ŻYWNOŚĆ. NAUKA. TECHNOLOGIA. JAKOŚĆ, 2024, 31, 4 (141), 100 – 116

DOI: 10.15193/zntj/2024/141/523

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THE EFFECT OF MULTI-LEVEL SOAKING IN ATUNG SEED POWDER SOLUTION (*PARINARIUM GLABERIMUM*, HASSK) AND PACKAGING TYPE ON THE QUALITY OF DRIED SALTED FISH

S u m m a r y

Background. Salted fish is a fishery product that has a high demand in the food business, in Chinese style food. However, salted fish usually uses synthetic preservatives such as formaldehyde, which have hazardous properties. Thus, a natural preservative should be developed to be a substitute. Atung (*Parinarium glaberrimum* Hassk.) is a local medicinal plant with potential food preservative potential because of its antibacterial activity. This study aims to determine the effect of multilevel soaking in salt and Atung seed powder solution and type of packaging on the quality of dried salted fish during storage. The fish and squid were soaked in a 10 % (w/v) saline solution for 30 minutes, followed by immersion in 5 % (w/v) Atung solution, and then dried.

Results and conclusions. The results showed that products packed in aluminum foil had the lowest water content for each type of fish and squid. The lowest salt content was obtained by yellowfish after six weeks of storage (3.94 %), while scad fish showed the lowest peroxide content after nine weeks of storage (374 mg.eq/kg). The TPCs of dried salted fish and squids were lower than the TPC of unpacked scad fish (4.72 log X). The drying-salting method in this study could maintain the protein content of yellowtail fish and scad fish up to 58.83 % and 58.44 % after nine weeks of storage. Meanwhile, the protein content of dried salted squid varied depending on the storage time and packaging type. The values of the lowest organoleptic (appearance, odor, taste, texture) were different depending on the fish and squid type.

Keywords: Atung seed powder; dried salted fish; packaging; storage time

Introduction

Salted fish is a popular fish product, especially in Chinese-style food, that is usually used to increase the flavor of many dishes. Fish is processed in salt and dried condition to improve its lifespan, so it can be consumed longer than fresh fish. Chinese-

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style salted fish were divided into two subtypes: hard salted fish, which is only prepared by directly salting and drying. Meanwhile, the soft salted fish involves salting and drying after natural decomposition [9]. Salted fish is the largest processed fishery product worldwide, including Indonesia. However, this commodity faces a big problem, including the use of formaldehyde for preservation. Despite its hazardous properties, several studies reported that salted fish with formaldehyde is widely spread in markets in Indonesia [3, 11, 22, 39, 52, 55]. Thus, in the present study, a natural preservative will be developed to substitute synthetic preservatives.

Atung (*Parinarium glaberrimum* Hassk.) is a local medicinal plant widespread in the Maluku province, Indonesia. Atung seeds are usually used to stop diarrhea, vaginal discharge and prevent premature bleeding in pregnant women [19]. Several studies have proven its antibacterial and antioxidant properties. Atung seed has a broad antibacterial spectrum, including pathogenic and destructive bacteria [29], while antioxidant properties were proven to be nine times stronger than synthetic antioxidant butylated hydroxytoluene (BHT) [44]. A previous study by Hehanussa et al. [17] reported that Atung has phytobiotic potential for poultry. A phytochemical test showed that Atung contains phenols, flavonoids, tannins, saponins and alkaloids. It also has nitrogen-free extract, phosphorus, calcium and high gross energy. Another study presented that Atung also contains bioactive phytosterols that can lower cholesterol levels [49]. In addition, Moniharapon et al. [30] demonstrated the potential of Atung as a fly repellent for salted skipjack tuna. The above studies encourage using Atung as a natural preservative for fish products. Most of the research on salted fish in Indonesia is about the salt fermentation time and salt concentration, as conducted by Reo, Riansyah et al., Tumbelaka et al., Kiayi et al., and Febriyanti [11, 23, 40, 41, 51]. Additionally, salted fish is mostly processed only with salt (single technology) with a high concentration (20 ÷ 30 %) for preservation. However, the high concentration of salt can be a serious problem for several reasons, such as rising blood pressure and the risk of cancer [42, 57]. Therefore, innovations are needed to obtain a higher-quality, safe and healthy product. By combining with Atung seeds, the use of salt will be reduced. The presence of Atung can increase the osmotic moisture extraction in the process [29]. The salt contents of 4.82 ÷ 8.67 % could maintain higher protein levels of flying fish of about 77.74 ÷ 79.15 %, with the highest percentage obtained by the lowest salt content. In contrast, the highest salt content of 18.68 % resulted in 53.26 % protein level [23]. Thus, products will not be salty and will have higher protein content.

In addition, the packaging process and the types of packaging will also affect the shelf life of salted fish products. Salted fish products are commonly packaged using polyethylene (PE) and high-density polyethylene (HDPE). The previous preservation research used 10 % salt followed by 5 % Atung, which resulted in good quality dried salted yellowtail fish, scad and squid. The quality of the products could be maintained for nine weeks in PE package [23]. In this study, the type of packaging was also analyzed to get the high quality of dried fish and squids. Therefore, the objective of this study was to determine the effect of multilevel soaking in salt and Atung seed powder solution, as well as the type of packaging that affects the quality of dried salted fish during storage.

Materials and Methods

Research Design

The material used in this study was Atung solution (*Parinarium glaberimum* Hassk) with concentrations of 10 % and 5 % (w/v) made from atung powder (g), and the solution temperature should be maintained at 50 °C or warm. The yellowtail fish (*Caesio* sp.), scad fish (*Decapterus macrosoma* Blkr), squid (*Loligo* sp.) were soaked in 10 % (w/v) saline solution for 30 minutes and subsequently soaked in Atung solution for 30 minutes. The types of packaging used were aluminum foil, HDPE, PE and unpackaged.

Atung Extraction Procedure

Atung extraction as a preservative was prepared as follows. First, Atung fruit was split and the seeds were taken. The flesh of Atung seeds was grated and air-dried for 2 ÷ 3 days. The dried Atung seeds were pounded and sieved while air-dried until completely mashed and dried. Atung solution (5 %) was prepared by dissolving Atung powder in warm water (1 : 20). After being macerated for 1 ÷ 2 nights, the solution was then filtered and ready to use [34].

Salted Fish Product Processing

Yellowtail fish, scad fish and squid were cut into butterfly-like shapes, washed and weighed about 4 kg each. The fish and squid were soaked in a 10 % (w/v) saline solution for 30 minutes, followed by immersion in 5 % (w/v) Atung solution. Furthermore, the yellowtail fish, scad fish and squids were dried for 4, 3 and 2 days, respectively. After drying, each salted fish and squid was weighed to determine the yield of each product. Each product was then packaged in aluminum foil (B1), high-density polyethylene (HDPE) (B2), polyethylene (PE) (B3) and unpackaged (B4). The packed fish and squid products were stored at room temperature (25º C) for nine weeks. The quality deterioration was observed in intervals of three weeks.

Sample analysis

The samples tested were stored for 0 weeks (A1), 3 weeks (A2), 6 weeks (A3) and 9 weeks (A4). The types of packaging were aluminum foil (B1), high-density polyethylene/HDPE (B2), polyethylene/PE (B3) and unpackaged (B4). Objectively, parameters observed included yield, water and protein content (SNI 01-2897-1992), salt content (SNI 01-2721-2009), peroxide value (SNI 01-3555-1998) and total plate count (TPC) (SNI 01-2891-1992). The subjective analysis was organoleptic, including appearance, odor, taste and texture (SNI 01-2343-1991 / 01).

Statistical Analysis

The objective parameter data was analyzed using ANOVA, with variance analysis according to the split-block design with four replications [14, 47]. In contrast, the subjective parameter was tested with the Friedman test followed by multiple comparisons [53].

Results and Discussion

Yield (Quantity)

Table 1 presents the average yield (%) for every dried salted fish and squid. The calculation was carried out with ten repetitions. The first row in every fish and squid shows the total weight, while the second row is the yield (%), obtained by following the equation:

$$\frac{total\ fish\ weight}{(10\ x\ average\ fish\ weight)} \times 100\ \%\ (1)$$

Table 1. Weight [g] and yield [%] of each type of fish and squid
Tabela 1. Masa [g] i wydajność [%] poszczególnych gatunków ryb i kalmarów

Repetition / Powtórzenie	Yellowtail fish / Ryba żółtoogonowa 135 g/head		Scad Fish / Ryba scad 98 g/head		Squid / Kałamarnica 35 g/head	
	Weight / Masa [g]	Yield / Wydajność [%]	Weight / Masa [g]	Yield / Wydajność [%]	Weight / Masa [g]	Yield / Wydajność [%]
1	544	40.30	342	34.89	50	14.29
2	583	43.18	343	35.00	56	16.00
3	541	40.07	366	37.35	55	15.71
4	561	41.56	354	36.12	56	16.00
5	538	39.85	357	36.43	54	15.43
6	559	41.41	349	35.61	51	14.57
7	549	40.67	352	35.92	56	16.00
8	561	41.56	362	36.94	58	16.57
9	537	39.78	354	36.12	52	14.86
10	544	40.30	339	34.59	58	16.57
Average / Średnia	551.7	40.87	351.8	35.90	54.6	15.60

Table 1 shows that the weight of each dried salted fish and squid was relatively stable, and the average yields (%) were 40.87 %, 35.90 % and 15.60 % for yellowtail fish, scad fish and squid, respectively. Compared to the previous study (unpublished work) in Table 2 [34], the present study resulted in a greater yield of yellowfish due to the larger size (135 g) of fish than the previous one (115 g). In contrast, the dried salted scad fish (35.90 %) and squid (15.60 %) in the present study resulted in a smaller yield than the previous study, which obtained 44.2 % for scad fish and 17.68 % for squid. The smaller yield of scad fish could be due to the weight used, about 98 g, while the previous study used 120 g. However, the squid weight in this study was the same as the previous one, but it yielded a smaller amount than the previous study. The difference can be caused by the drying method. In this study, the drying method used sun-drying, while the previous study involved sun-drying and smoking. Smoking method can affect the yield product, including giving a high moisture-effect and increasing the macronutrient component [1, 2]. The yield (%) of each fish and squid in the previous study can be seen in Table 2.

Table 2. The yield (%) of each type of fish and squid [20]
Tabela 2. Wydajność (%) poszczególnych gatunków ryb i kalmarów [20]

Treatment / Obróbka	Average yield of drying [%] each type of fish and squid / Średnia wydajność suszenia [%] każdego rodzaju ryby i kałamarnicy				
	Bony flyingfish / Raba latająca 75 g/head	Scad Fish / Ryba scad 120 g/head	Tuna Fish / Tuńczyk 130 g/head	Yellowtail fish / Ryba żółtoogonowa 115 g/head	Squid / Kałamarnica 35 g/head
A1B1C1	28.49[bc]	43.00[b]	44.70[b]	34.61[b]	17.62[b]
A1B1C2	28.18[bc]	44.90[b]	44.99[b]	35.19[b]	17.90[b]
A1B2C1	28.44[bc]	43.69[b]	44.41[b]	34.20[b]	17.43[b]
A1B2C2	26.93[c]	43.21[b]	44.90[b]	34.41[b]	17.66[b]
A2B1C1	28.09[bc]	44.69[b]	44.20[b]	34.61[b]	17.62[b]
A2B1C2	26.93[c]	44.62[b]	45.30[b]	34.34[b]	17.52[b]
A2B2C1	28.85[b]	45.00[b]	45.60[b]	33.92[b]	18.28[b]
A2B2C2	28.05[bc]	44.49[b]	45.10[b]	34.00[b]	17.43[b]
Control	33.60[a]	52.10[a]	50.20[a]	38.20[a]	24.86[a]
F hit.	36.40**	34.95**	29.32**	23.60**	45.80**
F Tab. α=0.05	2.78	2.78	2.78	2.78	2.78
α=0.01	4.18	4.18	4.18	4.18	4.18
HSD α=0.05	1.63	2.29	1.73	1.34	1.76

Explanatory notes / Objaśnienia:
A1: 5 % saline solution; A2: 10 % saline solution; B1: 5 % Atung solution; B2: 10 % Atung solution; C1: unsmoked with Atung fruit peel smoke; C2: smoked with Atung fruit peel smoke; HSD: Honestly Significant Difference / A1: 5 % roztwór soli fizjologicznej; A2: 10 % roztwór soli fizjologicznej; B1: 5 % roztwór Atung; B2: 10 % roztwór Atung; C1: niewędzony z dymem ze skórek owoców Atung; C2: wędzony z dymem ze skórek owoców Atung; HSD: najmniejsza istotna różnica.

Yield determination helps calculate the business profit analysis of developed products. The profit will be significant following the greater yield. The profit on fish burgers where larger ones can have Rp. 25,000 – Rp. 30,000 [37]; fish ball Rp. 70,000 [38], while fish sausage Rp. 60,000 [32].

Water Content

Salting process is a process to draw water out of fish, which also reduces the water activity. For instance, it will reduce microbial activity and prolong the fish lifespan. The salting process involves osmosis, leading to dehydration of microbial cells [12, 20, 24]. As shown in Table 3, the water contents of the dried salted fishes and squid tended to increase from 0 to 9 weeks. The increase of water content was followed by the increase of salt content. This finding is in line with the study conducted by [54].

Table 3. Recapitulation of the Least Significant Difference (LSD) test of objective parameters per type of dried salted fish and squid

Tabela 3. Podsumowanie testu najmniejszej znaczącej różnicy (LSD) obiektywnych parametrów według rodzaju suszonej solonej ryby i kalmarów

Fish	Treatment / Obróbka	Average and Significant Value / Wartość średnia i istotna				
		Water / Woda [%]	Protein / Bialko [%]	Salt / Sól [%]	Peroxide / Nadtlenki [mg.ek/kg]	TPC (Log X)
Yellowtail fish / Ryba żółtoogonowa	A1B1	A1 27.22^{c}		4.35^{fg}		4.10^{a}
	A1B2	A2 29.03^{b}		4.35^{fg}		4.10^{a}
	A1B3	A3 29.37^{b}		4.35^{fg}		4.10^{a}
	A1B4	A4 31.26^{a}		4.35^{fg}		4.10^{a}
	A2B1			4.60^{def}		2.32^{b}
	A2B2		A1 63.65^{a}	4.14^{fg}	A1 397^{c}	4.46
	A2B3		A2 62.48^{ab}	4.47^{ef}	A2 888^{abc}	2.94^{b}
	A2B4		A3 61.49^{ab}	5.18^{cd}	A3 1424^{ab}	3.99^{a}
	A3B1		A4 58.83^{b}	4.52^{ef}	A4 2302^{a}	2.84^{b}
	A3B2			3.94^{g}		4.18^{a}
	A3B3	B1 26.04^{b}		4.17^{fg}		4.10^{a}
	A3B4	B2 28.72^{a}		4.97^{cde}		3.95^{a}
	A4B1	B3 29.74^{a}		5.37^{bc}		2.59^{b}
	A4B2	B4 30.65^{a}		6.16^{a}		4.20^{a}
	A4B3			5.39^{bc}		3.98^{a}
	A4B4			5.78^{ab}		4.02^{a}
	LSD 0.05	A=0.74 B=2.39	4.11	0.51	0.891	0.67
Scad Fish / Ryba scad	A1B1		A1 65.04^{a}		374^{f}	A1 4.74^{a}
	A1B2		A2 61.29^{ab}		374^{f}	A2 4.26^{c}
	A1B3		A3 60.03^{ab}		374^{f}	A3 4.28^{c}
	A1B4		A4 58.44^{b}		374^{f}	A4 4.54^{b}
	A2B1				919^{def}	
	A2B2				826^{ef}	

	A2B3	A1 30.40^{b}		A1 4.22^{b}	1434^{bcde}	
	A2B4	A2 32.56^{ab}		A2 4.33^{b}	1555^{bc}	
	A3B1	A3 33.97^{ab}		A3 4.62^{b}	1434^{bcde}	
	A3B2	A4 34.88^{a}		A4 5.87^{a}	1304^{cde}	
	A3B3		B1 62.76^{a}		1726^{bc}	B1 4.18^{b}
	A3B4		B2 61.60^{ab}		1994^{ab}	B2 4.51^{ab}
	A4B1		B3 61.12^{ab}		1508 ^{bcd}	B3 4.50^{ab}
	A4B2		B4 57.96^{b}		1932^{b}	B4 4.72^{a}
	A4B3				1751^{bc}	
	A4B4				2423^{a}	
	LSD 0.05	3.95	A=4.71 B=4.41	1.01	669	A=0.19 B=0.46
Squid / Kałamarnica	A1B1	17.09^{c}	69.05^{bc}	13.44^{bc}	678^{d}	2.23^{c}
	A1B2	17.09^{c}	69.05^{bc}	13.44^{bc}	678^{d}	2.23^{c}
	A1B3	17.09^{c}	69.05^{bc}	13.44^{bc}	678^{d}	2.23^{c}
	A1B4	17.09^{c}	69.05^{bc}	13.44^{bc}	678^{d}	2.23^{c}
	A2B1	17.75^{bc}	63.44^{f}	13.79^{bc}	715^{d}	1.47^{de}
	A2B2	17.90^{bc}	62.66^{f}	13.73^{bc}	930^{cd}	0.61^{f}
	A2B3	17.62 ^{bc}	63.75^{f}	14.15^{b}	878^{d}	0.62^{f}
	A2B4	17.96 ^{bc}	68.74^{bcd}	11.65^{d}	1474^{b}	3.60^{b}
	A3B1	17.58 ^{bc}	70.79^{a}	13.36^{c}	1712^{a}	1.29^{e}
	A3B2	18.32^{ab}	70.14^{ab}	13.64^{bc}	2177^{a}	1.24^{e}
	A3B3	17.89 ^{bc}	71.06^{a}	13.47^{bc}	1468^{b}	1.47^{de}
	A3B4	18.91^{a}	68.72^{bcd}	13.22^{c}	2184^{a}	3.17^{b}
	A4B1	17.88^{bc}	67.02^{e}	14.99^{a}	1934^{a}	2.13^{c}
	A4B2	18.42^{ab}	68.55^{cd}	15.54^{a}	1399^{bc}	1.59^{de}
	A4B3	18.52^{ab}	67.86^{cd}	15.42^{a}	1712^{a}	1.74^{cd}
	A4B4	20.83^{a}	67.51^{de}	12.36^{d}	1942^{a}	4.28^{a}
	LSD 0.05	1.15	1.49	0.72	477	0.46

Explanatory notes / Objaśnienia:
Numbers followed by the same letter are not significantly different. Storage time (A) of 0 weeks (A1), 3 weeks (A2), 6 weeks (A3) and 9 weeks (A4). The types of packaging (B) were aluminum foil (B1), high-density polyethylene/HDPE (B2), polyethylene/PE (B3) and unpackaged (B4) / Liczby oznaczone tą samą literą nie różnią się znacząco. Czas przechowywania (A) 0 tygodni (A1), 3 tygodnie (A2), 6 tygodni (A3) i 9 tygodni (A4). Rodzaje opakowań (B) to folia aluminiowa (B1), polietylen o wysokiej gęstości/HDPE (B2), polietylen/PE (B3) i opakowanie nieopakowane (B4).

The multisoaking with Atung solution could enhance the osmotic effect due to the high concentration solution that will extract the water from tissues [17]. This multisoaking in Atung solution will give a synergetic effect to the salting process. Atung seeds are proven as a food preservative because it contains a fraction of bioactive components that can kill several types of pathogenic bacteria and food spoilers. The part of the Atung plant with antimicrobial activity is the fruit, especially seeds. Moniharapon and Hashinaga [28] investigated the ethyl acetate extract of Atung seeds that are effective in inhibiting microbial growth. Moniharapon et al. [27] also found that azelaic acid was the bioactive component found in Atung seeds. The bioactive compounds in Atung seeds, such as phenols [17], will act as an antibacterial agent by interacting with the bacterial membrane and leading to membrane disruption and cell damage [45]. Thus, the lifespan of dried fish and squid will be longer. It also will have a good impact on consumers' health and the economic sector. The use of Atung can reduce the high concentration of sodium-containing salt that reduces health issues like hypertension, kidney disease and a cardiovascular disease [43]. Additionally, compared to synthetic or artificial preservatives such as nitrates, sulfites and formaldehyde, the combination of salt and Atung solution will be safer since those artificial preservatives have the potential to life-threatening side effects [25]. Using the Atung solution will also positively impact economic issues, considering its abundance and the low cost of producing Atung.

Table 3 also shows that the type of packaging also affected the water content. Aluminum foil had the smallest water content compared to the other packaging. The AB interaction (storage time-packaging type) was clearly observed in dried salted squid, which resulted in water content in the range of 17.09 % (A1B1-A1B4) to 20.83 % (A4B4). Aluminum foil is included in the metal group packaging with a thickness of < 0.15 mm, which gives good protection against water, is resistant to temperature changes and has a lower permeability value [6, 10].

The water content of all types of fish in this study met the quality standard of salted fish according to SNI-2721-1-2009 [21], with a maximum water content of 40 %. Salt activity in bonding water is closely related to plasmolysis events, in which water will move from low salt to high salt concentration due to differences in osmotic pressure [7, 13, 16]. The low water content in dried salted fish was also probably due to the effect of soaking duration in the Atung solution.

Protein content

In contrast with its water content, the dried salted fish and squid gradually decreased protein content after nine weeks of storage (Table 3). However, using salt and Atung can prevent a decrease in the quality of salted fish and squid compared to when no preservatives are used. Moreover, packaging the dried salted fish and squid with aluminum foil resulted in the largest protein content compared to the other packaging types. The AB interaction in dried salted squid resulted in protein levels ranging from 62.66 % (A2B2) to 71.06 % (A3B3), indicating differences between the treatments.

To show the percentage of denatured protein during the process in each type of fish and squid, the protein content was calculated using the following formula:

$$\frac{(highest\ protein\ content - lowest\ protein\ content)}{highest\ protein\ content} \times 100\ \% \qquad (2)$$

Based on these calculations, dried salted squid had the highest denatured value of 11.82 %, followed by scad fish with 10.88 % and yellowtail fish with 8.18 %. The result was much lower than in the case of the high salting preservation technique, in which up to 60 % of protein was denatured [18]. The standard salt concentration used was 21 ÷ 30 %, in which salt concentration was parallel with the total salt-soluble protein being dissolved in the solution [4, 36]. Several studies focused on various salting techniques, including brine salting, dry salting, kench salting, pickling and pre-salting methods (injection, brining and pickling). All of these techniques lead to the speed of salt diffusion into fish, velocity of water discharge from fish, mass transfer of fish, drying kinetics, physicochemical changes in muscle protein and fish fat, protein denaturation and aggregation in the myosin and collagen parts of fish [5, 8, 15, 46, 48, 50]. Conformational changes in fish protein occur in a high salt concentration (15 ÷ 24 %), as high salt content accelerates muscle protein penetration and aggregation (total S-H and SS) [58, 59].

Salt Content

The average salt content of yellowtail fish, scad fish and squids were 3.94 ÷ 6.16 %, 4.22 ÷ 5.87 % and 11.65 ÷ 15.54 %, respectively (Table 3). The salt content in dried salted fish met the national standard (SNI-2721-1-2009), about 4 ÷ 20 % [34]. The dried salted fish in this study were not much different or even lower compared to the results by Moniharapon et al., which ranged from 2.46 to 5.09 % (yellowtail fish), 2.71 ÷ 4.43 % (scad fish), 4.38 ÷ 6.10 % (squid), 3.24 ÷ 7.87% (cob) and 4.18 ÷ 6.97 % (flying fish) [34].

Peroxide Content

The yellowtail fish after nine weeks of storage had the highest peroxide content, significantly different from 0 weeks of storage (Table 3). Meanwhile, dried salted scad fish and squid had peroxide values ranging from 374 (A1B1–A1B4) to 2,423 mg.eq/kg (A4B4) and 0.678 (A1B1–A1B4) to 2,184 mg.eq/kg (A4B4), respectively. Thus, dried salted yellowtail fish and scad fish tended to go rancid faster than squid.

Total Plate Count (TPC)

After the treatments, the average TPC values of yellowtail fish ranged from 2.32 (log X) or 2.09×10^2 colonies to 4.46 (log X) or 2.88×10^4 colonies. The lowest TPC for yellowtail fish was obtained by A1B1, packed with aluminum foil and stored for 3 weeks, while the largest one was achieved by A2B2, packed with HDPE and stored for 3 weeks. The TPCs of scad fish stored at week 0 (A1), week 3 (A2), week 6 (A3) and week 9 (A4) were 4.74, 4.26, 4.28 and 4.54 (log X), respectively, and were significantly different. The unpackaged dried salted scad fish (4.72 log X or 5.25×10^4 colonies) had the biggest TPC values and significantly differed from those packed with aluminum foil (4.18 log X or 1.51×10^4 colonies). Meanwhile, the TPCs of dried salted squid were lower than TPCs of yellowtail fish and scad fish (0.61 – 4.28 log X).

The treatment of soaking fish and squid with Atung solution for 30 minutes greatly affected the TPC value of all the fish and squid. It was due to the active ingredients, including azelaic acid [27], found in Atung seed extract that acts as humectants. Moniharapon et al. [35] investigated the ethyl acetate extract of Atung seeds, which was effective in inhibiting microbial growth. Based on the minimum inhibitory concentration results, it was found that the isolation of azelaic acid antibacterial in Atung seeds was effective against pathogenic bacteria and spores in food [31, 33, 35]. Humectants play a vital role in decreasing water content, which leads to the inhibition of microbial growth, hence microbes cannot develop and low TPC values can be obtained [44].

Appearance

Table 4 summarizes the multiple comparison tests of subjective (organoleptic) parameters. The results showed that the treatment of yellowtail fish with code A1B1 and A1B4 produced the highest averages of 58.0 and 8.8, respectively. Meanwhile, the A4B4 treatment was the lowest in all types of fish and squid. Appearance or color is an important factor in attracting target customers. Visually, the color factor will appear first and reflect the value of a product, as stated by Winarno [56]. As a humectant [31], Atung seed extract assists all products in obtaining good appearance values, at the average organoleptic value of 7. The packaging type also supports this test. Aluminum foil scored the highest average in all fish and squid products with respect to all parameters. This can be related to the aluminum properties mentioned earlier. Combining salt and Atung as preservatives and using aluminum foil as packaging could keep the good quality of fish and squid. On top of that, the materials are easy to find and low cost. The results of this test can be used as a benchmark for further research so that it can be commercialized.

Odor

The combination of storage time and packaging type of yellowtail fish with code A1B1 and A1B4 resulted in the highest averages of 58.0 and 8.7, respectively, while the lowest was at A4B4 for all fish and squid types. All dried salted fish and squid products produce good odor values and meet the quality standards of SNI-2721-1-2009 (Table 4).

Taste

The taste results were presented in the same way as the odor and appearance assessments. The yellowtail fish with code A1B1 and A1B4 treatments had the highest averages of 58.0 and 8.7, respectively. Meanwhile, the lowest value was found in the A4B4 treatment in all fish and squid (Table 4). The difference in taste of dried salted fish and squid products resulted from the different concentrations of salt and Atung

Table 4. Recapitulation of the multiple comparison test of subjective (organoleptic) parameters
Tabela 4. Podsumowanie testu wielokrotnych porównań parametrów subiektywnych (organoleptycznych)

Fish / Ryba	Treatment / Obróbka	Parameters / Parametr							
		Appearance / Wygląd	Average / Średnia	Odor / Zapach	Average / Średnia	Taste / Smak	Average / Średnia	Texture / Tekstura	Average / Średnia
Yellowtail fish / Ryba żółtoogonowa	A1B1	58.0^{a}	8.8	58.0^{a}	8.7	58.0^{a}	8.7	58.0^{a}	8.7
	A1B2	58.0^{a}	8.8	58.0^{a}	8.7	58.0^{a}	8.7	58.0^{a}	8.7
	A1B3	58.0^{a}	8.8	58.0^{a}	8.7	58.0^{a}	8.7	58.0^{a}	8.7
	A1B4	58.0^{a}	8.8	58.0^{a}	8.7	58.0^{a}	8.7	58.0^{a}	8.7
	A2B1	47.5^{ab}	8.4	46.5^{ab}	8.4	48.0^{ab}	8.4	47.0^{ab}	8.4
	A2B2	44.0^{abcd}	8.3	45.0^{ab}	8.3	44.0^{abc}	8.3	44.5^{abc}	8.3
	A2B3	40.5^{abcd}	8.1	40.5^{abc}	8.2	40.0^{abcd}	8.1	40.5^{abcd}	8.2
	A2B4	35.0^{abcde}	8.0	35.5^{abcd}	8.0	36.0^{abcd}	8.0	35.5^{abcd}	8.0
	A3B1	33.0^{abcde}	7.9	32.5^{bcde}	7.8	31.5^{bcd}	7.8	32.5^{abcde}	7.8
	A3B2	28.0^{bcdef}	7.7	28.0^{bcdef}	7.7	28.5^{bcde}	7.6	28.0^{bcdef}	7.7
	A3B3	24.0^{bcdef}	7.5	23.0^{bcdef}	7.5	24.0^{bcde}	7.5	22.5^{bcdef}	7.5
	A3B4	19.5^{cdef}	7.3	21.0^{bcdef}	7.4	19.5^{cde}	7.3	21.5^{bcdef}	7.5
	A4B1	16.0^{def}	7.3	15.0^{cdef}	7.1	14.5^{de}	7.2	14.5^{cdef}	7.2
	A4B2	12.5^{ef}	7.2	13.0^{ef}	7.1	11.5^{de}	7.2	12.0^{def}	7.1
	A4B3	8.0^{f}	7.0	8.0^{ef}	6.9	10.5^{de}	7.1	9.0^{ef}	7.0
	A4B4	4.0^{f}	6.7	4.0^{f}	6.6	4.0^{e}	6.9	4.5^{f}	6.9
X2i		58.9**		58.8**		58.3**		58.6**	
Scad Fish / Ryba scad	A1B1	58.0^{a}	8.5	58.0^{a}	8.6	57.5^{a}	8.6	57.5^{ab}	8.5
	A1B2	58.0^{a}	8.5	57.5^{a}	8.6	57.5^{a}	8.6	58.0^{a}	8.5
	A1B3	58.0^{a}	8.5	58.0^{a}	8.6	57.5^{a}	8.6	58.0^{a}	8.5
	A1B4	58.0^{a}	8.5	57.5^{a}	8.6	58.0^{a}	8.6	57.0^{ab}	8.5
	A2B1	46.0^{ab}	8.2	48.5^{ab}	8.4	49.5^{ab}	8.4	47.5^{abc}	8.3
	A2B2	46.0^{ab}	8.2	44.0^{ab}	8.3	43.5^{ab}c	8.3	45.0^{abcd}	8.2
	A2B3	40.0^{abcd}	8.0	40.0^{abc}	8.2	40.5^{ab}c	8.2	41.0^{abcde}	8.1
	A2B4	35.0^{abcde}	7.8	36.5^{abc}	8.0	34.5^{abcd}	8.0	5.5^{abcde}	7.9
	A3B1	32.5^{abcde}	7.7	31.0^{abcd}	7.6	33.0^{abcd}	7.8	31.5^{bcde}	7.7
	A3B2	28.5^{bcdef}	7.6	29.0^{bcde}	7.6	27.5^{bcde}	7.5	29.0^{bcdef}	7.6
	A3B3	24.0^{bcdef}	7.4	22.5^{bcde}	7.4	24.5^{bcde}	7.3	24.0^{cdef}	7.5
	A3B4	11.5^{cdef}	7.1	21.5cde	7.3	20.0^{cde}	7.2	20.0^{def}	7.4
	A4B1	19.5^{cdef}	7.2	15.0^{cde}	7.1	16.5^{de}	7.2	15.0^{ef}	7.2
	A4B2	14.0^{cdef}	7.1	13.0^{de}	7.1	11.5^{de}	7.1	11.0^{f}	7.1
	A4B3	11.0^{ef}	7.1	8.0^{de}	6.9	8.5^{de}	7.0	10.0^{f}	7.0
	A4B4	4.0^{f}	6.6	4.0^{e}	6.5	4.0^{e}	6.8	4.0^{f}	6.7
X2i		58.5**		58.6**		58.3**		58.2**	
Squid / Kałamarnica	A1B1	58.0^{a}	8.6	58.0^{a}	8.8	58.0^{a}	8.7	58.0^{a}	8.6
	A1B2	58.0^{a}	8.6	58.0^{a}	8.8	58.0^{a}	8.7	58.0^{a}	8.6
	A1B3	58.0^{a}	8.6	58.0^{a}	8.8	58.0^{a}	8.7	58.0^{a}	8.6
	A1B4	58.0^{a}	8.6	58.0^{a}	8.8	58.0^{a}	8.7	58.0^{a}	8.6
	A2B1	47.0^{ab}	8.2	46.5^{ab}	8.4	47.5^{ab}	8.4	47.0^{ab}	8.2
	A2B2	44.5^{abc}	8.3	45.0^{ab}	8.4	44.5^{abc}	8.3	44.5^{abc}	8.3
	A2B3	40.0^{abcd}	8.1	40.5^{abc}	8.2	40.0^{abcd}	8.2	40.0^{abcd}	8.1
	A2B4	35.5^{abcd}	7.9	34.5^{abc}	8.1	34.5^{abcd}	8.0	35.5^{abcd}	7.9

	A3B1	30.5^{bcd}	7.8	32.0^{abcd}	7.9	33.5^{bcd}	7.9	30.5^{bcd}	7.8
	A3B2	30.5^{bcd}	7.8	29.0^{bcde}	7.9	28.0^{bcd}	7.8	30.5^{bcd}	7.8
	A3B3	19.5^{cd}	7.5	24.5^{bcde}	7.8	23.5^{cd}	7.6	19.5^{cd}	7.5
	A3B4	15.5^{de}	7.4	15.0^{cde}	7.5	17.5^{de}	7.4	15.5^{de}	7.4
	A4B1	19.0^{cde}	7.5	16.0^{cde}	7.5	16.0^{cde}	7.4	19.0^{cde}	7.5
	A4B2	$16.5d^{e}$	7.4	15.0^{cde}	7.5	14.5^{de}	7.3	16.5^{de}	7.4
	A4B3	9.0^{e}	7.3	9.5^{de}	7.4	8.5^{e}	7.1	9.0^{e}	7.3
	A4B4	4.5^{e}	7.2	4.5^{e}	7.3	4.0^{e}	7.0	4.5^{e}	7.2
X2i		57.6**		58.0**		58.2**		57.6**	
Xi2Table p-1 = 16-1 = 15		α = 0.10 =25.0 α = 0.05 = 30.6		Multiple Comparison Test Values at the α value of 0.05 = 26.4					

Explanatory notes / Objaśnienia:
Numbers followed by the same letter are not significantly different. Storage time (A) of 0 weeks (A1), 3 weeks (A2), 6 weeks (A3) and 9 weeks (A4). The types of packaging (B) were aluminum foil (B1), high-density polyethylene/HDPE (B2), polyethylene/PE (B3) and unpackaged (B4) / Liczby oznaczone tą samą literą nie różnią się znacząco. Czas przechowywania (A) 0 tygodni (A1), 3 tygodnie (A2), 6 tygodni (A3) i 9 tygodni (A4). Rodzaje opakowań (B) to folia aluminiowa (B1), polietylen o wysokiej gęstości/HDPE (B2), polietylen/PE (B3) i opakowanie nieopakowane (B4).

extract used for fish and squid preservation. Surprisingly, using Atung for preservation can better reduce the saltiness and taste. A similar study also demonstrated that plant extract enhances taste and lowers sodium intake [26]. Salting causes fish and squid meat to be more compact due to water withdrawal and protein clumping by salt, which causes fish and squid to taste better [36].

Texture

In the texture assessment, yellowtail fish with code A1B1 and A1B4 had the highest values (58.0 and 8.7), while A4B4 had the lowest value in all fish and squid. Based on their organoleptic assessments, all dried salted fish and squid products in this study met the SNI standard. Salt can decrease water content and enter muscle tissue, leading to compact consistency and affect a texture. Moreover, salt can also remove excessive fishy odor in fish and squid [8].

Conclusions

1. Multilevel salt soaking with Atung seed maintained the quality of salted fish and squid, protein content and better organoleptic test results in yellowtail fish in aluminum foil packaging.
2. Multisoaking in Atung seed solution has many benefits, such as reducing sodium-containing salt, containing bioactive compounds that act as antibacterial agents and producing at a low cost. The presence of Atung seed extract could maintain the texture of fish and squid.

3. The type of packaging also had a synergetic effect on keeping the quality of the salted fish and squid. Aluminum foil was the best packaging type for the multisoaking products in this study.
4. This study will give an implication for storing food products, for example, surimi, nugget and tuna loin. For future research, evaluating the denaturation levels of protein in salted fish and squid during storage will be useful.

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WPŁYW WIELOPOZIOMOWEGO MOCZENIA W ROZTWORZE PROSZKU Z NASION ATUNG (*PARINARIUM GLABERIMUM*, HASSK) I RODZAJU OPAKOWANIA NA JAKOŚĆ SUSZONYCH SOLONYCH RYB

S t r e s z c z e n i e

Wprowadzenie. Solone ryby to produkt rybne, na które jest duże zapotrzebowanie chińskiego przemysłu spożywczego. Jednak solone ryby zwykle zawierają syntetyczne środki konserwujące, takie jak formaldehyd, które wykazują niebezpieczne właściwości. Z tego względu prowadzone są badania nad opracowaniem naturalnego środka konserwującego, który będzie ich substytutem. Atung (*Parinarium glaberrimum* Hassk.) to lokalna roślina lecznicza o potencjalnych właściwościach konserwujących żywność ze względu na jej działanie przeciwbakteryjne. Niniejsza praca ma na celu określenie wpływu wielopoziomowego moczenia w roztworze soli i proszku z nasion Atung oraz rodzaju opakowania na jakość suszonych solonych ryb podczas przechowywania. Ryby i kalmary moczono w 10% (w/v) roztworze soli fizjologicznej przez 30 min, a następnie zanurzano w 5% (w/v) roztworze Atung, a następnie suszono.

Wyniki i wnioski. Wyniki wykazały, że produkty opakowane w folię aluminiową wykazywały najniższą zawartość wody dla każdego rodzaju ryby i kalmara. Najniższą zawartość soli uzyskała żółtoogonowa ryba po 6 tygodniach przechowywania (3,94 %), podczas gdy ryba scad wykazała najniższą zawartość nadtlenków po 9 tygodniach przechowywania (374 mg.eq/kg). TPC suszonych solonych ryb i kalmarów było niższe niż TPC nieopakowanych ryb scad (4,72 log X). Metoda suszenia-solenia pozwoliła utrzymać zawartość białka w rybach żółtoogonowych i scad na poziomie 58,83 % i 58,44 % po 9 tygodniach przechowywania. Natomiast zawartość białka w suszonych i solonych kalmarach zmieniała się w zależności od czasu przechowywania i rodzaju opakowania. Wyniki oceny właściwości organoleptycznych (wygląd, zapach, smak, tekstura) były różne w zależności od rodzaju ryby i kalmara.

Słowa kluczowe: proszek z nasion Atung, suszona solona ryba, opakowanie, czas przechowywania