# Study on the Effect of Citric Acid and Sodium Chloride on Shredded Tuna (*Thunus albacares*) Meat (Abon Tuna)

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## ABSTRACTS

*Tuna (Thunus albacares) is usually processed as canned products and in other forms such as shredded (abon) tuna which is produced in home industries. 'Fishy' flavour of shredded tuna is the main problem, due to the trimethylamine (TMA) formation. Citric acid and sodium chloride can minimize this 'fishy' flavor, and avoid deterioration by decreasing the water activity. The best treatment was combination between 0.5% citric acid and 1.5% sodium chloride.*

*Keywords : shredded tuna, trimetylamine (TMA), trimetylamineoxide (TMAO)*

## INTRODUCTION

Tuna (*Thunus albacares*) is an impor-tant sea product, with many advantages. It has a nutritive value similar to other animal products, such as beef, chicken, shrimp, and milk.

Douglas and Glenn (1982) reported that among the tuna species, the 'yellow fin' (25-36% of total world catch), 'skip jack' (20-32%), and 'albacore' (20-24%) have great economic values.

Due to its highly perishable nature, tuna should be handled properly to avoid physical, chemical and microbiological changes. It can be processed as shreddec tuna (abon tuna) – an Intermediate Moisture Shreddec Fish Meat, which in some countries is processed as ε home industry. Purnomo (1996) stated that shreddec products (usually made from beef) are Intermediate Moisture Food (IMF) with water activity ($a_w$ values in the range of 0.60-0.80 and moisture content of 15-30% (wb). Spices are used for preparing the shredded products and influenced the quality. A problem of shredded tuna is the 'fishy' flavor due to the trimethylamine (TMA) derived from autolysis process (Tranggono, 1990). This 'fishy' flavor is unacceptable to consumers. Furthermore, the moisture content and water activity ($a_w$) affect the overall quality of the product.

Furia (1972) found that citric acid could prevent the off-odour, while Buckle,*et al.*1987) noted that sodium chloride decreased the moisture content and $a_w$ of the product.

This research determined the optimum concentration of citric acid and sodium chloride to produce shredded tuna ( abon tuna ) with good physical and chemical properties, nutritive value, colour, aroma and taste.

## MATERIALS AND METHODS

### Sample and experimental design

The tuna was purchased from a cold storage factory - PT. Aneka Tuna Indonesia, Pandaan, East Java. Citric acid (*analytical reagent*), sodium chloride (*analytical reagent*), cane sugar, 'nutmeg powder', and white pepper were purchased from local retail outlets.

This research was designed as a Random Nested Design with two factors: the concentration of citric acid and the concentration of sodium chloride. The three concentrations of citric acid solution used were: 0.0%, 0.5%, and 1.0%(v/ v) respectively.The concentrations of sodium chloride: 1.0%, 1.5%, and 2.0% (w/w) respectively. Each experimental combination was repeated three times.

The shredded tuna (abon tuna) was prepared as shown in Figure 1.

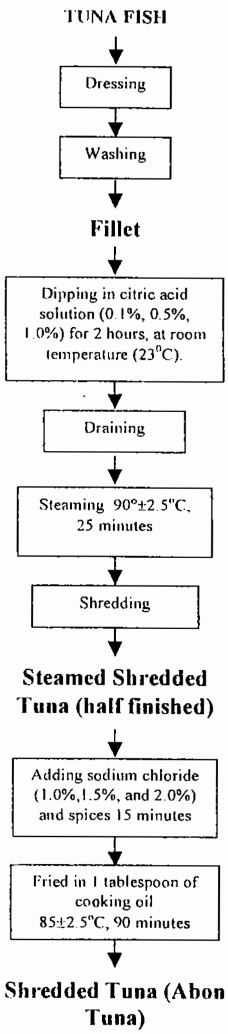


Fig.1 The process of shredded tuna (abon tuna)

The additives were cane sugar 3% (w/w), nutmeg powder 0.5% (w/w), white pepper 0.5% (w/w), and fresh milk 40% (v/w).

The fillet as raw material was examined by the following methods for trimethylamine (TMA) concentration (Hadiwiyoto, 1993), moisture content (AOAC, 1984), total plate count (TPC) (Fardiaz, 1992), and concentration of amino acids (HPLC, AOAC, 1984). The shredded tuna (abon tuna) was examined for TMA, moisture content, water activity ($a_w$) (Rotronic Hygroscope), total plate count (TPC), colour, aroma and taste (Soekarto, 1985). The method of sensory analysis was Hedonic Scale Scoring, 9 for most liked and 1 least liked. Thirty untrained panelists were involved.

Analysis of Variance (ANOVA) was carried out. The differences in means between pairs were resolved by Duncan's Multiple Range test (DMRT). Level of significance was set for p£0.05

## RESULTS AND DISCUSSION

***Moisture content.*** The moisture content of fresh tuna fillet was 69-76% (wb). Hadiwiyoto (1993) found that moisture content of fresh tuna fillet was 68.1% (wb), however this value is influenced by species, age and season. After the fillet had been treated, the moisture content was decreased to 48.61-49.40% (wb). The moisture contents of shredded tuna (abon tuna) products are presented in Table 1.

The tuna fillet protein consists of actin, myosin, and other protein compo-nents. Actin and myosin form actomyosin during rigor mortis. This complex com-

**Table 1**. Moisture content of shredded tuna (abon tuna).

| NaCl (%) | Moisture Content (% w.b) | | | DMRT($p \leq 0.05$) |
|---|---|---|---|---|
| | C 0% | C 0,5% | C 1% | |
| 1.0 | 49.40b | 49.35c | 49.22c | --- |
| 1.5 | 49.25b | 49.17b | 48.95b | 0.18 |
| 2.0 | 49.01a | 48.81a | 48.61a | 0.19 |

C = citric acid. Means with different letters in each column are significantly different ($p \leq 0.05$). Means of three replicates.

pound still exists even after rigor mortis has been resolved. In this condition tuna fillet will loose its capability to retain water. The citric acid solution decreased the pH to the isoelectric point of the protein and reduced the capability of protein to retain water, because the proteins were denatured. Hadiwiyoto (1993) found that the capability of fish meat to retain water is influenced by pH, cooking and curring method. Harijati (1995) found that 0.5-1% citric acid decreased the water content of mackerel significantly. Sodium chloride had the same effects and the higher concentration of sodium chloride the more moisture content decreased. Most of the water was evaporated during frying.

***Water activity.*** Water activity ($a_w$) influences the shelf-life of the shredded tuna (abon tuna) products and protects them from microbiological deterioration. The $a_w$ of the shredded tuna (abon tuna) is 0.46-0.49 (Table 2). In this range of $a_w$, shredded tuna (abon tuna) is expected to keep for at least two months in a vacuum pack at 2-5°C.

Due to the high protein content, the $a_w$ of the products should be controlled effectively to avoid microbiological dete-rioration. This research showed that citric acid and sodium chloride affect the $a_w$ of products significantly ($p \leq 0.05$) (Table 2).

**Table 2**. Water activity ($a_w$) of shredded tuna (abon tuna)

| NaCl (%) | Water activity ($a_w$) C 0% | C 0,5% | C 1% | DMRT($p \leq 0.05$) |
|---|---|---|---|---|
| 1.0 | 0.49b | 0.49b | 0.48b | — |
| 1.5 | 0.48a | 0.47a | 0.47a | 0.01 |
| 2.0 | 0.47a | 0.46a | 0.46a | 0.02 |

C = citric acid. Means with different letters in each column are significantly different ($p \leq 0.05$). Means of three replicates.

This agrees with Purnomo (1996) who found that sodium chloride gradually decreased the water in the products by osmosis and the $a_w$.

***TMA content.*** The TMA content of the fillet of untreated samples was 10-12 mg/100 g. After the fillet has been treated the TMA decreased to 7.90-9.78 mg/100 g (Table 3). The reduction of TMA greatly influences in the flavour of the products. Harijati (1995) stated that TMA could be reduced to 2.5-11% of a mackerel fillet and improved the shredded mackerel. Citric acid solution and sodium chloride both signi-ficantly decreased the TMA of the products ($p \leq 0.05$).

**Table 3**. TMA content of shredded tuna (abon tuna)

| NaCl (%) | TMA Content (mg/100 g) C 0% | C 0,5% | C 1% | DMRT($p \leq 0.05$) |
|---|---|---|---|---|
| 1.0 | 9.78ab | 8.47b | 7.99ab | - |
| 1.5 | 9.76a | 8.35a | 7.95a | 0.06 |
| 2.0 | 9.71a | 8.34a | 7.90a | 0.07 |

C = citric acid. Means with different letters in each column are significantly different ($p \leq 0.05$). Means of three replicates.

The highest TMA concentration occurs in 0% citric acid solution and 1% sodium chloride (9.78 mg/100 g), while in 1% citric acid solution and 2% sodium chloride shown the least (7.90 mg/100 g). Brown (1977) found that citric acid and TMA will form trimetylamonium citrate. Citric acid effectively decreased the pH, inhibited the growth of bacteria and inactivated the enzymes involved in TMA formation (Hartwig and McDaniel, 1995). This condition will reduce the trimetylaminoxide (TMAO) to TMA. TMAO is present in fresh fish and changed to TMA by autolysis reaction (Ohashi, *et al.*, 1991). TMA is produced in a postmortem state due to the endogenous reaction of bacterial enzymes (Ben-Gigirey, *et al.*, 1999). The decrease in TMA concentration could reduce the off-odour of the products. This study showed 0.5-1% citric acid can decreased the TMA concentration by 15-34%.

***Total Plate count.*** Due to its high nutritive value, shredded tuna is susceptible to microbial deterioration. Citric acid and sodium chloride could effectively inhibit the growth of bacteria as bactericide (p£0.05), making the products safe for consumption. Fresh tuna fillet contained 4.17 to 4.30 log cfu; while the processed tuna products contained 1.76 to 2.09 log cfu (Table 4). The reduction of microbes happens due to the citric acid solution and sodium chloride solution, these two substances can reduce the $a_w$ of the products and will inhibit the bacterial growth effectively. The bacteria content of shredded tuna (abon tuna) are presented in Table 4

**Table 4**. Total plate count of shredded tuna (abon tuna)

| NaCl (%) | Total bacteria content (log cfu/100 g) | | | DMRT($p \leq 0.05$) |
|---|---|---|---|---|
| | C 0% | C 0,5% | C 1% | |
| 1.0 | 2.08b | 2.00b | 1.99c | — |
| 1.5 | 1.96a | 1.90a | 1.88b | 0.09 |
| 2.0 | 1.90a | 1.82a | 1.77a | 0.10 |

C = citric acid. Means with different letters in each column are significantly different ($p \leq 0.05$). Means of three replicates.

Buckle *et al.* (1987) stated that acid has an antimicrobial effect. Citric acid as an organic acid could be used for food pro-cessing compared to other organic acids. Other advantage of citric acid is that it can act as an antioxidant.

Steaming, spicing and frying effect the total bacterial content, but in this research all these factors were implemented equally across all treatments.

***Amino acid content.*** The amino acid composition of the shredded tuna (abon tuna) processed with 0.5% citric acid and 1.5% sodium chloride showed the influence of citric acid and sodium chloride on the amino acid content after treatments. The amino acids composition of fresh tuna and shredded tuna are presented in Table 8. The amino acids in shredded tuna increased three times compared to the fresh tuna, except for histidine, which decreased. The increase of amino acid content suspected to be due to the citric acid and sodium chloride. Regenstein and Regenstein (1984) stated that in acid solution, the amino group will react with hydrogen ion and form a positive charge and influenced the amino acids and protein solubility. Milk protein (as one of the components) had a great influence in increasing the amino acids. In this shredded tuna (abon tuna), the concentration of lysine, methionine, and histidine are very high, 2.27%, 0.90%, and 1.03% respec-tively. The amount of lysine and methionine in shredded tuna (abon tuna) increased compared to the fresh tuna, due to the milk protein probably casein. The decrease in histidine is suspected to be due to the degradation of tuna protein by enzymes during processing. Bender (1975) stated that the degradation of histidine to histamine is catalysed by histamin decarboxylase. The presence of histamin in the products has no influence to the aroma and taste, but it could be harmful to consumers in high concen-tration.

**Table 8.** Amino acids composition in fresh tuna and shredded tuna (abon tuna) treated with 0.5% citric acid and 1.5% sodium chloride.

| No. | Amino acid | Fresh tuna (%w/w) | Shredded tuna (%w/w) |
|---|---|---|---|
| 01. | Aspartic | 1.01 | 3.35 |
| 02. | Serine | 0.06 | 0.49 |
| 03. | Histidine | 2.05 | 1.03 |
| 04. | Glysine | 0.53 | 0.93 |
| 05. | Threonine | undetected | 1.27 |
| 06. | Arginine | 0.19 | 1.67 |
| 07. | Alanine | 0.30 | 1.33 |
| 08. | Tyrosine | 0.41 | 0.82 |
| 09. | Methionine | undetected | 0.90 |
| 10. | Valine | 0.56 | 1.00 |
| 11. | Phenylalanin | 0.40 | 1.16 |
| 12. | Isoleusine | undetected | 1.33 |
| 13. | Leusine | 0.59 | 2.07 |
| 14 | Lysine | 0.64 | 2.27 |
| | TOTAL | 6.74 | 19.62 |

***Sensory evaluation.*** Preference testing was carried out involving 30 panelists who evaluated colour, aroma, and taste.

***Colour.*** The panelists preferred a white colour for shredded tuna (abon tuna). The score was 5.1-6.0 (Table 5 ).

**Table 5.** Color acceptability of the shredded tuna (abon tuna)

| Treatments | | Means of preference scores | DMRT (p≤0.05) |
|---|---|---|---|
| Citric acid(%) | NaCl (%) | | |
| 1 | 1.5 | 5.1 a | — |
| 1 | 1 | 5.2 a | 0.64 |
| 1 | 2 | 5.2 a | 0.67 |
| 0 | 2 | 5.4 a | 0.69 |
| 0 | 1 | 5.5 a | 0.71 |
| 0 | 1.5 | 5.6 a | 0.72 |
| 0.5 | 1 | 5.7 a | 0.73 |
| 0.5 | 2 | 5.7 a | 0.74 |
| 0.5 | 1.5 | 6.0 ab | 0.75 |

Means with different letters are significantly different (p≤0.05). Means of three replicates.

Part of the hemoglobin and myglobin pigments in the products were dissolved in the citric acid solution which gave a pale colour to the products.

***Aroma.*** Aroma is one of the most important properties of shredded tuna (abon tuna). The aroma of the shredded tuna (abon tuna) was not successfully acceptable to the panelist. The highest score was 4.5, which means that the product was unaccepted. Aroma acceptability is presented in Table 6.

The combination of 0.5% citric acid and 1.5% sodium chloride was significantly preferred to other combination of treatments. Harijati (1995) reported that fillet dipped in 0.5% citric acid solution gave the best aroma of shredded mackerel. Furia (1972) stated that citric acid could effectively decrease the fishy aroma of shredded mackerel. Sodium chloride apparently inhibited micro-organisms and enzymes – which influenced in reduction of the TMAO to TMA, and indirectly influenced the aroma of the products.

***Taste.*** The taste of the shredded tuna (abon tuna) was not fully accepted by the panelist. The score was 3.1-5.9; indicating that the taste of shredded tuna (abon tuna) was not accepted. The taste of shredded tuna (abon tuna) is more influenced by spices, like cane sugar, table salt and other components. Taste acceptability of the shredded tuna (abon tuna) is presented in Table 7. Citric acid has an extremely sour taste, so the use of 1% citric acid increases the sour taste.

**Table 6.** Aroma acceptability of the shredded tuna (abon tuna)

| Treatments | | Means of preference scores | DMRT (p≤0.05) |
|---|---|---|---|
| Citric acid(%) | NaCl (%) | | |
| 1 | 2 | 3.5 ab | — |
| 1 | 1 | 3.5 ab | 0.54 |
| 1 | 1.5 | 3.6 ab | 0.57 |
| 0.5 | 2 | 3.7 ab | 0.59 |
| 0.5 | 1 | 3.7 ab | 0.61 |
| 1 | 2 | 4.0 a | 0.62 |
| 1 | 1 | 4.1 a | 0.63 |
| 1 | 1.5 | 4.1 a | 0.64 |
| 0.5 | 1.5 | 4.5 a | 0.64 |

Means with different letters are significantly different (p≤0.05). Means of three replicates.

**Table 7.** Taste acceptability of the shredded tuna (abon tuna)

| Treatments | | Means of preference scores | DMRT (p≤0.05) |
|---|---|---|---|
| Citric acid(%) | NaCl (%) | | |
| 0 | 1 | 3.1 ab | — |
| 0 | 1.5 | 3.9 ab | 0.69 |
| 0.5 | 1 | 4.6 a | 0.72 |
| 1 | 1 | 4.7 a | 0.75 |
| 0.5 | 2 | 5.0 a | 0.76 |
| 1 | 2 | 5.0 a | 0.78 |
| 0 | 2 | 5.1 a | 0.79 |
| 1 | 1.5 | 5.1 a | 0.80 |
| 0.5 | 1.5 | 5.9 a | 0.81 |

Means with different letters are significantly different (p≤0.05). Means of three replicates.

There was a tendency that the highest citric acid concentration gave the highest posibilities to be rejected by the panelists. The highest score of the taste acceptability of the products was 0.5% citric acid and 1.5% sodium chloride. The combination of 0% citric acid solution and 1% sodium chloride produced an undesirable taste or bad taste.

Based on sensory evaluation, the researchers determined that combination of 0.5% citric acid and 1.5% sodium chloride was the best treatment for shredded tuna (abon tuna).

## CONCLUSIONS

Citric acid and sodium chloride influenced the moisture content, $a_w$, TMA , total plate count, amino acid content, and organoleptic properties of shredded tuna (abon tuna). The best shredded tuna (abon tuna) was treated with 0.5% citric acid and 1.5% sodium chloride judged by moisture content, $a_w$, TMA content, and total plate count. While colour, aroma and taste should be considered. This treatment increased the total amino acids from 6.74% (w/w) to 19.62% (w/w).

The researchers suggest that this research should be continued to examine the influence of garlic, monosodium glutamate and other food additives, commonly used as flavour enhancers.

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