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Effects of frozen storage and organic acid solution dipping treatment on the quality of Sarawak raw fish salad (umai) from red tilapia

(Kesan perlakuan sejuk beku dan celupan larutan asid organik terhadap kualiti umai daripada tilapia merah)

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Key words: umai, red tilapia, frozen treatment, dipping treatment, organic acid

Abstract

A study was conducted to evaluate the possibility of extending the shelf life of freshwater red tilapia umai stored by combination of frozen and dipping treatment in aqueous solution containing food-grade organic acids. The implications of applying these treatments were measured by physical, chemical, microbiological and sensory evaluation. The results showed that at least 60% of the panellists indicated that fillet samples frozen at –23 °C for 7 days were equal or better than the fresh samples for all the sensory attributes evaluated.

Shelf life of chilled umai cutlets increased when they were treated with dipping solution containing organic acid (citric acid, lactic acid and acetic acid) with pH fixed at 4. Samples treated with dipping solution 1.5% citric acid gave the best storage quality in terms of total aerobes count and colour intensity. Control samples and samples without organic acid treatment were considered spoiled after 8 days of storage with total volatile base nitrogen value (TVBN) and total aerobes count exceeded or close to the limit of acceptability.

Introduction

'Umai' or better known as Sarawak raw fish salad is a famous traditional raw fish dish originated by the Melanaus community in the Mukah region. It is basically made up of thinly sliced raw fish mixed in gravy of sour fruits, chillies, salt and other spices. Very little information on umai is available in literature. Sashimi, another type of raw fish dish, is the nearest equivalent to umai but it differs in terms of formulation and preparation method.

The nation's consumption of chilled and frozen food products is expected to increase by 80% over the next 10 years (Schoemaker 1991; Kam 2000). There exists a prospect for umai to be introduced as a specialty product for both the domestic and export markets. However, the traditional method of preparing umai limits its commercial potential beyond in situ preparation and consumption due to its short shelf life and perishability. This not only results in wastage but also limits the distribution of the product. Hence, a satisfactory method for extending the storage life of pre-packed umai is needed to ensure quality, safety and minimal wastage (Chua and Saniah 2000).

With the increase in popularity of raw or uncooked seafood dishes, concern for the safety of these products has correspondingly

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risen since the consumption of such products is considered a risk factor for various diseases particularly those caused by parasites such as nematodes (*Anisakis* sp.) and trematodes (*Heterophyes* sp.) (Schantz 1989; Huss 1991; Adams et al. 1994). Due to this safety factor, it is obvious that fish of guaranteed freshness and suitable pre-treatments are required. The U.S. Food and Drug Administration's fish and fishery products hazards and controls guide for example; has stipulated that fish served raw, marinated or partially cooked to be blast-frozen to at least –35 °C for 15 h; or frozen by regular means to at least –23 °C for 7 days (FDA 1987). However, this practice has not been adopted in traditional umai preparation due to the belief that it may cause undesirable changes in the product eating quality.

The aim of this study was to assess the effect of two different frozen treatments on eating quality of freshwater red tilapia fillets, and dipping treatment of umai cutlets in organic acids solution to extend its chill-storage life. The implications of applying these treatments were measured by physical, chemical, microbiological and sensory evaluation.

Materials and methods

Freezing of fish fillets

Live red tilapia *(Oreochromis niloticus)* were purchased from a commercial producer at Kampung Sejijak, Petra Jaya, Kuching. The fish were cut into boneless fillets and dipped in 2% sodium tripolyphosphate (STPP) solution for 2 min. STTP at concentration of 2% was used individually in preliminary study and found to be effective in reducing rancidity and dripping rate. The fillets were then divided into two groups; one group kept frozen at –23 °C as stipulated by FDA (F1) and another group at 0 °C by regular means (F2). The frozen duration for both groups was fixed at 7 days. Fresh fillets without any frozen treatment were used as control (C).

Preparation of umai cutlets for sensory evaluation

In carrying out sensory evaluation using paired comparisons test (Larmond 1970), both F1 and F2 treated fillets were thawed at 4 °C for 6 h and allowed to drain, then sliced into umai cutlets of average size 5 cm x 1 cm x 3 mm. The cutlets were then made into umai using ready-made umai sauce established by Chua and Saniah (2002). These were then presented to a taste panel of 10 persons who were asked to compare both F1 and F2 to the control sample for freshness, texture, juiciness, flavour and colour. For safety reason, all sensory evaluations were carried out after the results of the microbiological evaluations obtained showed that the products were safe for consumption.

Preparation of dipping solutions

Fillets applied with the most acceptable frozen treatment were used for this experiment. Three dipping solutions were prepared by resolving organic acids in deionised distilled water. The strength of organic acids used is shown in *Table 1*. The strength of the acids added was fixed depending on the pH of the dipping solution where its final value were fixed at 4.00 ± 0.20. The pH value was fixed at 4 as the preliminary studies carried out on dipping solution with pH below 4 showed undesirable changes in taste, texture and colour of the samples; whereas pH above 4 were ineffective in extending the samples shelf life.

Umai cutlets dipping treatments

The thawed fillets were sliced into umai cutlets of average size 5 cm x 1 cm x 3 mm. Duplicate samples of about 100 g cutlets were dipped in each of the 300 mL dipping solution and agitated gently for 2 min at room temperature. Upon removal from the above dipping solutions, cutlets were allowed to drain for 5 min and packed in polypropylene containers. After sealing, the containers were placed in a –18 ± 1 °C

Table 1. Strength of organic acids and pH of dipping solutions

Dipping solution	Strength of acid	pH
Citric acid	1.5 ± 0.2%	4.00 ± 0.20
Lactic acid	2.0 ± 0.2%	4.00 ± 0.20
Acetic acid	3.0 ± 0.2%	4.00 ± 0.20
Control	0	8.00 ± 0.20

freezer and held for 10 min to deep chill the cutlets. After chilling, the containers were then transferred to refrigerated storage at temperature of 2 ± 2 °C. Refrigerator temperature was monitored by means of a thermometer. Untreated cutlets were used as control.

Sampling for analysis

The study took place over predetermined 8-day storage. At scheduled intervals, cutlet samples were withdrawn from the refrigerator and evaluated. The effects of the dipping treatment on the cutlets quality were measured by physical (pH and colour intensity), chemical (total volatile base nitrogen), microbiological analyses (total aerobes and coliform count) and sensory evaluation.

pH determination

A pH meter (Cyberscan 500) was used to measure the pH of the dipping solutions and the umai cutlet samples. An amount of 5 g of umai cutlets were homogenized with 45 mL deionized distilled water in a blender (Waring) to provide uniform slurries. pH values were recorded after equilibration (Lim 1987).

Total volatile base nitrogen (TVBN) determination

Determination method was adapted from Schormuller (1968). A water vapour distillation method was used. The sample was boiled and the vapour components held with 0.1 M HCl. HCl was titrated with 0.1 M NaOH and the TVB-N was expressed as milligrammes N/100 g cutlet samples.

Preparation of umai cutlets for sensory evaluation

The cutlets were then made into umai using ready-made umai sauce established by Chua and Saniah (2002). These were then presented to a taste panel of 10 persons who were asked to compare treated and control samples for acceptability. Sensory scores were assessed using a 9-point hedonic rating scale, ranging from 1 (dislike extremely) to 9 (like extremely) (Larmond 1970). All sensory evaluations were carried out after the results of the microbiological evaluations obtained showed that the products were safe for consumption.

Microbiological analysis

Standard microbiological methods were used for examination of the samples (MOH 1996; Harrigan 1998). An amount of 10 g umai sample was placed in a sterile stomacher bag and added with 90 mL of quarter-strength Ringer's solution, which gave a 10^{-1} dilution. The mixture was then homogenized using stomacher (Interscience) for 2 min. Further 10-fold serial dilutions were prepared from the 10^{-1} homogenate using 9 mL of quarter-strength Ringer's solution as diluent.

Total aerobic count was determined by the pour plate method using plate count agar (Oxoid) and incubated at 37 °C for 48 h. Total coliform of the homogenate was determined by the pour plate method using violet red bile agar (Oxoid) and incubated at 37 °C for 48 h. Plates from duplicate samples were averaged and expressed as log colony forming units per gramme sample (cfu/g). Total faecal coliform was determined by Most Probable Number (MPN) method using brilliant green lactose bile broth (Oxoid).

Colour intensity

Surface colour intensity of the umai cutlet samples during storage was measured using a Minolta CR-300 series chromameter based on the Hunter's system (L, a and b values). L* denotes lightness on a 0–100 scale from black to white, a* denotes redness (+) or greenness (-), and b* denotes yellowness (+) or blueness (-). Readings were taken at four separate areas on the surface of each umai cutlet samples and the average of the four readings recorded.

Statistical analysis

Data were analysed using Analysis of Variance Method at 5% level. Significance was determined using Duncan Multiple Range Test on all possible pairs of treatment means.

Results and discussion

Effect of frozen treatments on eating quality of fillet for umai processing

As most food products begin to deteriorate rapidly when containing more than 10^6 microorganisms per gramme, a maximum total plate count of 10^6 was taken as the guideline for umai acceptability. The microbiological evaluations obtained showed that all samples including control were safe for consumption with total plate count below 10^6.

For all the sensory attributes evaluated, at least 60% of the panellists indicated that samples frozen at –23 °C for 7 days (F1) were equal or better than the fresh control samples (C) *(Table 2).* Furthermore, panellists who preferred the control samples indicated only a slight difference between control and sample F1. On the other hand, at least 50% of the panellists found that samples frozen at 0 °C by regular means (F2) were inferior as compared to the control samples (C) *(Table 2).*

Frozen treatment is a convenient preservation method particularly used for fish products but it has been reported may result in undesirable changes leading to quality losses in texture and flavour (Krivchenia and Fennema 1998). According to Reid (1993), a slow freezing process causes formation of large ice crystals that irreversibly damages tissues and resulting in a poor structural quality of food products.

Since the taste panellists indicated that umai samples under frozen treatment at –23 °C for 7 days were acceptable, it was therefore unnecessary to evaluate the above factors again using samples kept under lower temperature.

Effect of organic acid solution dipping treatments on the chill-storage quality of umai

In this experiment, organic acids were used for additive effect as bacteriostatic to create an environment hostile to spoilage and pathogenic microorganisms (Smulders et al. 1986; Acuff 1991). The result of the physical, chemical, microbiological analysis and sensory evaluation of organic acid solutions treated umai cutlets are shown in

Table 2. Sensory evaluation of umai made from fillet frozen at –23 °C (F1), 0 °C (F2) and fresh control sample (C) by 10 taste panellists

	Freshness	Texture	Juiciness	Flavour	Colour
Fillet frozen at –23 °C (F1) vs. control (C)					
F1 better than C	3	3	2	2	3
F1 equals to C	4	3	5	6	3
F1 inferior to C	3	4	3	2	4
% of indication for F1 equals or better than C	70%	60%	70%	80%	60%
Fillet frozen at 0 °C (F2) vs. control (C)					
F2 better than C	0	0	2	2	1
F2 equals to C	2	3	2	3	1
F2 inferior to C	8	7	6	5	8
% of indication for F2 inferior to C	80%	70%	60%	50%	80%

Table 3 and *Figure 1*. Mean value of Least Significant Difference Test of organic acid solution treated umai cutlets on the 8th day of storage at 2 ± 2 °C are shown in *Table 4*.

pH There was a consistent increase in pH value of the umai cutlets during the 8-day storage. This may be partly attributed to the formation of alkaline compounds such as amines and ammonia by spoilage bacteria (Bramstedt and Auerbach 1965; Stammen et al. 1990). The pH value for fresh fish is about 6.0–6.5 and it normally increases during storage. The limit of acceptability is usually 6.8–7.0 (Metin et al. 2001). The value would be lower in samples treated with acid.

The pH of control samples was measured as 6.13 before storage and dipping treatment. The value increased and reached up to 7.05 on the 8th day of storage. Control samples showed an increase from the initial pH of 6.23 to 6.72 whereas other samples dipped in organic acids showed small

Table 3. Effect of dipping treatment on colour intensity of umai cutlets stored at 2 ± 2 °C

Storage period (days)	Control	Citric acid 1.5%	Lactic acid 2%	Acetic acid 3%
L*				
0	46.94	47.86	48.10	47.91
2	47.52	47.73	49.21	48.76
4	54.76	48.36	48.69	51.03
6	60.03	49.12	50.36	53.17
8	62.58	50.26	51.36	57.43
a* (positive value)				
0	2.04	2.14	2.26	2.21
2	1.85	2.24	2.07	2.01
4	2.01	2.03	1.94	1.84
6	1.66	1.93	1.72	1.90
8	1.69	1.86	1.66	1.74
b* (negative value)				
0	4.08	4.03	4.24	4.12
2	4.16	4.12	4.25	4.23
4	4.25	4.34	4.38	4.15
6	4.26	4.28	4.19	4.16
8	4.29	4.33	4.21	4.05

Table 4. Mean value of Least Significant Difference Test of organic acid solutions treated umai cutlets on the 8th day of storage at 2 ± 2 °C

		Dipping treatments			
		Control	Citric acid 1.5%	Lactic acid 2%	Acetic acid 3%
pH		7.05a	5.11b	5.14b	5.18b
TVBN (mg N/100 g)		39.81a	24.62b	27.04b	24.47b
Sensory scores		5.2a	7.3bc	6.9c	7.4bc
Total aerobes (log cfu/g)		6.30a	3.51b	4.06bc	4.67c
Total coliform (log cfu/g)		3.32a	2.36c	2.87b	2.24c
Faecal coliform (log cfu/g)		<1.47a	<1.47a	<1.47a	<1.47a
Colour	L	62.58a	50.26bc	51.36c	57.43d
	a	1.69a	1.86a	1.66a	1.74a
	b	4.29a	4.33a	4.21c	4.05b

*Means in the same row with the same letter are not significantly different (*p* >0.05)

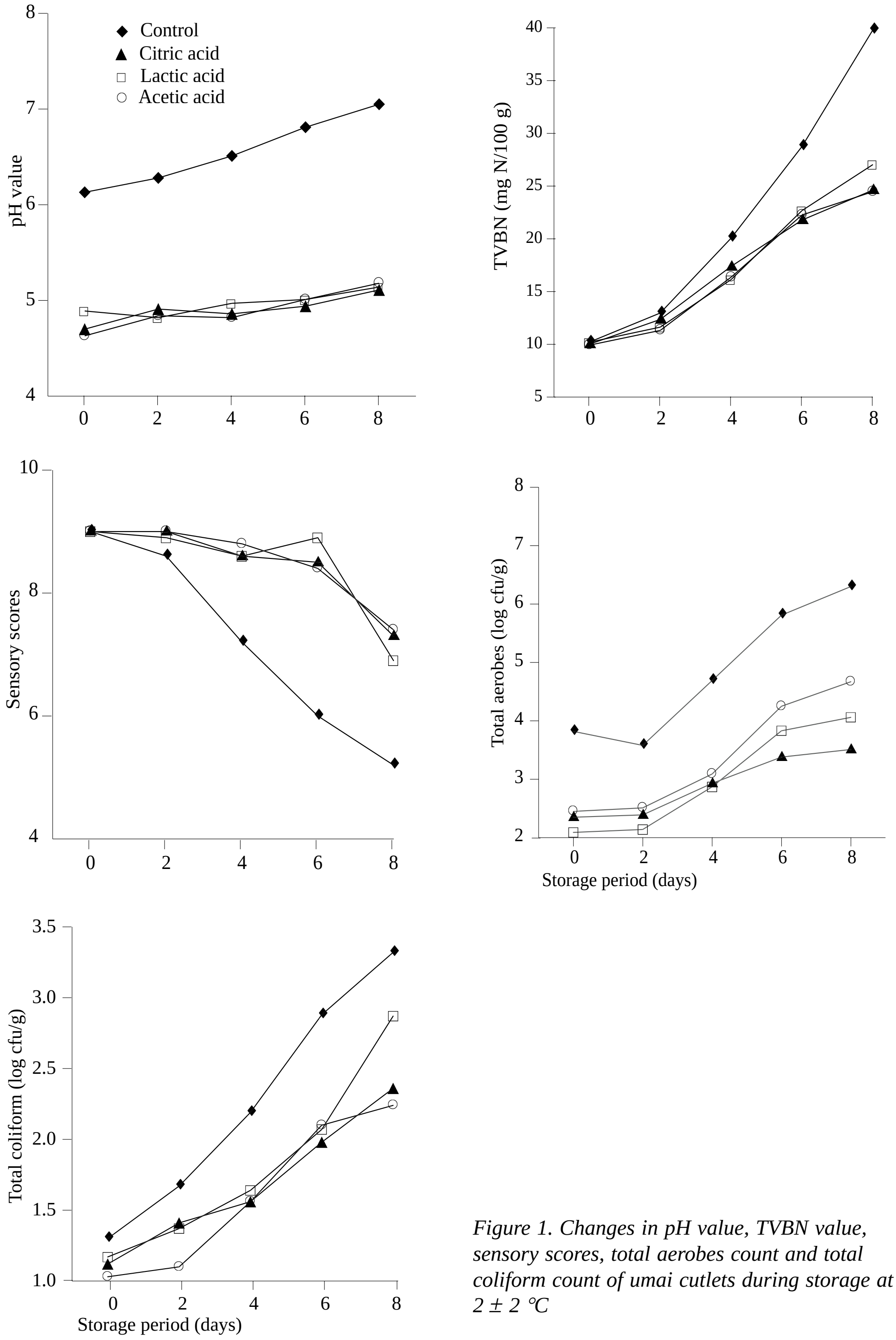

Figure 1. Changes in pH value, TVBN value, sensory scores, total aerobes count and total coliform count of umai cutlets during storage at 2 ± 2 ℃

increase in pH from average initial 4.74 to 5.14. However, differences in pH between these treated samples were found to be statistically not significant (p >0.05).

According to Lima dos Santos (1981), pH is not a good parameter for fish quality assessment because the increase in pH was not sufficiently great to be related to the onset of spoilage of seafood. However, the changes of pH reflect microbial activity. In order to act as an active anti-microbial agent, most organic acids need a condition of low pH values around 5.5 (Smulders et al. 1986).

Total volatile base nitrogen The TVBN are produced by microbial spoilage and endogenous enzymes. It has been proposed that 35 mg TVBN/100 g as the limit of acceptability for fish (Metin 2001). All treated samples did not exceed the limit during the storage. The TVBN values of samples treated with organic acid solution were significantly lower (p <0.05) than control samples at the 8th day of storage. Microbial loads were reduced and spoilage slowed in acid treated samples and therefore all these samples showed a lower TVBN values. The results were in agreement with that observed by Metin et al. (2001) on fresh chub mackerel fillets.

TVBN value of control samples was 39.81 mg/100 g at the 8th day of storage. These values were over or close to the limit of 35 mg/100 g and therefore were considered less acceptable according to the sensory evaluation. All three organic acids treated samples were still acceptable with TVBN below 28 mg/100 g.

Sensory scores Umai cutlets were considered to be in good condition and acceptable when there were no change in odour, appearance and texture with score of above 6. Results of the sensory evaluation showed that there was a significant difference (p <0.05) among the control and treated samples after 8th day of storage. The panellists showed a preference for treated samples than control. It was also observed that the treated samples generally had higher scores than the control until the 6th day of storage. Acidified dipping solution with pH fixed at 4 did not cause any significant undesirable changes in taste and texture of the samples.

The use of STPP dipping solution before freezing of fish fillets was reported could have helped to increase the water holding capacity and at a certain extent reduced its rancidity (Chuah and Mohd. Yunus 1997). The study by Lamkey et al. (1986) found that the addition of phosphate to beef steaks reduces the rate of rancidity development.

Microbiological analysis Bacterial level is a useful and objective indicator of gross spoilage of fish products and is imperative for safety considerations (Du et al. 2001). All the umai samples showed time-related increases in total aerobes and coliform count. The total aerobes and coliform count load of the control samples at the beginning were 3.82 and 1.30 log cfu/g respectively. It increased and reached up to 6.30 and 3.32 log cfu/g at the 8th day of storage.

Statistical analysis of the microbial quality data revealed significant differences (p <0.05) in the total aerobes and coliform count between control samples and organic acid treated samples. The aerobes count of acid-treated samples did not reach 6.00 log cfu/g (10^6 cfu/g) and therefore, it was determined that treatment with organic acids slowed the growth of mesophilic aerobic bacteria. Dipping solution citric acid 1.5% showed the lowest value in total aerobes count after the 8th day of storage.

Coliform and faecal coliform are land-borne microorganisms and their presence in large amount is usually the result of non-hygienic practices during processing (Corlett 1989). All samples treated with organic acids solution showed significant lower count in total coliform. Dipping solution acetic acid 3% or citric acid 1.5% showed the lowest value in total coliform count after the 8th day of storage.

The faecal coliform count gave no information about the quality changes during the chilled-storage while remain almost constant. It was lower than 1.47 log cfu/g (30 cfu/g) at the beginning and did not exceed 1.47 log cfu/g in all the samples during storage. It was not influenced by the treatment of all three acid solution dipping.

Colour intensity Although there are several quality attributes of umai cutlets, colour is one of the most important criterion consumers look for. Results of the colour measured showed that there was significant difference ($p < 0.05$) among the control and treated samples after the 8th day storage. In control samples, the lightness value L* of the umai cutlets increased from an initial of 46.94 to 62.58 and the redness value a* decreased from +2.04 to +1.69 throughout the 8-day storage period. Dipping solution citric acid 1.5% showed the best colour maintenance.

Conclusion

Significant extension of chill-storage life for red tilapia umai may be obtained by dipping treatment in organic acid solution. Samples treated with dipping solution 1.5% citric acid gave the best storage quality in terms of total aerobes count, total coliform count and colour intensity. The control samples were considered unacceptable after 8 days of storage with TBVN value and total aerobes count exceeded the limit of acceptability.

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Abstrak

Kemungkinan melanjutkan hayat simpan umai ikan tilapia merah menggunakan kombinasi perlakuan sejuk beku dan celupan di dalam larutan asid organik gred makanan telah dikaji. Kesan perlakuan dinilai dari segi fizikal, kimia, mikrobiologi dan uji rasa. Sekurang-kurangnya 60% ahli panel mendapati sampel filet yang disejukbekukan pada –23 °C selama 7 hari adalah setaraf atau lebih baik daripada sampel segar dari segi nilai rasa.

Hayat simpan kutlet umai sejuk dingin dapat ditingkatkan apabila dicelup di dalam larutan asid organik (asid sitrik, asid laktik dan asid asetik) dengan pH dikekalkan pada 4. Sampel yang dicelup di dalam larutan 1.5% asid sitrik menunjukkan kualiti penyimpanan yang terbaik dari segi kandungan jumlah aerob dan warna. Sampel kawalan dan sampel tanpa perlakuan asid organik didapati rosak selepas 8 hari penyimpanan dengan nilai jumlah bes nitrogen meruap (TVBN) dan jumlah aerob melebihi atau menghampiri had penerimaan.

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