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The effect of ratio between Tilapia fish (*Oreochromis niloticus*) and Otoshimi on properties of sago fish crackers

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Abstract

Fish crackers are deep fried crackers normally made using fish and starch, and is a well known snack in South East Asia. Formulation of the fish crackers plays an important role not just in the quality of the product, but also for branding. In this study, fish formulation using tilapia and otoshimi was used which was added with sago as the starch base. A tilapia-based formulation of 1:1 with Sago showed good puffing with the highest expansion percentage at 4.21±0.66 and lowered hardness (2832.0±437.97 N/cm^2) compared to the other formulations. Meanwhile, although increase expansion was associated with increase oil absorption, the 1:1 ratio of tilapia to sago had lower oil absorption percentage (4.20±0.86) compared to increasing sago in the formulation (1:1:4, Tilapia, Otoshimi, Sago which had oil absorption percentage of 6.53±3.22 %, and 1:0:2 which had oil absorption percentage of 5.50±1.37). Although the overall quality does not reflect a good quality cracker, it was interesting to note that tilapia alone with sago showed better expansion, low oil absorption and reduce hardness.

1. INTRODUCTION

Fish crackers are deep fried crackers made from marine fish and seasoning that serve as flavouring. The crackers also mixed with tapioca flour and or sago flour as the main ingredients and the salt, sugar and monosodium glutamate (MSG) as seasonings. Fish crackers are favorite snack for Malaysian and its neighbouring countries such as in Thailand, Indonesia and Vietnam. According to Nurul *et al.,* (2009), fish crackers have many names such as keropok in Malaysia, kerupuk in Indonesia, kaew krab pla in Thailand or banh phong tom in Vietnam. In Malaysia, there because fish crackers are made with marine fish, its production is mostly concentrated in coastal areas of Kelantan, Terengganu, Pahang, Johor and Kedah. Mostly, the fish used to make crackers are Wolf herring (ikan parang), Sardines (ikan tamban), Round scad (ikan selayang), Threadfin bream (ikan kerisi), Ox-eyed scad (ikan lolong bara), Goatfish (ikan biji nangka), Lizard fish (ikan conor) and others. Marine fish is more common than freshwater fish. While in commercial production, fish type chosen is dependent on its availability, price and quality of the final product obtained. Otoshimi is a Japanese term for the ground meat of fish normally marine fish. Although there are many kinds of fish that have been used to make cracker, not many studies are available that compares fish types or how the choice affects cracker quality. Fish protein hydrolysate (Yu and Tan, 1990) and surimi (Huda *et al.,* 2000, 2001) in dried powder form have also been used for fish cracker formulation (in laboratory studies). Washed water protein from fish ball processing (such as surimi) is also used for fish cracker formulation by Yu *et al.* (1994). The use of fresh water fish for making fish crackers are not so common, but with decreasing landed marine fish, and increasing fish farming may one day see fish crackers manufacturer to change their raw material. The acceptance of technology varies amongst producers (Termezai *et al.,* 2017) have been used to produce fish crackers with applications of machinery developed and applied to some extent (Rasat *et al.,* 2017).

Traditionally, fish crackers are made by forming a dough from mixing fish meat with starch, water, sugar

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and salt. The majority of commercial producers add monosodium glutamate as flavouring. The dough is then shaped into round, oblique, stick or longitudinal forms and gelatinized by boiling or steaming (Chng *et al.,* 1991; Zzaman *et al.,* 2017). The gelatinized dough was left to cooldown, and something refrigerated to ease the slicing process, before being dried until the moisture content reaches 10% or less (Zzaman *et al.,* 2017). The final product quality, in particular the expansion is shown to be affected by the raw materials used in the formulation. As the final puffed product can comprise only starchy flour (with moisture), the properties of starch itself through manipulation and modification can lead to different output. Extensive studies on starch, particularly its characteristics can be found in quite a number of reviews (Butt *et al.,* 2018; Taewee, 2011). When focusing on a single type of protein component such as fish, and a narrow range of compositions (mixing ratios) perhaps dictated by consumer taste, the variations in quality are probably primarily controlled by starch quality and its changes during the processing, and the interference of the other components with these changes. For these reasons, this literature review is heavily weighted on the starch component and understanding of its properties in various formulations can assist in developing good quality assurance protocol in the manufacturing process of fish based food products (Lau *et al.,* 2016).

During the frying process, the crackers expanded into a low-density porous product and the degree of expansion, called linear expansion, is one of the important quality parameters of crackers (Yu *et al.,* 1991). Mostly customer preferred fish crackers with the highest linear expansion. Increase expansion meanwhile lead to a more porous product, which allows oil to be absorbed, which may affect the product quality upon extended storage (Ibadullah *et al.,* 2019). The application of additional additives (Jiamjariyatam, 2019; Aukkanit *et al.,* 2018) or cooking cycle (Nor *et al.,* 2014) have shown some degree of reduction in oil absorbed, thus highly sought after to reduce rancidity with extended storage time.

Starch is one of the main ingredients that is used in a wide variety of food products either as additives for thickening, preservation and quality enhancer in baked foods, confectioneries, pastas and noodles, soups and sauces, and even mayonnaises. Starch is a polysaccharide of glucose made of two types of α-d-glucan chains, amylose and amylopectin. Plant is the major source of starch, and widely differ according to the raw materials due to molecules produced by each plant through its specific structures and compositions (such as length of glucose chains or the amylose/amylopectin ratio). Other elements in these raw materials such as protein and fat content which differs greatly between sources also lead to different quality and end composition of the starch. In research studies, different kinds of starch/flour have been tried and tested for making cracker, for example cassava, rice or sago starches. From those studies, the emerging consensus appears to be that sago and cassava provide better expansion of cracker than the other starches. However, keropok made from cassava starch has a higher expansion that one made from sago starch (Mohamed *et al.,* 1989; Tongdang *et al.,* 2008). Mixing of the different starches lead to a variety of expansion ability of the product (Mohamed *et al.,* 1989; Nurul *et al.,* 2009; Tongdang *et al.,* 2008). There was no clear explanation why sago is added in the mix, but Sago is known to have higher amylose content compared with other starch, promoting retrodegradation, resulting in a stronger gel, sago starch resistant expansion (Mustafa Kamal *et al.,* 2019).

2. MATERIALS AND METHODS

Fresh tilapia (500-700 gram per fish) was obtained from Universiti Malaysia Kelantan Agropark, and proceeds within 2 hours of harvesting, by descaling and removal of its inner organ. After washing, the fish was filleted, and stored chilled before being used within 24hour.

Otoshimi was obtained from FRI (Fish Research Institute Malaysia, Kuala Terengganu) in frozen 10kg blocks. The blocks were cut into portion when needed. The dough formulated using different ratio of Tilapia, Otoshimi and sago was prepared as in Table 1.

Table 1: Tilapia, Otoshimi and Sago Ratio

Ratio	Tilapia	Otoshimi	Sago
A	0	1	1
B	1	1	2
C	1	0	1
D	0	1	2
E	1	1	4
F	1	0	2
G	0	2	1
H	1	1	1
I	2	0	1

All ratio formulated was added with salt (2%), sugar (1%), monosodium glutamate (0.5%), and ice water (20%), and mixed using a food processor. The dough was then shaped into round, oblique, stick or longitudinal forms and gelatinized by boiling or steaming. The dough was steamed for 30 minutes, left cooled, vacuum packed and kept at -18˚C for 12hour, before being slice to the thickness of 2mm using a slicer. The sliced product was later dried under direct sunlight until the moisture reaches 10%.

Dried slices were cooked in palm oil at 180˚C and left to cool for 10 minutes before being measured. The percentage linear expansion (LE) was calculated based on Yu (1991), by measuring expansion of the crackers diameter before and after frying.

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$$LE\ (\%) = \frac{Length\ after\ puffing - length\ before\ puffing}{Length\ before\ puffing} \times 100$$

Oil absorption (OA) percentage was measured according to the method proposed by Mohamed *et al.,* (1988), by measuring the weight difference before and after frying. The samples were ground and dried in the oven overnight and the moisture content was determined to calculate the oil absorption according to the following formula.

$$OA\ (\%) = \frac{W\ of\ fried\ sample - W\ of\ unfreid\ sample}{W\ of\ unfried\ sampl} \times 100$$

Hardness was measured according to Nurul *et al*., (2009) using the Texture Analyzer (TA-XT2) Stable Micro System, England). The conditions of the texture analyser were as follow: pre-test speed, 2.0 mm/s; post-test speed, 5.0mm/s;distance, 5.0mm;time, 5.0s:trigger type and auto and trigger force, 10g. The dried slices were ball probes (p/0.25) s stainless steel ball probe). This rig was used to measure the factorability by means of a penetration test. The parameter used in the measurement for hardness was N/cm^2.

The data obtained were analysed by using one-way analysis of variance (ANOVA) and followed by Turkey's Multiple Range Test of the Statistical Package Social Science (SPSS) version 16.00. The means of treatment showing significant differences ($p< 0.05$) were subjected to Turkey's Multiple Range Test.

3. RESULT AND DISCUSSION

The basic observation on fish crackers focuses on its ability to expand, oil absorbed and the hardness of the product. These parameters are directly related to some extent on the quality of the product prior to storage and its acceptance by consumer (Chudasama *et al.,* 2019).

Table 2: Tilapia, Otoshimi and Sago ratio, linear expansion,noil absorption and hardness

Ratio (tilapia: otoshimi: sago)	Linear expansion (%)	Oil absorption (%)	Hardness (N/cm^2)
A (0:1:1)	-	-	-
B (1:1:2)	$2.29{\pm}0.27^{b}$	$2.77{\pm}2.19^{a}$	$4678.8{\pm}229.33^{b}$
C (1:0:1)	$4.21{\pm}0.66^{d}$	$4.20{\pm}0.86^{a}$	$2832.0{\pm}437.97^{a}$
D (0:1:2)	$0.40{\pm}0.20^{a}$	$2.68{\pm}1.79^{a}$	$6431.0{\pm}566.54^{c}$
E (1:1:4)	$2.79{\pm}1.09^{bc}$	$6.53{\pm}3.22^{b}$	$6961.30{\pm}1189.21^{c}$
F (1:0:2)	$2.83{\pm}1.32^{c}$	$5.50{\pm}1.37^{b}$	$5124.20{\pm}72.81^{bc}$
G (0:2:1)	-	-	-
H (1:1:1)	-	-	-
I (2:0:1)	$2.12{\pm}0.15^{b}$	$3.48{\pm}0.49^{ab}$	$6221.8{\pm}1544.66^{bc}$

*Value is means of 10 replications.
a-b mean with different letter within the same column are significantly different ($p<0.05$).

Not all formulation undertaken was possible to make the dough. As reported in table 2, when otoshimi was used without tilapia the dough could not be formed, unless the sago ratio was higher. Meanwhile when tilapia was used, even at a higher fish ratio of up to 2:1 with sago, the dough can be formed and used to make crackers. Different species of fish generate different protein gelation leading to diverse textural properties because of differences in structure, formation, action and appearance of myofibrillar. Stronger gel has been associated with white muscle over dark muscle (Sun and Holley, 2011) which may explain why tilapia-based formulation was able to be shaped and steamed without falling apart. Freshness has influence on the action and appearance of the myofibrillar protein and enzyme systems of the muscle. Enzyme activity influences the gelling properties of mince by hydrolysing myosin or cross-linking myosin. Endogenous proteinases and transglutaminases are the most common enzymes present in fresh fish and can significantly increase myofibrillar protein gel strength (Aberoumand and Baesi, 2021; Sun and Holley, 2011).

The linear expansion upon frying was highest when only tilapia alone was used in the formulation. A mixed tilapia: otoshimi formulation showed some degree of expansion, while otoshimi alone had very little expansion ability. There are three factors that influenced the degree of linear expansion. Firstly, Kyaw *et al.,* (1999) reported that excessive steaming time will result in the poor linear expansion of the fish crackers. Secondly, Peranginangin *et al.,* (1997) found that the slicing of crackers into a thickness of more than 2 mm will produce fish crackers with the lower degree of linear expansion. Then, the ratio of fish and starch also influences the degree of linear expansion and the crispiness of the fish crackers (King, 2002; Ramesh *et al.,* 2018; Tuhumury *et al.,* 2020; An *et al.,* 1996). However, moisture content in crackers needs to be controlled during production process to optimize the quality of the product. Insufficient water content may lead to incomplete gelatinization of starch during the steaming process (Mohamed *et al.,* 1988).

For sample (C) ratio tilapia to otoshimi to sago flour (1:0:1) linear expansion is low due to small amount of sago flour. According to Mohamed *et al.* (1989) study, the linear expansion, oil absorption and the crispiness of the crackers correlated with the total of amylopectin content in the flour. Besides, the incomplete gelatinization of the starch during the steaming process causes the reduced linear expansion of the products. Among various starch flour, tapioca flour is known to produce fish crackers with excellent expansion properties (Mohamed *et al.,* 1988; Yu, 1991, Tongdang *et al.,* 2008). Clearly the final product quality, especially its expansion, will be affected by the raw materials and its processing steps. As the final puffed product can comprise only starchy flour (with moisture), the properties of starch

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and the role they play in and modifying the processing requires extensive observation. Due to an extensive history of starch research, important raw material characteristics and at least a partial interpretation of the effects of the processing steps are available but have not been readily conclusive due to the sheer data available (Taewee, 2011). When focusing on a single type of protein component such as fish, and a narrow range of compositions (mixing ratios) perhaps dictated by consumer taste, the variations in quality are probably primarily controlled by starch quality and its changes during the processing, and the interference of flavours and other derived characteristics of the other components with these changes.

Mixtures in various ratios of cassava and sago starches have been used for cracker making and compared to cassava cracker (Tongdang *et al.,* 2008). In these studies, cassava starch provided higher expansion of cracker than the mixed starches. Increase of sago starch fraction in the mixture results in a decrease of expansion. The promotion of retrogradation can be produced by the higher amylose content in Sago, leading to stronger gelling activities, thus resisting expansion. A similar observation was obtained when cassava was replaced by mung bean starch (Mohamed *et al.,* 1989). Meanwhile Saeleaw and Schleining (2010) used mixtures of four types of flour (cassava, waxy rice, non-waxy rice and wheat flour) for making cracker, with higher cassava showing higher expansion. The effect of pre gelatizing starch was also previously observed to make crackers (Yu and Low, 1992) to reduce the cooking time of keropok dough. This process naturally affected the linear expansion, and it was found that cracker could be more easily cooked compared to using native starch.

The tilapia sago formulation which showed the higher expansion had lower oil absorption compared to the high sago ratio formulated crackers. Starch is an oil absorbing component in may type of food (Vongsawasdi, *et al.,* 2008), which was why when sago ratio was high, even the slight expansion allows more aoil to be absorbed. Oil absorption should be directly proportional with linear expansion, since it was shown increase linear expansion will increase oil absorption. Mohamed *et al.,* (1988). It was propose that larger surface area will allow more oil trapped on the surface layer of the bigger air "cells" when the expansion was increased. Huda *et al.,* (2000: 2001) and King (2002) reported that as a result oil absorption, the fat content of fried fish crackers is higher in the sample with the higher linear expansion compared to the sample with a lower linear expansion. As shown in table 2, the higher the degree of the linear expansion of the cracker may have resulted in more air cells being form thus the more oil may have been trapped, consequently may have resulted in the higher degree of oil absorption.

Increase in linear expansion will increase the oil absorption and decrease the hardness value. The hardness values for sample C were the lowest at 2832.0±437.97 N/cm^2, which was significantly different ($p<0.05$) compared to the next hardness level for sample B 4678.8±229.33 N/cm^2. All the other samples which were measured (Sample D, E, F, and I) had higher hardness than that of sample B. Ratio tilapia to otoshimi to sago flour (2:0:1) have low linear expansion and oil absorption but higher value of hardness. Similarly with ratio (1:0:2) that have high value of hardness. Slicing of fish crackers into high thickness will produce fish crackers with the lower degree of linear expansion as well as oil absorption and high value of hardness. Low hardness will be shown as a high crispiness score and consumers prefer fish crackers with a high crispiness score. According to Peranginangin *et al.,* (1997) found that increasing linear expansion will increase the crispiness thus the crackers have lower hardness value.

4. CONCLUSION

The high degree of linear expansion resulted in high degree of oil absorption and were more crisps (reduced hardness). High moisture content in otoshimi makes unsuitable for making fish crackers because the dough cannot be shaped and become more flaccid compared using tilapia that have lower moisture content. Fish crackers from tilapia and sago flour gave higher degree of linear expansion and oil absorption compared with fish crackers made up from tilapia mixed with otoshimi and sago flour. Although the overall quality does not reflect a good quality cracker, it was interesting to note that tilapia alone with sago showed better expansion, low oil absorption and reduce hardness.

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