Food Research 8 (1) : 349 - 358 (February 2024)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

RESEARCH PAPER

Decreasing fishy odour from catfish (*Clarias* sp.) flour as a food ingredient by using various soaking solutions

[1]Noviana, A., [1,*]Palupi, E., [2,3]Giriwono, P.E. and [1]Rimbawan, R.

[1]*Department of Community Nutrition, Faculty of Human Ecology, IPB University, Bogor, West Java, 16680, Indonesia*
[2]*Department of Food Science and Technology, Faculty of Agricultural Engineering and Technology, IPB University, Bogor, West Java, 16680, Indonesia*
[3]*Southeast Asian Food and Agricultural Science and Technology (SEAFAST) Center, IPB University, Bogor, West Java, 16680, Indonesia*

Article history:
Received: 1 April 2022
Received in revised form: 10 May 2022
Accepted: 7 October 2022
Available Online: 28 February 2024

Keywords:
Clarias sp.,
Fish flour,
Sensory improvement,
Trimethylamine

DOI:
https://doi.org/10.26656/fr.2017.8(1).123

Abstract

Catfish (*Clarias* sp.) has become one of Indonesia's most popular aquaculture products. However, it is very perishable and has a short shelf life. It can be preserved by drying it into catfish flour. Therefore, it is easy to be further utilized for substituting other flour in the production of foods to enhance their nutritional value. However, the fishy odour of catfish flour hinders this flour for wide utilization. Various soaking solutions such as lime juice, lemon juice, milk, coconut water and vinegar are commonly used to decrease the fishy odour. This study aimed to establish a sensory lexicon by Quantitative Descriptive Analysis (QDA) and to evaluate the pH and trimethylamine (TMA) value of catfish flour soaked by various types of soaking solutions. According to a sensory evaluation, 19 attributes were identified. The coconut water at 5% was determined as the most preferred with a score of 0.74±0.72. It had a high intensity of saltiness and smoky fish aroma (pleasant attributes), as well as a low fishy smell (unpleasant attribute). The lime juice at 5% had the strongest fishy smell (unpleasant attribute) and umami taste (pleasant attribute). The pH values of all samples were in the range of 4.16-6.59. The highest pH value was found in milk at 5%, whereas the lowest one was found in lime juice at 100%. TMA values ranged from 2.44 to 5.19 mg N/100 g catfish flour. The highest TMA value was found in lime juice at 5%, but it was within an acceptable range and lower than the control (6.10±0.86 mg N/100 g catfish flour). The results of this study indicated that catfish flour made from catfish meat soaked in lime juice, lemon juice, milk, coconut water, and vinegar provided good quality characteristics, as well as pH and TMA values within an acceptable range. Therefore, they had the potential to be further developed and could be considered as an alternative for other flours in developing food products.

1. Introduction

Fish is one of the most important sources of high-quality animal protein and a relatively less expensive meat source for an ever-increasing demand in a world with an ever-increasing population. Total global catch fisheries production attained 96.4 million tons in 2018, the highest amount ever recorded, up to 5.4% from the preceding three years' average (Food and Agriculture of the United Nations, 2020). In 2018, global aquaculture production reached another all-time record of 114.5 million tons of live weight. Indonesia is one of the largest producers of aquaculture in the world (Food and Agriculture of the United Nations, 2020).

Catfish (*Clarias* sp.) has become one of Indonesia's most popular aquaculture products. National catfish production in Indonesia surged by 131% from 767,797 tons in 2016 to 1,770,000 tons in 2017 (Ministry of Marine Affairs and Fisheries of The Republic of Indonesia, 2018). Catfish has also a high nutritional value. A hundred grams of catfish contains 92 kcal of energy, 6.2 g of protein, 2.82 g of fat, 14 mg of calcium, 70 mg of vitamin A, 42 mg of sodium, and 0.25 mg of iron (Ministry of Health of the Republic of Indonesia, 2018). Fresh fish, on the other hand, is perishable and has a short shelf life (Prabhakar *et al.,* 2020). Quality losses might occur quickly after harvest, especially in hot temperatures and tropical places with insufficient

*Corresponding author.
Email: *enypalupi@apps.ipb.ac.id*

eISSN: 2550-2166
Published by Rynnye Lyan Resources

refrigeration facilities (Jummai *et al.,* 2016). Furthermore, pH, one of the intrinsic factors, is closely associated with fish stress conditions as it influences the growth of spoilage bacteria (Zampacavallo *et al.,* 2015). This emphasizes the importance of appropriate handling, processing, and distribution. The management and reduction of post-harvest losses necessitate resource efficiency, spoilage reduction, and the conversion of raw resources into products for direct human consumption. Catfish can be processed into catfish flour to prolong its shelf life and improve the easiness of food application to improve its nutritional value (Aminullah *et al.,* 2021). However, according to a previous study, adding fish to the manufacturing of food products generates an undesirable smell, particularly a strong fishy smell, which affects its acceptance (Xue *et al.,* 2018).

Quantitative descriptive analysis (QDA) is a method for identifying the type of sensory qualities and quantifying their intensity immediately after stimulation (Stone and Sidel, 2004). The ability to train panellists to measure certain attributes in a reproducible manner to produce a comprehensive quantitative description acceptable to statistical analysis is the basis of QDA (Chapman *et al.,* 2001). The resulting data can be statistically analysed using analysis of variance and multivariate statistical techniques and then graphically depicted.

Trimethylamine (TMA) is a predominant trigger of fish malodour and can be recognized by a distinct fishy smell (Hebard *et al.,* 1982). TMA is a tertiary amine gas that smells like rotting fish when exposed to normal temperatures (Emmanuel *et al.,* 1984). Humans have been reported to be able to recognize TMA levels as low as 0.00021 ppm (Hernandez *et al.,* 2003). Freshwater fish utilize Trimethylamine Oxide (TMA-O) to prevent tissue waterlogging (Leonardos *et al.,* 1969). *Shewanella putrefaciens, Aeromonas* spp., *Psychrotolerant Enterobacteriaceae*, *Photobacterium phosphoreum,* and *Vibrio* spp., are several bacteria that can receive energy by converting TMA-O to TMA, which creates unpleasant odours and tastes (Gram and Dalgaard, 2002; Zhuang *et al.,* 2021). Soaking fish or aquaculture products into any ingredient is one of the methods used to reduce fishy odour. Heu *et al.* (2008) reported that salmon frame soaked in soybean milk was the most efficient method among the other methods (adding anchovy and adding spices) for masking fishy odour. Certain ingredients such as lime juice, lemon juice, milk, coconut water, and vinegar are some of the most common ingredients used to soak fish and other aquaculture products to reduce or eliminate fishy odour (Kouakou *et al.,* 2014; Keyimu and Abdullah, 2014; Herath *et al.,* 2019; Hidayat and Suprayitno, 2019).

Nevertheless, there was no data about sensory lexicon, pH, and TMA levels for catfish flour made from catfish meat soaked in various types of soaking ingredients. Therefore, the study aimed to establish a sensory lexicon by the QDA method and to evaluate the pH and TMA value of catfish flour made from catfish meat soaked in various types of soaking solutions.

2. Materials and methods

2.1 Source of materials

The fish sample used in this study was catfish (*Clarias* sp.). The catfish, lime, lemon, milk, coconut water and vinegar used in this study were all purchased locally and prepared immediately.

2.2 Preparation of catfish flour

The visceral, skins, head, and bones of the catfish were removed, and the meat was rinsed three times in water. Soaking solutions were made from lime, lemon, milk, coconut water and vinegar. Firstly, lime and lemon were squeezed separately to obtain the lime juice and lemon juice. Lime juice at 5% (LJ 5%) was made by combining lime juice and water in a 1:19 ratio. Whereas, lime juice at 100% (100% LJ) was prepared from pure lime juice without the addition of water. Like 5% LJ, lemon juice at 5% (5% L), milk at 5% (5% M), and coconut water at 5% (5% CW) were made by mixing each of these ingredients and water in a 1:19 ratio. Lemon juice at 100% (100% L), milk at 100% (100% M), and coconut water at 100% (100% CW) were created from each of these ingredients without the addition of water. In contrast, vinegar at 5% (5% V) was made by combining vinegar (containing 25% food-grade acetic acid) and water in a 1:4 ratio. While vinegar at 25% (25% V) was prepared from vinegar containing 25% food-grade acetic acid without water addition. The characteristics of soaking solutions are presented in Table 1. The meat was then divided into ten parts and soaked for 30 min in 5% LJ, 100% LJ, 5% L, 100% L, 5% M, 100% M, 5% CW, 100% CW, 5% V and 25% V. They were steamed for 15 min. The cooked catfish meat was squeezed until it was nearly dry and then roasted for 120 mins at 90°C in an oven. The dried catfish meat was ground into a powder.

2.3 Sensory evaluation

Sensory evaluation was performed by a sensory panel (9 sensory assessors: 8 females and 1 male) from the Department of Community Nutrition, IPB University, who were selected and trained according to ISO 8586:2014 (International Organization for Standardization, 2014). A standard sensory room was decorated in accordance with ISO 8589:2007 guidelines

https://doi.org/10.26656/fr.2017.8(1).123

Table 1. pH values, %Brix, and acetic acid content of soaking solutions

Soaking Solution	pH	%Brix	%Acetic Acid
Lime juice at 5%	2.79±0.05[e]	0.00±0.00[e]	-
Lime juice at 100%	2.36±0.29[g]	7.00±0.00[b]	-
Lemon juice at 5%	2.76±0.03[e]	0.00±0.00[e]	-
Lemon juice at 100%	2.29±0.06[g]	6.00±0.00[c]	-
Milk at 5%	7.15±0.10[a]	0.00±0.00[e]	-
Milk at 100%	6.33±0.52[b]	12.00±0.00[a]	-
Coconut water at 5%	7.23±0.05[a]	0.00±0.00[e]	-
Coconut water at 100%	5.78±0.01[c]	5.00±0.00[d]	-
Vinegar at 5%	3.84±0.03[d]	0.00±0.00[e]	5.00±0.00
Vinegar at 25%	2.55±0.07[f]	0.00±0.00[e]	25.00±0.00

Values are presented as mean±SD, n = 9. Values with different superscript within the same column are statistically significantly difference (p<0.05).

(International Organization for Standardization, 2007). Referring to ISO 11132:2012, the sensory lexicon was established using the Quantitative Descriptive Analysis (QDA) method (International Organization for Standardization, 2012). Firstly, ten samples were offered to sensory assessors in a Focus Group Discussion (FGD). The assessors identified attributes of catfish flour. Then they were asked to rate each sensory attribute on a scale of 0 to 10, with 0 representing a low intensity and 10 representing a high intensity. Sensory assessors were given all of the samples and asked to rank them in descending or ascending order of preference, according to ISO 6658:2017 (International Organization for Standardization, 2017). The first rank was the most preferred and the tenth rank was the least preferred.

2.4 Determination of pH

The pH was determined using a standard method (Association of Official Agricultural Chemists, 2000). A digital pH meter that had been pre-calibrated with buffers at 4, 7 and 9 was used to measure the pH of catfish flour. The samples (2 g) were homogenized with distilled water (10 mL) and the homogenate was subjected to pH determination.

2.5 Determination of trimethylamine

TMA were determined by Conway's method as described by The National Standardization Agency of Indonesia (National Standardization Agency, 2009). Trichloroacetic acid 7% (75 mL) was used to homogenize the 25 g samples. The homogenate was filtered using Whatman No.1 filter paper, and the filtrate was used for the analyses. One side of the outer ring was filled with 1 mL sample extract. The inner ring was then pipetted with a 2 mL boric acid (H_3BO_3) 2% solution containing 2 drops of the Conway indicator. K_2CO_3 (1 mL) containing 0.5 mL concentrated formaldehyde which was pipetted on another side of the outer ring, was mixed with the sample extract to start the reaction. The Conway unit was closed and incubated for 120 mins at 37°C. The TMA values (mg N/100 g sample) were calculated as:

$$\mathrm{TMA} = \frac{(\mathrm{Vc} - \mathrm{Vb}) \times \mathrm{N} \times 14.007 \times \mathrm{fp}\ (100) \times 100}{\mathrm{W}}$$

where "Vc" was volume of HCl solution of sample titration, "Vb" was volume of HCl solution of blank titration, "N" was normality of HCl solution, "14.007" was atomic weight of nitrogen, "fp(100)" was dilution factor, "(100)" was TVB content of 100 g of sample, and "W" was sample weight used.

2.6 Statistical analysis

Duncan's Multiple Range Test was used in Statistical Product and Service Solutions (version 16.0; SPSS) software to assess differences between means using one-way variance analysis (ANOVA). The significance level was set at 0.05. The results of the preference test were prior transformed into scores contained in the Fisher and Yates Table. Therefore, the analysis of variance could be carried out (Setyaningsih *et al.* 2010). Based on that table, the first, second, third, fourth, fifth, sixth, seventh, eighth, ninth and tenth ranks had scores of 1.54, 1.00, 0.66, 0.38, 0.12, -0.12, -0.38, -0.66, -1.00, and -1.54, respectively. After transforming the data into these scores, data were analyzed using one-way ANOVA to determine whether there was a significant difference (p<0.05), then it was further analysed with Duncan if there was a significant difference from each sample. The sample with the highest average rank score is the first rank or the most preferred, while the sample with the lowest average rank score is the tenth first or the least preferred.

3. Results and discussion

A scientific and comprehensive sensory lexicon can be used to standardize sensory evaluation, ensure product quality and optimize product (Baker *et al.,* 2014). According to an evaluation of catfish flour made from catfish meat with various types of soaking solutions,

https://doi.org/10.26656/fr.2017.8(1).123

several attributes were identified (Table 2). "Yellowness", "greyish", "brownness", "homogeneity", "smoky fish aroma", "milky aroma", "citrus aroma", "fineness", "fishy smell", "vinegar aroma", "agglomeration", "stringy-texture", "sourness", "burnt taste", "grittiness-mouth feel" and "stickiness-mouth feel" all had significant differences in intensity among the different treatment solutions (p<0.05) (Table 3). There were significant differences in the attributes of "yellowness", "brownness", "homogeneity", "fishy smell", "vinegar aroma", "agglomeration", "stringy-texture" and "sourness" between catfish flour soaked in vinegar at low (5%) and high (25%) concentrations (p<0.05) (Table 3). However, no significant differences in any of the attributes appeared among 5% LJ and 100% LJ, 5% L and 100% L, 5% M and 100% M, as well as 5% CW and 100% CW. There were significant differences among all samples (p<0.05) according to the results of the preference test. The preferences ranked first to last were 5% CW, 5% V, 100% CW, 5% M, 100% M, 5% L, 100% L, 100% LJ, 25% V and 5% LJ (Figure 1).

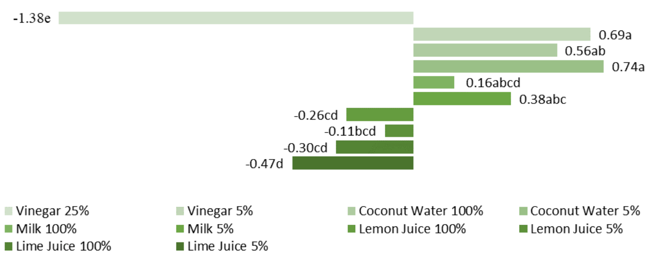

Figure 1. Preference rank score of catfish flour made from catfish meat soaked in various types of soaking solutions. Mean values followed by different alphabets are significantly different (p<0.05).

The aroma and taste of catfish flour are the most important characteristics that determine consumer preference. The 5% CW was determined as the most preferred with a score of 0.74±0.72 (Figure 1). Moreover, it had high intense saltiness and smoky fish aroma (pleasant attribute) of 0.89±1.17 and 6.44±2.51, respectively, as well as a low intense fishy smell (unpleasant attribute) of 2.78±1.39 (Table 3; Figure 2). The less fishy smell in 5% CW and 100% CW might be due to the phenolic compound of coconut water which inhibits fish spoilage. The coconut water was reported to have a total phenol content of 1.48±0.43 (mg/g GAE) and total flavonoid content of 0.53±0.02 (mg/g QE) which might be ascribed to its ability to scavenge ABTS and DPPH *in vitro* (Oluwarotimi *et al.*, 2021). As an

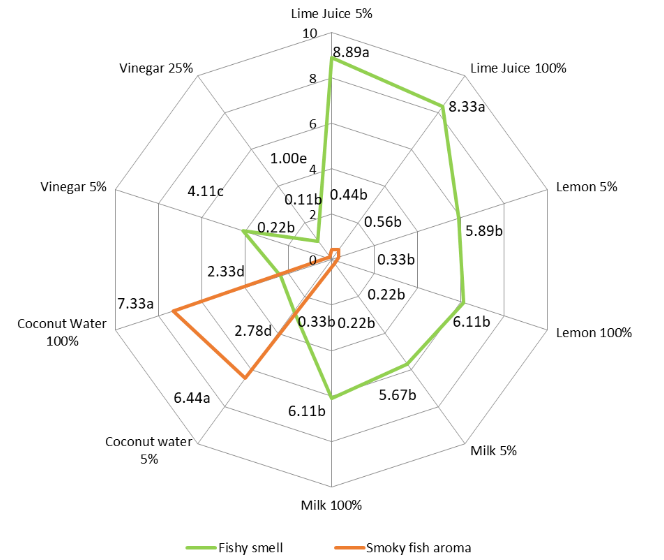

Figure 2. Intensity value of fishy odour and smoky fish flavor attribute of catfish flour with various types of soaking solutions. Mean values followed by different alphabets are significantly different (p<0.05).

Table 2. Identified sensory attributes of catfish flour

Attributes	Specific attributes	Description
Pleasant attributes	Yellowishness	Yellow intensity colour indicates the denaturation of protein after adding acid
	Greyish	Grey intensity colour indicates the denaturation of protein after heat treatment (steaming (15 mins), roasting (90°C;120 mins))
	Brownness	Brown intensity colour after heat treatment (roasting; 90°C; 120 mins)
	Homogeneity	The state of being similar kind or having a uniform structure of composition (homogeneous)
	Smoky fish aroma	Flavor of pleasant roasted, smoked fish like
	Milky aroma	Milk like aroma
	Citrus aroma	Citrus like aroma
	Fineness	The state of being fine
	Umami	The core fifth taste includes sweet, sour, bitter and salty
	Saltiness	Salt intensity taste
Unpleasant attributes	Fishy smell	Aroma similar to rotten fish
	Vinegar aroma	Pungent aroma similar to vinegar or acetic acid
	Agglomeration	The sticking of particles to one another or to solid surface
	Stringy-texture	Texture like full of long thin pieces
	Sourness	Sour intensity taste, like acid taste
	Burnt taste	Somewhat bitter taste produced by roasting process
	Grittiness-mouthfeel	The gritty intensity when chewed in the mouth, effect of particle size
	Stickiness-mouthfeel	The sticky intensity when chewed in the mouth, adhering or sticking to a surface
	Bitter-after taste	Bitter taste intensity after swallowing the catfish flour

https://doi.org/10.26656/fr.2017.8(1).123

Table 3. Results of quantitative descriptive analysis of catfish flour.

Attributes	Specific attributes	Lime juice at 5%	Lime juice at 100%	Lemon juice at 5%	Lemon juice at 100%	Milk at 5%
Pleasant attributes	Yellowishness	1.56±0.73[cd]	1.78±0.67[c]	0.89±0.60[de]	1.00±0.50[de]	3.44±0.73[b]
	Greyish	3.11±1.45[cd]	3.00±1.41[cde]	6.11±0.78[a]	6.11±0.78[a]	1.89±1.17[e]
	Brownness	2.78±0.83[abc]	3.78±0.44[ab]	2.33±0.71[bc]	2.11±0.78[c]	3.22±2.33[abc]
	Homogeneity	5.67±1.73[bc]	5.22±1.30[bc]	6.44±1.51[ab]	7.22±1.92[a]	4.56±0.53[cd]
	Smoky fish aroma	0.44±0.73[b]	0.56±0.88[b]	0.33±0.71[b]	0.22±0.67[b]	0.22±0.67[b]
	Milky aroma	0.22±0.67[b]	0.22±0.67[b]	0.22±0.67[b]	0.22±0.67[b]	3.67±2.96[a]
	Citrus aroma	0.89±1.69[b]	1.33±1.94[ab]	1.89±2.03[ab]	2.78±2.11[a]	0.44±0.88[b]
	Fineness	7.00±1.41[ab]	8.00±0.87[a]	7.11±0.93[ab]	7.22±1.79[ab]	6.11±1.54[bcd]
	Umami	5.33±1.58[a]	5.00±1.80[a]	4.11±2.21[a]	4.00±2.35[a]	4.78±1.79[a]
	Saltiness	0.67±0.87[a]	0.78±1.09[a]	0.67±0.87[a]	0.89±1.27[a]	0.89±1.17[a]
Unpleasant attributes	Fishy smell	8.89±0.33[a]	8.33±0.50[a]	5.89±1.90[b]	6.11±1.61[b]	5.67±1.94[b]
	Vinegar aroma	0.33±0.70[c]	0.33±0.70[c]	0.33±0.70[c]	0.33±0.70[c]	0.22±0.67[c]
	Agglomeration	5.89±1.27[a]	6.33±1.32[a]	5.22±1.79[ab]	5.33±1.73[ab]	4.89±1.17[abc]
	Stringy-texture	1.56±1.01[d]	1.67±1.00[d]	1.56±1.01[d]	1.67±1.00[d]	2.44±1.33[cd]
	Sourness	2.44±1.59[bcd]	5.56±2.36[a]	2.56±1.88[bc]	5.78±2.22[a]	0.44±1.01[d]
	Burnt taste	0.22±0.44[b]	0.22±0.44[b]	0.22±0.44[b]	0.22±0.44[b]	0.22±0.44[b]
	Grittiness-mouthfeel	2.11±1.27[b]	2.44±1.81[b]	2.44±1.33[b]	2.44±1.8[b]	2.89±2.09[b]
	Stickiness-mouthfeel	2.11±1.67[c]	2.11±1.17[c]	1.89±1.36[c]	1.89±1.54[c]	4.33±2.83[b]
	Bitter-after taste	1.00±1.23[a]	1.22±1.30[a]	1.00±1.12[a]	0.78±1.09[a]	1.44±2.35[a]

Values are presented as mean±SD, n = 9. Values with different superscript within the same column are statistically significantly difference (p<0.05).

antioxidant, they can inhibit lipid peroxidation and perform a variety of physiological functions (Takó *et al.,* 2020). In addition, plant phenolic can also be effective inhibitors of many foodborne pathogenic and spoilage bacteria (Gyawali and Ibrahim, 2014; Zambrano *et al.,* 2019). The phenolic compounds can manifest their microbicide effect in a variety of ways. These molecules can inhibit various microbial pathogenicity factors (e.g., by reduction of host ligand adhesion, inhibition of biofilm formation, and neutralization of bacterial toxins), diminish membrane fluidity, impede nucleic acids and the cell wall synthesis, as well as energy metabolism (Quideau *et al.,* 2011; Górniak *et al.,* 2019).

The phenolic compound in coconut water was reported to have metal chelation and antimicrobial activity. Mahayothee *et al.* (2016) reported that catechin and salicylic acid were the predominant phenolic compounds found in coconut water. According to Pazos *et al.* (2013), because of its ability to neutralize free radicals and chelate metal ions, catechin was expected to provide antioxidant protection to proteins. Furthermore, catechin has antimicrobial properties, making it suitable for the preservation of red meat, poultry, and seafood (Wu *et al.,* 2010). Wu *et al.* (2010) included catechin, an antimicrobial and antioxidant phytochemical, into a biodegradable PVA (polyvinyl alcohol) film that was utilized as a wrap for fresh meat products such as seafood, poultry, and red meat. This PVA-starch film model inhibited the growth of airborne microorganisms at 1.000 ppm catechin and the best antioxidant activity on cooking oil at 500 ppm catechin. Salicylic acid has also antimicrobial activity. Salicylic acid strongly inhibited bacterial growth (*E. coli, P. aeruginosa, E. faecalis, S. aureus*) with a minimal inhibitory concentration (MIC) of 250-500 µg/ml (Adamczak *et al.,* 2020). As bacteria can cause the formation of trimethylamine, inhibiting their growth result in a decrease in trimethylamine production, which is the major compound responsible for the fishy smell (Hebard *et al.,* 1982). As presented in Table 1, the %Brix of 100% CW was 5%. Manjunatha and Raju (2013) reported that fresh tender coconut water contains 5.3^{0}Brix and 4.69% reduced sugar. The sugar contained in coconut water promotes a Maillard reaction which can minimize or mask the fishy odour (Kouakou *et al.,* 2014). The Maillard Reaction is a complicated series of chemical reactions that decrease sugar and amino acids, peptides, or proteins, leading to a variety of intermediates, by-products, and brown compounds (melanoidins), all of which contribute to the aroma, taste, and colour of processed foods (Lertittikul *et al.,* 2007). The Maillard reaction produces a wide range of compounds and aromas with implications of roasted caramel at its final stage, which is known to stimulate the appetite (Kouakou *et al.,* 2014).

The smoky fish aroma of 5% CW and 100% CW was higher than others. This is because phenolic compounds contained in coconut water play key roles in the smoky aroma (Pu *et al.,* 2020). Furthermore, reducing sugar contained in coconut water that promotes the Maillard reaction generates this roasted aroma (Manjunatha and Raju, 2013; Kouakou *et al.* 2014). Whereas, a salty taste at 5% CW indicated the content of sodium chloride (NaCl). According to data found by Assa *et al.* (2013), the sodium chloride content of coconut water ranks from $8.90.10^{-2}$% to $11.90.10^{-2}$%. In contrast, the 5% LJ had the strongest fishy smell of 8.89±0.33 (Table 3). However, the trimethylamine (TMA) (a major compound which generates fishy odour) value of 5% LJ was lower than the control. It indicated that the fishy odour of 5% LJ was lower than the control. The study by Herath *et al.* (2019) mentioned that lime juice can reduce the fishy odour (Herath *et al.,* 2019). Lime juice which contains acid can inhibit the growth of bacteria in fish meat so it might prevent the formation of trimethylamine which is the main factor in the fishy smell formation (Ghaly *et al.,* 2010). In this study, the soaking using 5% LJ was possible to prevent the formation of a fishy aroma, but not as much as in other samples. On the other hand, it had the strongest umami taste (pleasant attribute) of 5.33±1.58 even though no significant differences were found among all samples (Figure 3). The major umami effective stimulus is free L-glutamate (glutamic acid). Heat treatment of fish causes a rise in free amino acids, such as L-glutamate, as well as umami potentiating ribonucleotides (disodium 5'inosinate Monophosphate) IMP and/or (disodium 5'guanylate monophosphate) GMP) (Ninomiya, 1998; Kurihara, 2015). Proteolysis occurring from heat treatment of fish that contain high concentrations of protein (tasteless) produces a complex mixture of amino acids, including L-glutamate. Because fish products naturally contain high concentrations of IMP, the umami taste potentiation between IMP and L-glutamate can arise (Ninomiya, 1998; Kurihara, 2015).

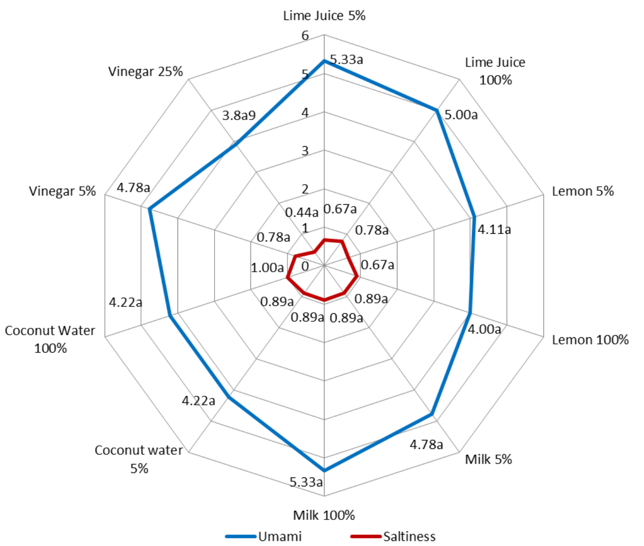

Figure 3. Intensity value of umami and saltiness attribute of cat fish flour with various types of soaking solutions. Mean values followed by different alphabets are significantly different ($p<0.05$).

The hydrogen ionic potential (pH) has the function of indicating the acidity, alkalinity or neutrality of fish muscle. The determination of pH represents an important factor in the quality evaluation of various foods. Table 4 shows that the pH of catfish flour produced from catfish meat soaked in several types of soaking ingredients differed significantly ($p<0.05$). They were in the range of 4.16-6.59. A previous study reported that the pH of fresh fish meat after post-mortem varies from 6.0 to 6.8 (Khalafalla *et al.,* 2015). In this study, the highest pH value was found in 5% M (Table 4). Its pH value was 6.59. The 100% M had a pH value close to its where the pH value was 6.41. It could be due to the pH value of cow milk that was slightly acidic or close to neutral pH, between 6.5 and 6.7 (Marouf and Elmhal, 2017). In contrast, 100% L had the lowest pH value (Table 4). It might be owing to the pH of lemon juice, in which the pH value was about 2.076 (Pham *et al.,* 2020). Nonetheless, all pH values were under 7. The determination of pH represents an important factor in the quality evaluation of various foods, such as fish, which is considered a food of low acidity (pH higher than 4.5). When the hydrolytic, oxidative, or fermentative degradation of muscle is conducted at a higher pH and with more bacterial activity, the concentration of hydrogen ions almost invariably changes. However, it is not conclusive as the sole parameter for determining the degree of freshness of the fish, and other chemical, microbiological, microscopic and/or sensorial analyses should be carried out to ensure higher reliability of the results. The pH of the seafood could be altered depending on how the process was carried out, including capturing, storing on board, landing, processing, and storing, even if the seafood did not lose its original quality, because numerous chemical and biochemical reactions are triggered in the post-mortem of fish. There is no pH analysis as the freshness index, nor is there any indication that this characteristic defines the fish as unfit for consumption. Only in Argentina's legislation (Argentine Food Code) is a fish considered unfit for consumption if the pH is greater than 7.5, the ammoniacal nitrogen level exceeds 125 mg/100 g dry matter, and the sensory qualities are abnormal (Gonçalves, 2017).

TMA is a product of bacterial spoilage and the content is frequently used as an index to assess the quality and shelf-life of seafood products (Phetsang *et al.,* 2021). The TMA value of catfish flour made from catfish meat soaked in various types of soaking ingredients is shown in Table 5. It could be noticed that these TMA values were significantly different ($p<0.05$). It ranged from 2.44 to 5.19 mg N/100 g catfish flour. Although the highest TMA value was found in 5% LJ, it was lower than the control (Table 5) and within an

https://doi.org/10.26656/fr.2017.8(1).123

acceptable range. It was because the TMA value decreased by lemon juice at 5% as Herath *et al.* (2019) had reported that treating seafood with lime juice reduced the quantity of free TMA. All samples were within the acceptable range of 5 to 10 mg N/100 g tissues (Table 5) (Baixas-Nogueras *et al.,* 2003). TMA is produced by the reduction of trimethylamine oxide (TMA-O) by TMA-O reductase-producing organisms and possibly through the action of intrinsic enzymes and typically has a fishy odour. When compared to marine fish, the presence of TMA-O in freshwater fish is less common, but it does exist (Niizeki *et al.,* 2002). TMA is also used as a fish quality indicator and commonly used as acceptance evaluation criteria.

Table 4. pH values of catfish flour soaked in various types of solutions.

Soaking Solution	pH
Lime juice at 5%	6.26±0.12[d]
Lime juice at 100%	4.92±0.02[g]
Lemon juice at 5%	6.22±0.01[e]
Lemon juice at 100%	4.16±0.02[i]
Milk at 5%	6.59±0.01[a]
Milk at 100%	6.41±0.02[c]
Coconut water at 5%	6.51±0.02[b]
Coconut water at 100%	6.20±0.01[e]
Vinegar at 5%	5.60±0.02[f]
Vinegar at 25%	4.73±0.02[h]

Values are presented as mean±SD, n = 9. Values with different superscript within the same column are statistically significantly difference (p<0.05).

Table 5. TMA values of catfish flour

Soaking Solution	TMA
Lime juice at 5%	5.19±0.43[b]
Lime juice at 100%	3.96±0.42[cde]
Lemon juice at 5%	3.66±0.00[de]
Lemon juice at 100%	4.58±0.43[bcd]
Milk at 5%	4.88±0.00[bc]
Milk at 100%	3.36±0.43[ef]
Coconut water at 5%	2.44±0.00[f]
Coconut water at 100%	3.36±0.42[ef]
Vinegar at 5%	4.57±0.42[bcd]
Vinegar at 25%	4.87±0.00[bc]
Control (without soaking process)	6.10±0.86[a]

Values are presented as mean±SD, n = 9. Values with different superscript within the same column are statistically significantly difference (p<0.05).

4. Conclusion

Nineteen attributes were identified as key attributes of catfish flour made from catfish meat soaked in various types of solutions using the QDA method. pH value and TMA content of catfish flour made from catfish meat soaked in lime juice at 5%, lime juice at 100%, lemon juice at 5%, lemon juice at 100%, milk at 5%, milk at 100%, coconut water at 5%, coconut water at 100%, vinegar at 5%, and vinegar at 5% were within an acceptable range. The results of this study indicate that catfish flour made from catfish meat soaked in lime juice, lemon juice, milk, coconut water, and vinegar had the potential to be further developed and could be considered as an alternative to other flour in developing food products with good quality characteristics.

Conflict of interest

The authors herewith declare no conflict of interest.

Acknowledgements

We would like to thank The Indonesia Endowment Fund for Education (LPDP) for funding this research.

References

Adamczak, A., O˙zarowski, M. and Karpinski, T.M. (2020). Antibacterial activity of some flavonoids and organic acids widely distributed in plants. *Journal of Clinical Medicine,* 9(109), 11-17. https://doi.org/10.3390/jcm9010109

Aminullah, Marwiyah, S.W. and Kusumaningrum, I. (2021). Application of catfish flour on texture and hedonic profiles of pempek lenjer. *Agrointek,* 15(2), 441-451. https://doi.org/10.21107/agrointek.v15i2.8566

Assa, R.R., Prades, A., Konan, A.G., Nemlin, J. and Konan, J.L. (2013). Sensory evaluation and sugars contents of coconut (*Coconut nucifera* L.) water during nuts ripening. *African Journal of Food Science,* 7(7), 186–192. https://doi.org/10.5897/AJFS2012.0601

Association of Official Agricultural Chemists (AOAC). (2000). Official Methods of Analysis. 17 ed. Gaithersburg, USA: AOAC.

Baixas-Nogueras, S., Bover-Cid, S., Veciana-Nogués, M.T. and Vidal-Carou, M.C. (2003). Suitability of volatile amines as freshness indexes for iced Mediterranean hake. *Journal of Food Science*, 68(5), 1607–1610. https://doi.org/10.1111/j.1365-2621.2003.tb12299.x

Baker, A.K., Vixie, B., Rasco, B.A., Ovissipour, M. and Ross, C.F. (2014). Development of a lexicon for caviar and its usefulness for determining consumer preference. *Journal of Food Science,* 79(12), S2533–S2541. https://doi.org/10.1111/1750-3841.12703

Chapman, K.W., Lawless, H.T. and Boor, K.J. (2001). Quantitative descriptive analysis and principal component analysis for sensory characterization of ultrapasteurized milk. *Journal of Dairy Science,* 84 (1), 12–20. https://doi.org/10.3168/jds.S0022-0302 (01)74446-3

Emmanuel, B., Goh, Y.K., Berzins, R., Robblee, A.R. and Clandinin, D.R. (1984). The entry rate of trimethylamine and its deposition in eggs of intact and cecectomized chickens fed rations containing rapeseed meal or supplementary choline. *Poultry Science Journal*, 63(1), 139–143. https://doi.org/10.3382/ps.0630139

Food and Agriculture Organization of the United Nations (FAO). (2020). The state of world fisheries and aquaculture. Retrieved on January 4, 2022 from FAO Website: https://www.fao.org/state-of-fisheries-aquaculture

Ghaly, A.E., Dave, D., Budge, S. and Brooks, M.S. (2010). Fish spoilage mechanisms and preservation techniques: Review. *American Journal of Applied Science,* 7(7), 859-877. https://doi.org/10.3844/ajassp.2010.859.877

Gonçalves, A.A. (2017). The pH of the seafood meat: A problem that deserves to be clarified. *MOJ Food Processing and Technology,* 4(1), 25-26. https://doi.org/10.15406/mojfpt.2017.04.00081

Górniak, I., Bartoszewski, R. and Króliczewski, J. (2019). Comprehensive review of antimicrobial activities of plant flavonoids. *Phytochemistry Reviews,* 18(1), 241–272. https://doi.org/10.1007/s11101-018-9591-z

Gram, L. and Dalgaard, P. (2002). Fish spoilage bacteria problems and solutions. *Current Opinion in Biotechnology*, 13(3), 262-266. https://doi.org/10.1016/S0958-1669(02)00309-9

Gyawali, R. and Ibrahim, S.A. (2014). Natural products as antimicrobial agents. *Food Control,* 46, 412–429. https://doi.org/10.1016/j.foodcont.2014.05.047

Hebard, C.E., Flick, G.J. and Martin, R.E. (1982). Occurrence and significance of trimethylamine oxide and its derivatives in fish and shellfish. In Martin, R.E., Flick, G.J. and Hebard, C.E. (Eds.) Chemistry and biochemistry of marine food products. Westport, USA: AVI Publishing Group.

Herath, I.S., O'Donnell, T.E., Pavlov, J. and Attygalle, A.B. (2019). Screening freshness of seafood by measuring trimethylamine (TMA) levels using helium-plasma ionization mass spectrometry (HePIMS). *Analytical Science and Technology,* 10,32. https://doi.org/10.1186/s40543-019-0190-4

Hernandez, D., Addou, S., Lee, D., Orengo, C., Shephard, E.A. and Phillips, I.R. (2003). Trimethylaminuria and a human FMO3 mutation database. *Human Mutation*, 22(3), 209–213. https://doi.org/10.1002/humu.10252

Heu, M.S., Park, S.H., Kim, H., Kim, H.J., Han, B.W., Ji, S.G., Kim, J., Yoon, M.S. and Kim, J. (2008). Improvement on fish odor of extracts from salmon frame soaked in soybean milk. *Journal of the Korean Society of Food Science and Nutrition*, 37(2), 223-230. 10.3746/jkfn.2008.37.2.223

Hidayat, M.I. and Suprayitno, E. (2019). The effect of addition of skim milk and natrium alginate to the quality of crude albumin fish cork (*Ophiocephalus striata*) (drying with vacuum drying). *International Journal of Scientific and Research Publication,* 9(5), 202-209. https://doi.org/10.29322/IJSRP.9.05.2019.p8922

International Organization for Standardization. (2007). Sensory Analysis- General Guidance for The Design of Test Rooms (ISO 8589:2007). Retrieved from ISO website: https://www.iso.org/standard/36385.html

International Organization for Standardization. (2012). Sensory Analysis-Methodology-Guidelines for monitoring the performance of quantitative sensory panel (ISO 11132:2012). Retrieved from ISO website: https://www.iso.org/standard/50124.html

International Organization for Standardization. (2014). Sensory Analysis-General Guidelines for the selection, training, and monitoring of selected assessors and expert sensory assessors (ISO 8586:2014). Retrieved from ISO website: https://www.iso.org/standard/45352.html

International Organization for Standardization. (2017). Sensory Analysis-Metodhology-General Guidance, Jenewa: International Organization for Standardization (ISO 6658:2017), Retrieved from ISO website: https://www.iso.org/standard/65519.html

Jummai, A.T., Negbenebor, C.A. and Okoli, B.J. (2016). Physical Quality, Proximate Composition and Trimethylamine Content of *Clarias gariepinus* (Catfish) Stored with Local Spices. *Open Access Library*, 3, 1-11. https://doi.org/10.4236/oalib.1102927

Keyimu, X.G. and Abdullah, A. (2014). Elimination of seaweed odour and its efferct on antioxidant, presented at The 2014 UKM FST Postgraduate Colloqium, Selangor, 2014. New York, USA: AIP Publishing. https://doi.org/10.1063/1.4895230

Khalafalla, F.A., Ali, F.H.M. and Hassan, A.R.H.A. (2015). Quality improvement and shelf-life extension of refrigerated Nile tilapia (*Oreochromis niloticus*) fillets using natural herbs. *Beni-Suef University Journal of Basic and Applied Science*, 4

(1), 33−40. https://doi.org/10.1016/j.bjbas.2015.02.005

Kouakou, C., Berge, J., Lethuaut, L., Prost, C. and Cardinal, M. (2014). Odour modification in salmon hydrolysates using the Maillard reaction. *Journal of Aquatic Food Product Technology,* 23(5), 453-467. https://doi.org/10.1080/10498850.2012.724153

Kurihara, K. (2015). Umami the fifth basic taste: History of Studies on Receptor Mechanisms and Role as a Food Flavor. *BioMed Research International*, 2015, 189402. https://doi.org/10.1155/2015/189402

Leonardos, G., Kendall, D. and Barnard, N. (1969). Odor threshold determinations of 53 odorant chemicals. *Journal of the Air Pollution Control Association*, 19 (2), 91–95. https://doi.org/10.1080/00022470.1969.10466465

Lertittikul, W., Benjakul, S. and Tanaka, M. (2007). Characteristics and antioxidative activity of Maillard reaction products from a porcine plasma protein-glucose model system as influenced by pH. *Food Chemistry,* 100(2), 669-677. https://doi.org/10.1016/j.foodchem.2005.09.085

Mahayothee, B., Koomyart, I., Khuwijitjaru, P., Siriwongwilaichat, P., Nagle, M. and Müller, J. (2016). Phenolic compound, antioxidant activity, and medium chain fatty acids profiles of coconut water and meat at different maturity stages. *International Journal of Food Properties,* 19(9), 2041-2051. https://doi.org/10.1080/10942912.2015.1099042

Manjunatha, S.S. and Raju, P.S. (2013). Modelling the rheological behaviour of tender coconut (*Cocos nucifera* L) water and its concentrates. *International Food Research Journal,* 20(2), 731-743.

Marouf, A.A.S. and Elmhal, S.I. (2017). Monitoring pH during pasteurization of cow's milk using Nd: YAG laser. *International Journal of Advanced Research,* 4 (12), 1-4. 10.20431/IJARPS.2017.4.12.2

Ministry of Health of the Republic of Indonesia. (2018). Table of Indonesian Food Composition 2017. Jakarta, Indonesia: Ministry of Health of the Republic of Indonesia.

National Standardization Agency. (2009). Chemical test method- Part 8: Determination of Total Volatile Base Nitrogen (TVB-N) and Trimethyl Amino Nitrogen (TVB-N) levels (SNI 2354.8-2009). Retrieved from website: https://pesta.bsn.go.id/produk/detail/7980-sni235482009

Niizeki, N., Daikoku, T., Hirata, T., El-Shourbagy, I., Song, X. and Sakaguchi, M. (2002). Mechanism of biosynthesis of trimethylamine oxide from choline in the teleost tilapia, *Oreochromis niloticus*, under freshwater conditions. *Comparative Biochemistry and Physiology. Part B, Biochemistry and Molecular Biology*, 131(3), 371–386. https://doi.org/10.1016/S1096-4959(01)00508-5

Ninomiya, K. (1998). Natural occurrence. *Food Reviews International,* 14(2-3), 177-211. https://doi.org/10.1080/87559129809541157

Oluwarotimi, E.A., Odubanjo, V.O., Adesanmi, J.I., Alo, O.J., Aminu, R.S. and Faturoti, I.E. (2021). Antioxidant capacity and effect of coconut water on AlcI3 Amnesic-Induced Drosophila Melanogaster. *Journal of Analytical Techniques and Research,* 3 (1), 1-13. 10.26502/jatri.018

Pazos, M., Maestre, R., Gallardo, J.M. and Medina, I. (2013). Proteomic evaluation of myofibrillar carbonylation in chilled fish mince and its inhibition by catechin. *Food Chemistry,* 136(1), 64-72. https://doi.org/10.1016/j.foodchem.2012.07.109

Pham, T., Nguyen, N.T.P., Dinh, D.V., Kieu, N.T., Bach, L.G., Phong, H.X., Muoi, N.V. and Truc, T.T. (2020). Evaluate the chemical composition of peels and juice of seedless lemon (*Citrus latifolia*) grown in Hau Giang Province, Vietnam. *IOP Conference Series: Materials Science and Engineering*, 991, 012127. https://doi.org/10.1088/1757-899X/991/1/012127

Phetsang, H., Panpipat, W., Panya, A., Phonsatta, N. and Chaijan, M. (2021). Occurrence and development of off-odor compounds in farmer hybrid catfish (*Clarias macrocephlaus* x *Clarias gariepinus*) muscle during refrigerated storage: Chemical and volatilomic analysis. *Foods,* 10(8), 1841. https://doi.org/10.3390/foods10081841

Prabhakar, P.K., Vatsa, S., Srivastav, P.P. and Pathak, S.S. (2020). A Comprehensive Review on Freshness of Fish and Assessment: Analytical Methods and Recent Innovations. *Food Research International,* 133, 109157. https://doi.org/10.1016/j.foodres.2020.109157

Pu, D., Zhang, Y., Zhang, H., Sun, B., Ren, F., Chen, H. and Tang, Y. (2020). Characterization of the key aroma compounds in traditional human smoke-cured pork leg (Larou, THSL) by aroma extract dilution analysis (AEDA), odor activity value (OAV), and sensory evaluation experiments. *Foods,* 9(4), 413. https://doi.org/10.3390/foods9040413

Quideau, S., Deffieux, D., Douat-Casassus, C. and Pouységu, L. (2011). Plant polyphenols: Chemical properties, biological activities, and synthesis. *Angewandte Chemie International Edition,* 50(3), 586–621. https://doi.org/10.1002/anie.201000044

Setyaningsih, D., Apriyantono, A. and Sari, M.P. (2010). Food Sensory Analysis for Food and Agro Industry. Bogor, Indonesia: IPB Press.

Stone, H. and Sidel, J.L. (2004). Sensory Evaluation Practices. Redwood City, USA: Academic Press Inc.

Takó, M., Kerekes, E.B., Zambrano, C., Kotogán, A., Papp, T., Krisch, J. and Vágvölgyi, C. (2020). Plant phenolics and phenolic-enriched extracts as antimicrobial agents against food-contaminating microorganisms. *Antioxidants*, 9(2), 165. https://doi.org/10.3390/antiox9020165

Wu, J., Wang, P. And Chen, S.C. (2010). Antioxidant and antimicrobial effectiveness of catechin-impregnated PVA-starch film on red meat. *Journal of Food Quality,* 33, 780-801. https://doi.org/10.1111/j.1745-4557.2010.00350.x

Xue, D., He, T., You, M., Song, H., Gong, L. and Pan, W. (2018). Effects of different treatments on fishy odour of fish soup. *Journal of Aquatic Food Product Technology,* 27(6), 722–732. https://doi.org/10.1080/10498850.2018.1484831

Zambrano, C., Kerekes, E.B., Kotogán, A., Papp, T., Vágvölgyi, C., Krisch, J. and Takó, M. (2019). Antimicrobial activity of grape, apple and pitahaya residue extracts after carbohydrase treatment against food-related bacteria. *LWT Food Science and Technology,* 100, 416–425. https://doi.org/10.1016/j.lwt.2018.10.044

Zampacavallo, G., Parisi, G., Mecatti, M., Lupi, P., Giorgi, G. and Poli, B.M. (2015). Evaluation of different methods of stunning/killing sea bass (*Dicentrarchus labrax*) by tissue stress/quality indicators. *Journal of Food Science and Technology*, 52(5), 2585–2597. https://doi.org/10.1007/s13197-014-1324-8

Zhuang, S., Hong, H., Zhang, L. and Luo, Y. (2021). Spoilage-related microbiota in fish and crustaceans during storage: Research progress and future trends. *Comprehensive Reviews in Food Science and Food Safety,* 20(4), 252-288. https://doi.org/10.1111/1541-4337.12659

