.03^{a}	**DEF**
	-	0.58±0.02^{a}	0.58±0.04^{c}	0.61±0.05^{a}	0.68±0.22^{a}	0.78±0.12^{ab}	0.85±0.05^{ab}	**DEA**
	-	0.49±0.01^{ab}	0.54±0.02^{a}	0.56±0.02^{a}	0.59±0.07^{ab}	0.69±0.13^{a}	0.78±0.12^{a}	**DEP**
C20:2 cis	0.15±0.01	0.16±0.02^{a}	0.19±0.01^{a}	0.20±0.02^{a}	0.22±0.02^{a}	0.24±0.02^{a}	0.26±0.04^{a}	**CF**
	-	0.19±0.03^{a}	0.21±0.03^{a}	0.22±0.02^{a}	0.24±0.06^{a}	0.26±0.02^{b}	0.28±0.02^{a}	**CA**
	-	0.17±0.01^{a}	0.18±0.02^{a}	0.19±0.01^{a}	0.21±0.01^{a}	0.21±0.03^{ab}	0.18±0.02^{a}	**CP**
	0.19±0.01	0.18±0.02^{a}	0.20±0.04^{a}	0.23±0.01^{a}	0.25±0.01^{a}	0.28±0.02^{ab}	0.28±0.03^{a}	**DEF**
	-	0.19±0.01^{a}	0.21±0.01^{a}	0.25±0.03^{a}	0.26±0.02^{a}	0.30±0.02^{a}	0.30±0.01^{a}	**DEA**
	-	0.18±0.01^{a}	0.19±0.01^{a}	0.21±0.01^{a}	0.23±0.03^{a}	0.26±0.04^{ab}	0.26±0.02^{a}	**DEP**
C20:3 n6	0.36±0.04	0.38±0.02^{a}	0.42±0.12^{a}	0.46±0.02^{a}	0.49±0.03^{bc}	0.51±0.01^{a}	0.55±0.03^{a}	**CF**
	-	0.37±0.03^{a}	0.45±0.03^{a}	0.44±0.02^{a}	0.54±0.12^{ab}	0.55±0.03^{b}	0.57±0.09^{ab}	**CA**
	-	0.31±0.01^{a}	0.41±0.01^{a}	0.41±0.03^{a}	0.55±0.01^{c}	0.49±0.03^{ab}	0.51±0.01^{b}	**CP**
	0.38±0.02	0.42±0.02^{a}	0.46±0.04^{a}	0.49±0.02^{a}	0.51±0.01^{a}	0.56±0.04^{ab}	0.59±0.04^{ab}	**DEF**
	-	0.45±0.13^{a}	0.47±0.07^{a}	0.51±0.01^{a}	0.56±0.12^{bc}	0.59±0.03^{ab}	0.60±0.12^{ab}	**DEA**
	-	0.39±0.03^{a}	0.44±0.02^{a}	0.46±0.01^{a}	0.48±0.02^{c}	0.54±0.04^{ab}	0.56±0.06^{ab}	**DEP**
C20:4 n6	1.02±0.02	0.47±0.04^{c}	0.86±0.06^{b}	0.35±0.01^{a}	0.34±0.03^{ab}	0.41±0.02^{ab}	0.38±0.04^{a}	**CF**
	-	1.35±0.20^{a}	1.39±0.08^{a}	0.52±0.02^{a}	0.33±0.02^{ab}	0.36±0.04^{bc}	0.34±0.02^{a}	**CA**
	-	0.23±0.04^{c}	0.37±0.05^{c}	0.31±0.01^{a}	0.27±0.03^{b}	0.34±0.04^{bc}	0.27±0.01^{a}	**CP**
	1.15±0.03	0.30±0.08^{c}	0.30±0.01^{c}	0.28±0.01^{a}	0.37±0.05^{a}	0.31±0.01^{c}	0.97±0.35^{a}	**DEF**
	-	0.72±0.11^{b}	1.47±0.12^{a}	0.81±0.70^{a}	0.30±0.01^{ab}	0.32±0.06^{bc}	0.30±0.01^{a}	**DEA**
	-	1.25±0.11^{a}	0.35±0.05^{c}	0.30±0.03^{a}	0.35±0.04^{a}	0.48±0.04^{a}	0.39±0.02^{a}	**DEP**
	6.94±0.16	4.90±0.02^{c}	4.99±0.13^{b}	5.09±0.11^{d}	5.28±0.12^{d}	5.28±0.06^{c}	5.39±0.13^{c}	**CF**
C20:5 n3	-	4.95±0.12^{ab}	5.01±0.11^{a}	5.18±0.06^{a}	5.34±0.06^{a}	5.36±0.12^{ab}	5.48±0.12^{ab}	**CA**
	-	4.70±0.03^{ab}	4.91±0.13^{a}	5.01±0.01^{b}	5.14±0.02^{bc}	5.16±0.08^{bc}	5.31±0.07^{b}	**CP**
	6.82±0.22	4.99±0.07^{b}	5.13±0.05^{a}	5.15±0.07^{b}	5.22±0.08^{ab}	5.46±0.12^{a}	5.58±0.06^{ab}	**DEF**
	-	5.02±0.06^{b}	5.17±0.11^{a}	5.22±0.06^{ab}	5.39±0.07^{c}	5.60±0.10^{a}	5.65±0.17^{ab}	**DEA**
	-	4.93±0.01^{a}	4.98±0.12^{a}	5.04±0.12^{bc}	5.19±0.11^{c}	5.40±0.08^{a}	5.41±0.09^{ab}	**DEP**
C22:2 cis	0.21±0.03	0.22±0.02^{a}	0.22±0.01^{ab}	0.20±0.02^{a}	0.20±0.02^{b}	0.22±0.02^{ab}	0.24±0.02^{a}	**CF**
	-	0.23±0.01^{bc}	0.20±0.00^{bc}	0.19±0.01^{a}	0.22±0.04^{ab}	0.23±0.01^{b}	0.22±0.02^{a}	**CA**
	-	0.19±0.01^{c}	0.18±0.02^{c}	0.17±0.01^{a}	0.20±0.02^{ab}	0.22±0.04^{ab}	0.20±0.00^{a}	**CP**
	0.26±0.04	0.24±0.02^{ab}	0.23±0.01^{ab}	0.21±0.01^{a}	0.23±0.01^{a}	0.19±0.01^{b}	0.24±0.03^{a}	**DEF**
	-	0.23±0.01^{bc}	0.24±0.02^{a}	0.22±0.02^{a}	0.25±0.01^{ab}	0.25±0.01^{a}	0.26±0.02^{a}	**DEA**
	-	0.20±0.00^{bc}	0.20±0.02^{ab}	0.18±0.02^{a}	0.21±0.04^{ab}	0.24±0.02^{ab}	0.24±0.02^{a}	**DEP**
C22:6 n3	14.81±0.04	14.48±0.16^{b}	13.19±0.92^{b}	11.42±0.08^{c}	10.91±0.21^{d}	10.72±0.11^{c}	9.45±0.08^{c}	**CF**
	-	14.98±0.03^{a}	12.45±0.13^{ab}	11.33±0.03^{b}	11.08±0.04^{bc}	9.93±0.11^{bcd}	9.69±0.13^{b}	**CA**
	-	14.48±0.25^{a}	11.96±0.04^{ab}	11.07±0.03^{a}	10.75±0.07^{a}	9.05±0.13^{abc}	9.44±0.12^{bc}	**CP**
	15.04±0.06	14.55±0.11^{a}	14.12±0.06^{a}	12.06±0.04^{b}	11.19±0.07^{bc}	10.07±0.15^{ab}	9.96±0.02^{a}	**DEF**
	-	14.58±0.16^{a}	14.41±0.03^{a}	12.19±0.07^{b}	11.42±0.12^{ab}	11.19±0.07^{cd}	9.99±0.13^{d}	**DEA**
	-	13.99±0.22^{a}	13.54±0.12^{ab}	11.56±0.12^{a}	11.54±0.06^{c}	11.28±0.26^{d}	9.85±0.03^{cd}	**DEP**
	36.16	**36.17**	**35.63**	**33.67**	**34.49**	**35.04**	**34.16**	**CF**
∑ PUFA	-	**37.70**	**35.54**	**33.96**	**35.19**	**34.57**	**35.58**	**CA**
	-	**35.50**	**33.69**	**32.98**	**33.72**	**33.14**	**36.17**	**CP**
	37.58	**36.52**	**36.36**	**34.96**	**35.14**	**35.72**	**37.7**	**DEF**
	-	**37.31**	**38.00**	**35.80**	**35.68**	**37.50**	**35.5**	**DEA**
	-	**36.58**	**35.52**	**33.83**	**35.25**	**36.98**	**36.5**	**DEP**
PUFA/SFA	1.81	1.70	1.70	1.69	1.69	1.72	1.66	**CF**
	-	1.85	1.62	1.78	1.73	1.71	1.73	**CA**
	-	1.74	1.54	1.65	1.68	1.66	1.75	**CP**
	1.91	1.78	1.70	1.74	1.75	1.83	1.81	**DEF**
		1.73	1.68	1.78	1.80	1.87	1.72	**DEA**

		1.67	1.57	1.70	1.76	1.82	1.76	**DEP**
∑n6	14.50	15,89	16,50	16,19	17,29	12,97	15,31	**CF**
	-	16,82	17,12	16,45	17,79	14,16	14,40	**CA**
	-	15,47	15,95	15,99	16,92	12,95	15,14	**CP**
	15.64	16,00	16,12	16,73	17,60	14,99	17,40	**DEF**
	-	16,71	17,39	17,31	17,68	15,38	16,49	**DEA**
	-	16,79	16,07	16,28	17,49	15,14	16,40	**DEP**
∑n3	21.30	19.90	18.72	17.08	16.78	16.61	15.52	**CF**
	-	20.46	18.01	17.10	16.94	15.92	15.91	**CA**
	-	19.67	17.38	16.63	16.39	14.76	15.39	**CP**
	21.49	20.10	19.81	17.79	17.06	16.26	16.35	**DEF**
		20.18	20.16	18.02	17.49	17.57	16.49	**DEA**
		19.41	19.06	17.16	17.32	17.37	16.04	**DEP**
Unidentified	9,36	8,29	8,44	10,64	8,02	6,09	5,57	**CF**
	-	6,65	6,7	10,25	5,54	8,03	3,16	**CA**
	-	8,08	7,8	10,76	10,85	10,65	4,97	**CP**
	7,03	6,75	4,46	5,68	3,89	3,37	1,5	**DEF**
	-	4,76	2,61	4,14	3,18	0,42	0,62	**DEA**
	-	5,52	5,96	9,51	7,59	4,52	2,8	**DEP**

Data are expressed as mean value ± standard deviation of 3 replicates in duplicate

Means sharing the same letter in the same row (a-e) indicate significant differences ($P < 0.05$) among groups.

Groups: CF: Control tuna pate stored in flint glass jar, CA: Control tuna pate stored in amber glass jar, CP: Control tuna pate stored in plastic container, DEF: Dill leaf enriched tuna pate stored in flint glass jar, DEA: Dill leaf enriched tuna pate stored in amber glass jar, DEP: Dill leaf enriched tuna pate stored in plastic container.

CONCLUSION

Tuna pate enriched with dill leaf proved lower oxidation value indices in terms of fatty acid degradation due to the antioxidant responds of enrichment of this plant. In terms of packaging material, stored in glass jar especially in amber glass jar prevent the lipid oxidation and deterioration of fatty acid composition. SFA, MUFA and PUFA content impacted positively by treatment groups among tuna pate groups in terms of not only with or without dill leaf enrichment but also the packaging material. This report recommended that dill leaf could be a useful additive for other pate products, which are highly susceptible for oxidation and deterioration. Additionally, packaging in amber glass jar could extend the shelf life of pate type products.

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