Studies On The Quality Indices And Preservation Methods For Boiled, Dried Anchovies (*Stolephorus* sp.)

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Abstract

Boiled, dried anchovies sold in Singapore are mainly imported from neighbouring countries. A survey was conducted to obtain an understanding of the quality of this product which is sold packed in polypropylene bags at supermarkets. The survey showed that the product had a high moisture content (≥25% dry wt) and hence should be categorised as an intermediate-moisture product rather than as a dried product. It also had a high percentage breakage, a considerable amount of foreign matter, high water activity from 0.663 to 0.700 and total lipid of 7.0 - 8.6%. The organoleptic quality of most samples was acceptable. This survey showed that the quality of this product at retail outlets could be improved.

The following are suitable quality indicators: percentage breakage, protein content, salt content, ash and acid insoluble ash, but they need not be monitored in storage studies. The suitable quality indices for quality changes of this product were identified as moisture content, water activity, total volatile basic nitrogen, total lipid, peroxide value, thiobarbituric acid number, colour and sensory evaluation. Trimethylamine nitrogen is, however not a suitable parameter.

The effect of storage at different conditions (refrigerated: 7±2°C, 80% RH; room temperature exposed to light and kept in the dark: 27±40°C, 73±16% RH) on the shelflife of the product was also investigated. The samples were again found to have a high moisture and hence mould growth was the main contributor to spoilage at room temperature. Refrigerated storage extended the shelflife beyond six weeks, yielding a fairly good quality product. However it caused the moisture and water activity to increase with storage. The shelflife of samples stored at room temperature exposed to light was 4 weeks and those in the dark was two weeks.

Drying and vacuum packing were done to study their effect on shelflife extension. The samples were further dried to a moisture of ≤25% (dry weight) using the oven and low temperature vacuum dryer, then vacuum packed and stored in an air-conditioned room. These were compared with two other samples that were not further dried; one lot was stored exposed at room temperature and the other was vacuum packed and stored in an air-conditioned room. The samples were monitored weekly for the first 6 weeks and thereafter monthly. The first 6 weeks of this experiment is reported here; these preliminary results showed that further drying and vacuum packaging effectively reduced the moisture and also retarded mould growth. Thus the product is still fairly good even after six weeks.

Note: This paper was presented at the Seminar by Ms Low.

Introduction

Anchovies found in the region are mainly *Stolephorus* sp. Of the 344,918 mt landed in 1988, Indonesia caught 33.5% (115,601 mt), Malaysia 9.3% (32,065 mt), Philippines 36.6% (126,373 mt), Singapore 0.02% (543 mt) and Thailand 20.1% (69,378 mt) (SEAFDEC, 1988). The total value of the anchovies caught in 1988 was US$108,213,000. Wholesale prices were US$0.64 in the Philippines, US$0.52 in Malaysia, and US$0.65 in Singapore (SEAFDEC, 1988).

The anchovies are usually processed by traditional methods into boiled, dried products. Boiled, dried anchovies are a popular food item in Southeast Asian countries. They are usually used as a flavouring condiment in soups and vegetable dishes or consumed fried with peanuts as a snack. Pulverised boiled, dried anchovies are also added to infant and young children's porridge as a supplementary source of calcium.

The current processing of boiled, dried anchovies is a low-technology operation resulting in a product of inconsistent quality and short shelflife. Freshly caught anchovies are usually processed on board after being caught by purse seine (as practised in West Malaysia) or on the *kelong* (as practised in Tanjong Pinang, Indonesia). They are first boiled in about 10% brine solution then removed from the brine solution and allowed to drain and cool. The cooked anchovies are then brought to shore where they are spread on straw mats on the ground and sun-dried. The drying process usually takes one fine day, or more under less sunny conditions. The dried products from Malaysia usually arrive in Singapore in large plastic bags, boxed in paper cartons, and those from Indonesia in large polyethylene-lined jute sacks. The retail price of boiled, dried anchovies in Singapore ranged from S$5.00 to S$8.00 per kg.

The quality of the final product is highly dependent on the processors' skills and the weather. In the hot and humid climate of this region, poor handling causes the quality of boiled, dried anchovies to deteriorate rapidly. As the anchovy catch in this region is large, and since boiled, dried anchovies are a popular food item, quality and preservation studies are important to upgrade the product and to extend shelflife.

This paper comprises three parts. Part I is a quality survey of boiled, dried anchovies sold in local supermarkets. Part II is a study of the quality deterioration and shelflife of the product under room temperature and refrigerated storage. Part III is a study of the effects of a moisture content level of 25% (dry weight) and of vacuum packing on the shelflife of the product.

Part I - Quality Survey Of Boiled, Dried Anchovies

Objective

A survey of boiled, dried anchovies was conducted to evaluate the present quality of this product and to identify areas for improvement.

Materials And Methods

Ten supermarkets were surveyed and 29 samples tested. The boiled, dried anchovies randomly sampled at these supermarkets were packed by four dried food packing companies which will be referred to as Suppliers SF, M, LKT, and UF. The boiled, dried anchovies are usually packed in polypropylene bags with net weights of either 75 or 100 g. Except for Supplier M, the companies usually seal the bags without vacuum. Supplier M also included oxygen-absorbent satchets in each package.

The packets of anchovies were brought to the laboratory and the following parameters were studied: total length (cm), total weight (g), percentage breakage (%), oxygen levels in the package (%), moisture content (%), water activity (Aw), salt (NaCl) content (%), trimethylamine-nitrogen (TMA-N, mg/100 g), total volatile basic nitrogen (VB-N, mg/100 g), total lipid content (TL, %), acid value (AV), peroxide value (PV, meq/kg) and thiobarbituric acid number (TBA). All analyses were carried out according to the methods in Hasegawa (1987).

Results And Discussion

The boiled, dried anchovies which originated from Malaysia had mean total lengths of 3.26 - 3.65 cm, and were categorised as small, based on the Malaysian Standard (SIRIM, 1984). According to the Japan Agricultural Standard (JAS, 1969), anchovies of body length between 3.0 and 7.5 cm are categorised as small. The mean total weight of individual fish was 0.19 g. The percentage breakage ranged from 17.9 to 35.6% and can be considered as Grade C by SIRIM. However if compared with JAS, then Suppliers UF had Grade A quality, Supplier LKT and M had Grade B quality and Supplier SF had Grade C quality.

Foreign matter was found in all samples, mainly in the form of small, dried shrimps, shells, jute fibres and other species of small fishes. The percentage of foreign matter based on the net weight of the products ranged from 0.6 to 2.0%. Only Supplier M vacuum-sealed the products - although not always - and with a mean oxygen level of 12.9%. The oxygen levels in the other samples ranged from 18.2 to 20.6%. Salt content of individual samples ranged from 5.4 to 12.0% (dry weight) indicating inconsistent quality and processing control.

The products were slightly moist to touch with moisture content ranging from 25 to 33.5% (dry weight). This is high compared to JAS standard of 20% (wet weight) or 25% (dry weight) for small boiled, dried sardines. The water activity (Aw) ranged from 0.663 to 0.700. As confirmed by subsequent observation, this moist product was susceptible to fungal and bacterial attack. The high moisture content of the boiled, dried anchovies qualifies this product to be categorised as an intermediate-moisture product rather than as a dried product.

The boiled, dried anchovies had lipid contents ranging from 7.0 to 8.6%. Even though the acid values ranged from 21.7 to 25.6, the peroxide values from 14.0 to 31.1 meq/kg and the TBA number from 16.9 to 21.4, no obvious rancid odour was observed. Most of the samples however had yellow bellies, an indication of fat oxidation.

The TMA-N levels ranged from 2.46 to 3.01 mg/100 g and VB-N was 22.03 to 23.25 mg/ 100 g showing that the samples were of average quality. The VB-N levels of most samples were not high enough to cause the anchovies to have ureal odour though one individual sample with VB-N of 35.5 mg/100 g had a distinct ureal odour.

Sensory evaluation of the samples showed that 86% had fresh odour, 10% mouldy odour and 3% were rejected because of stale and ureal odour. Moulds were present in 41% of the samples and 7% showed the presence of halophilic bacteria in the form of pink growth spots on the body. The samples ranged from yellow to brown-grey in body colour with grey eyes. The majority (93%) were of acceptable standard in terms of general appearance, 3% were of borderline quality and 3% were of reject quality. This unexpectedly high percentage of acceptance is due to the higher tolerance of local consumers to the presence of moulds on the products and lower expectation regarding product colour.

The survey gives a good understanding of the quality of boiled, dried anchovies in local supermarkets. The quality is considered to be superior to that usually found at wholesale and other retail outlets such as wet markets and provision shops.

Conclusion

The survey showed that although boiled, dried anchovies available in Singapore were generally of acceptable quality, there is much room for improvement. The main problems identified were inconsistent quality due to the lack of quality control in processing, quality deterioration due to overexposure to high temperatures and humid climate, and mould infestation due to high moisture content. Poor packing and handling conditions at the manufacturing, wholesale and retail levels also contribute to quality deterioration. The high moisture content of this product disqualifies it as a dried product. Thus the anchovies presently available in Singapore should be re-classified as an intermediate-moisture product.

To upgrade the product and extend its shelflife, the product should have a lower moisture

content. Care should be taken in packing to sort out and reduce the amount of foreign matter present and to lower the percentage of breakages. The product could be vacuum packed to reduce exposure to moisture and oxygen in order to slow down mould infestation and lipid oxidation.

Part II - Quality Deterioration And Shelflife Of Boiled, Dried Anchovies Under Room Temperature And Refrigerated Storage

Objective

The objective of this study is to identify suitable indices for quality changes of boiled, dried anchovies during storage; and to study changes of the product under different storage temperatures.

Materials And Methods

Freshly processed boiled, dried anchovies were purchased from Tanjong Pinang, Indonesia. On arrival at the laboratory, the moisture, salt, ash, lipid and protein content were determined. The anchovies were then packed in polyvinylidene chloride coated with biaxially oriented polypropylene vacuum bags (KOP/NEO), vacuumed and stored at -60°C for about a month.

For the present investigation the materials were thawed overnight at room temperature, packed into double-layered brown paper bags, and stored under different conditions as follows:

1) Refrigerated storage (7±2°C and 80% RH),
2) Room temperature, exposed to light (27±4°C and 73+16% RH), and
3) Room temperature, kept in the dark (27±4°C and 73+16% RH).

At weekly intervals, the samples were monitored for changes in the total lipid (TL), peroxide value (PV), thiobarbituric acid number (TBA), trimethylamine-nitrogen (TMA-N), total volatile basic nitrogen (VB-N), moisture, ash and salt (Hasegawa, 1987), and acid insoluble ash (using the Malaysian Standard, 1984). Water activity was determined using the Novasina Thermoconstanter and colour (CIE.Lab system) using Minolta Colour Meter Model R-200. Percentage breakage was determined based on the percentage of un-intact fish in 50 g samples. Sensory evaluation was carried out using a round table discussion panel of seven members and by a triangle-preference test with 10 panelists.

Results And Discussion

On arrival from Tanjong Pinang, the freshly processed boiled, dried anchovies had 43.26% moisture, 7.98% salt, 19.86% ash, 6.38% lipid and 76.86% protein based on dry weight.

The salt content, ash and acid insoluble ash did not change during storage under the various storage conditions. The salt content ranged from 7.19 to 8.10%. The stable ash content ranging from 19.19 to 20.92% dry weight under the different storage conditions and time indicate that the mineral content of the samples is independent of the storage condition and time. The acid-insoluble ash content of 0.13 to 0.44% showed that the level of impurities was low and unaffected by storage conditions and time. According to the Malaysian Standard, acid-insoluble ash should not exceed 1.5% by weight.

The product with a higher percentage of intact fish command a higher price. Hence, the percentage breakage should be low. The percentage breakage ranged from 30.6 to 60.3%. The values were generally high when compared with the Malaysian Standard which requires less than 5% percentage breakage for Grade A, 5 - 10% for Grade B and greater than 10% to be Grade C. Thus all samples in this study would then be Grade C. But if compared with the JAS the samples were either of Grade C (≥30% and ≤50%) or Grade D (≥50%).

The moisture content and water activity levels were high for a dried product. Refrigerated storage increased the moisture content and water activity with time from 43.26 to 57.51% and 0.768 to 0.848 respectively, after 6 weeks. The high

humidity (80% RH) in the refrigerator resulted in the moisture and water activity of the refrigerated samples to be higher than those held at room temperature. However, the lower temperature retarded the rate of mould growth in the samples. When mould growth was detected in the samples stored at room temperatures the Aw was 0.760 for samples exposed to light and 0.746 for those in the dark. At these Aw mouldy odours were also detected (Table 1).

No clear trend in the changes of TMA-N with storage was observed. The values fluctuated randomly and hence TMA-N is not a suitable quality index for boiled, dried anchovies. The VB-N of the samples stored at room temperatures increased significantly ($P<0.05$) with storage (Fig 1). When the values exceeded 111.6 mg/100 g (dry weight) a distinct ammoniacal/ureal odour was detected in the samples. However this was masked by the even stronger mouldy odour. The VB-N of the refrigerated samples however did not change with

Table 1. Sensory evaluation of boiled, dried anchovies (from Tanjong Pinang) during storage under room temperature and refrigerated storage conditions.

Storage Conditions	Storage Time (week)	Odour	Colour	Texture	Mould	Overall
Refrigerated (7 ± 2°C)	1	Fresh	Yellow	Slightly moist & soft	Not mouldy	Acceptable
	2	Fresh	Yellow	Very slightly moist & soft	Not mouldy	Acceptable
	3	Fresh	Yellow	Pliable, moist & soft	Not mouldy	Acceptable
	4	Fresh	Yellow	Slightly damp	Not mouldy	Acceptable
	5	Fresh	Yellow	Slightly damp	Not mouldy	Acceptable
	6	Fresh	Yellow	Slightly firm	Not mouldy	Acceptable
Room temperature/ light (27 ± 4°C)	1	Fresh	Yellow-brown	Dry, firm	Not mouldy	Acceptable
	2	Fresh	Brown	Dry, firm	Not mouldy	Acceptable
	3	Stale	Brown	Dry, firm	Not mouldy	Acceptable
	4	Off-odour	Brown	Firm	Slightly mouldy	Borderline
	5	Mouldy	Brown	Firm	Very mouldy	Unacceptable
	6	-	-	-	-	-
Room temperature/ dark (27 ± 4°C)	1	Fresh	Yellow-brown	Dry, firm	Not mouldy	Acceptable
	2	Slightly rancid	Yellow-brown	Dry, firm	Not mouldy	Acceptable
	3	Mouldy	Brown	Dry, firm	Mouldy	Unacceptable
	4	-	-	-	-	-
	5	-	-	-	-	-
	6	-	-	-	-	-

- means that the experiment was terminated.

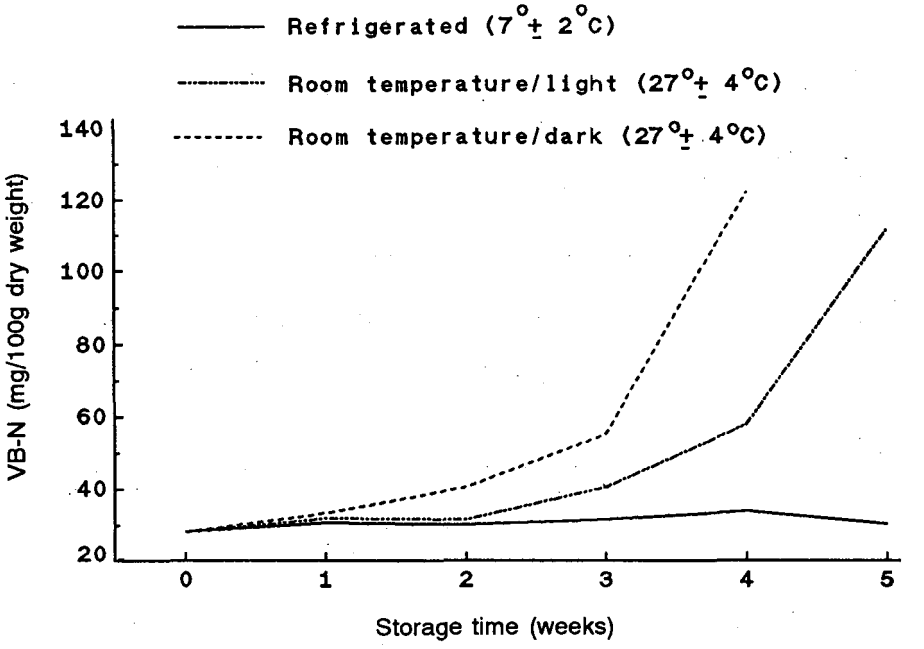

Fig. 1. Changes in total volatile basic nitrogen of boiled, dried anchovies during storage under various conditions.

storage time indicating that low temperature storage slows down the formation of volatile amines. When stale, off-flavour and mouldy odour were detected in the samples (Table 1), the VB-N values were 40.5 mg/100 g (dry weight basis).

The lipid deterioration of boiled, dried anchovies under various conditions during storage were determined by PV and TBA. The PV in general decreased with storage time likewise with the TBA. During the study, slight rancid odours were detected in samples stored in the dark at room temperature after 2 weeks of storage (Table 1). The high initial PV (39.1 meq/ kg) and TBA (81.0) values seem to indicate that the original samples are already fairly badly oxidised and the subsequent decreases in PV and TBA are actually indications of the degradation of peroxides and malonaldehydes to other breakdown products.

The samples stored at room temperatures developed deeper yellow colour with storage time (Fig 2). The low temperatures of refrigerated storage helped to slow down the yellowing process. When the samples were discarded, the b-values (yellowness) were +18.6 for samples kept at room temperature and exposed to light, and +17.2 for samples kept at room temperature in the dark.

Sensory evaluation (Table 1) showed that the refrigerated samples had fresh odour throughout storage and were of acceptable quality. No moulds were present throughout the storage period. The only disadvantage was that the samples were slightly moist and soft. Samples kept at room temperature in the dark had mould growth after three weeks, and had to be discarded. For those kept at room temperature exposed to light, stale odour developed on the third week, and after four weeks off-odour and the presence of moulds were detected. The samples which were badly infested by moulds at five weeks emitted a mouldy odour, and were discarded.

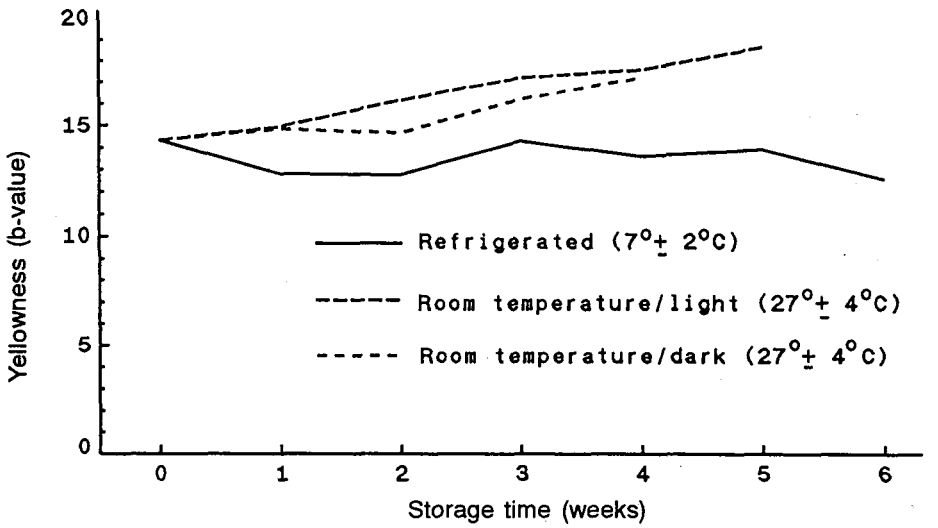

Fig. 2. Changes in the yellowness (b value) of boiled, dried anchovies during storage under various conditions.

Conclusion

From this set of data, the following were found to be suitable quality indices of boiled, dried anchovies, especially for storage studies: moisture content, water activity, total volatile basic nitrogen, total lipid, peroxide value, thiobarbituric acid number, and colour. It was recommended that acid value be included as one of the parameters for future studies. The following are good quality indices but are not necessary for continuous monitoring in a storage study: percentage breakage, protein content, salt content, ash and acid insoluble ash. Sensory evaluation is essential to complement and correctly interpret the chemical data.

The shelflife of boiled, dried anchovies stored at room temperature was four weeks when exposed to light and two weeks when kept in the dark. Refrigerated storage enabled the samples to be stored beyond six weeks.

As observed in the previous survey, the moisture of these products was also high and mould growth was also the main problem. Thus, the following study was conducted to study the effect of reduced moisture (25% dry weight) on shelflife.

Part III - Study Of The Effect Of Moisture Content Of 25% (Dry Weight) And Vacuum Packing On Shelflife

Objectives

The effect of reducing the moisture of boiled, dried anchovies to 25% (dry weight) and vacuum packing on shelflife was studied using different methods of reducing the moisture.

Materials And Methods

Good quality boiled, dried anchovies were purchased from Pasir Panjang Wholesale Market. They arrived from Malaysia 4 days before they were used for study. The moisture, water activity,

salt, ash, acid insoluble ash, protein content, total volatile basic nitrogen, total lipid, acid value, peroxide value and thiobarbituric acid number were determined for the O-day sample. Colour was determined using the Minolta CR-200 Colour Meter. Sensory evaluation was also done. For subsequent storage study salt, ash, acid insoluble ash and protein content were not monitored because, as observed in the previous study, they are not affected by the length of storage.

The samples were divided into four lots and subjected to four different treatments as follows:

Lot CI:

The boiled, dried anchovies were not further dried but simply stored in loose form in a box lined with plastic sheets on the inside to simulate the practice at the wholesale center. The box was covered with a fine wire mesh to keep out cockroaches, lizards, rats and cats. The box was left at room temperature (23 - 29°C, 57 - 91% RH) and three samples were taken from it weekly for monitoring.

Lot CII:

The boiled, dried anchovies were not further dried but were packed in KOP/NEO bags. Each vacuum sealed bag contained about 100 g of anchovies. They were stored in an airconditioned room (22 - 26°C, 56 - 71% RH). Three packets were used for each weekly monitoring.

Lot CIII (OVEN):

The boiled, dried anchovies were further dried in an oven at 35±1°C for 3 hr till the moisture of the anchovies was about 25% (dry weight). They were than packed into KOP/ NEO bags (100 g each), vacuum sealed and stored in an air-conditioned room (22 - 26°C, 56 - 71% RH). Three packets were used for each weekly monitoring.

Lot CIV (VACUUM):

The boiled, dried anchovies were further dried in a low temperature, vacuum dryer at 20±1°C (fish temperature) for $2\frac{1}{2}$ hr until the moisture of the anchovies was about 25% (dry weight). They were then packed in KOP/NEO bags (100 g each), vacuum sealed and stored in an air-conditioned room (22 - 26°C, 56 - 71% RH). Three packets were used for each weekly monitoring.

KOP/NEO bags are made of polyvinylidene chloride (PVDC) coated with biaxially oriented polypropylene (OPP) with excellent moisture proofing, water proofing, oil proofing, gas impermeability and transparency characteristics.

All the samples were monitored weekly for six weeks and treatments CII, OVEN and VACUUM were monitored monthly thereafter. As this study is still in progress, the results of the first six weeks of storage will be reported and discussed here.

Results And Discussion

On arrival, the boiled, dried anchovies had a moisture of 36.1% (dry weight), water activity of 0.702, salt content of 13.0% (dry weight), ash of 26.82% (dry weight), acid insoluble ash of 0.18% (dry weight) and protein content of 44.2% (dry weight). The total volatile basic nitrogen was 14.8 mgN/100 g (dry weight), total lipid content was 6.3% (dry weight), acid value was 21.3, peroxide value was 23.8 meq/kg and thiobarbituric acid was 38.4. Compared with those from Tanjong Pinang which were used in the previous study, these samples were of better initial quality.

The samples at O-day were white-yellow (Table 2a & b). During storage the yellowness increased significantly ($P<0.05$; Fig 3) for all 4 treatments (CI, CII, OVEN and VACUUM). Yellowing of the boiled, dried anchovies is due to rancidity and non-enzymatic browning reactions. After 1 week, all the treated samples were significantly yellower than the O-day sample. As storage progresses, all the other samples were significantly ($P<0.05$) yellower than the VACUUM.

Table 2a. Sensory evaluation of boiled, dried anchovies (from wholesale market) which were not further dried, and stored under different storage conditions.

Storage Conditions	Storage Time (weeks)	Odour	Colour	Texture	Mould	Bacterial Spots	Insect Infestation	Overall
	0	Fresh	White	Firm	Not mouldy	Absent	No	Acceptable
	1	Fresh	White-yellow	Firm	Not mouldy	Absent	Yes	Acceptable
CI: No further drying; loose form, room temperature	2	Fresh	Yellow	Firm	Not mouldy	Absent	Yes	Acceptable
	3	Fresh	Yellow	Slightly soft, moist	Mouldy	Absent	Yes	Acceptable
(23 - 29°C,	4	Fresh	Yellow-brown	Slightly soft, moist	Mouldy	Absent	Yes	Acceptable
57 - 91% RH)	5	Fresh	Brown	Soft, very moist	Mouldy	Present	Yes	Borderline
	6	Stale	Brown	Soft, very moist	Mouldy	Present	Yes	Borderline
	0	Fresh	White	Firm	Not mouldy	Absent	No	Acceptable
CII: No further drying; vacuum packed; air-conditioned temperature	1	Fresh	White-yellow	Firm	Not mouldy	Absent	No	Acceptable
	2	Fresh	Yellow	Firm	Not mouldy	Absent	No	Acceptable
	3	Fresh	Yellow	Firm	Not mouldy	Absent	No	Acceptable
	4	Fresh	Yellow	Firm	Not mouldy	Absent	No	Acceptable
(22 - 26°C,	5	Fresh	Yellow-Brown	Firm	Slightly mouldy	Absent	No	Acceptable
56 - 71% RH)	6	Fresh	Yellow-Brown	Firm	Mouldy	Absent	No	Acceptable

Percentage breakage is a good indicator of quality which does not significantly change during storage; the percentage breakage ranged from about 8 to 18%. These results showed that proper handling and packing of the samples reduced the extent of breakage when compared to the results of the previous study. The samples in this study could be categorised as Grade A according to JAS and Grades B and C according to the Malaysian Standard.

The moisture content of CI and CII samples was significantly higher ($P<0.05$) than the moisture content of the OVEN and VACUUM samples throughout the whole study (Fig 4). Further drying and vacuum packing enabled the samples to maintain a stable moisture of about 25±2% throughout the whole six weeks.

Water activity did not change significantly ($P<0.05$) with storage time for all treatments (Fig 5). However, for all weeks, the water activity of OVEN and VACUUM samples was significantly ($P<0.05$) lower than those of CI and CII samples. VACUUM samples had the lowest water activity. The Aw in general ranged from 0.647 to 0.704. The lower Aw as compared to samples from Tanjong Pinang resulted in the presence of mould only after five weeks of storage for CI samples (Table 2a).

Table 2b. Sensory evaluation of boiled, dried anchovies (from wholesale market) which were further dried, and stored under different storage conditions.

Storage Conditions	Storage Time (weeks)	Odour	Colour	Texture	Mould	Bacterial Spots	Insect Infestation	Overall
CIII (OVEN):	0	Fresh	White	Firm	Not mouldy	Absent	No	Acceptable
Dried in oven	1	Fresh	White-yellow	Firm	Not mouldy	Absent	No	Acceptable
at 35 ± 1°C								
for 3h; vacuum	2	Fresh	White-Yellow	Firm	Not mouldy	Absent	No	Acceptable
packed; air-								
conditioned	3	Fresh	Yellow	Firm	Not mouldy	Absent	No	Acceptable
temperature	4	Fresh	Yellow	Firm	Not mouldy	Absent	No	Acceptable
(22 - 26°C,	5	Fresh	Yellow-brown	Firm	Not mouldy	Absent	No	Acceptable
56 - 71% RH)								
	6	Stale	Yellow-brown	Firm	Not mouldy	Absent	No	Acceptable
CIV (VACUUM)	0	Fresh	White	Firm	Not mouldy	Absent	No	Acceptable
Dried in	1	Fresh	White-yellow	Firm	Not mouldy	Absent	No	Acceptable
vacuum dryer								
at 20 ± 1°C for	2	Fresh	Yellow	Firm	Not mouldy	Absent	No	Acceptable
2.5h; vacuum	3	Fresh	Yellow	Firm	Not mouldy	Absent	No	Acceptable
packed; air-	4	Fresh	Yellow	Firm	Not mouldy	Absent	No	Acceptable
conditioned	5	Fresh	Yellow	Firm	Not mouldy	Absent	No	Acceptable
temperature	6	Fresh	Yellow-Brown	Firm	Not mouldy	Absent	No	Acceptable
(22 - 26°C,								
56 - 71% RH)								

The total volatile basic nitrogen increased significantly ($P<0.05$) with storage time for all treatments (Fig. 6). The vacuum packed samples had significantly higher VB-N than the loose samples (CI) as the volatile vapours were trapped in the package. The values were low compared with those from Fig 1 and no off-odours were detected in these samples. The values obtained ranged from 14.8 to 22.2 mgN/100 g (dry weight).

The total lipid content did not vary significantly ($P<0.05$) with storage and range from 5.9 to 7.3% (dry weight). The acid value increased significantly ($P<0.05$) with storage time for CI, CII and VACUUM (Fig 7). Generally OVEN and VACUUM samples had the lowest acid values. Peroxide values increased and then decreased with storage time for all treatments (Table 3). CI and. OVEN samples peaked at week 2 and then declined. The VACUUM sample peaked at week 3. The VACUUM samples had lowest PV throughout. TBA decreased significantly ($P<0.05$) with storage (Fig 8).

Sensory evaluation (Tables 2a and 2b) showed that vacuum packaging was highly effective in maintaining the fresh odour and firm texture of the samples, and in delaying mould growth and

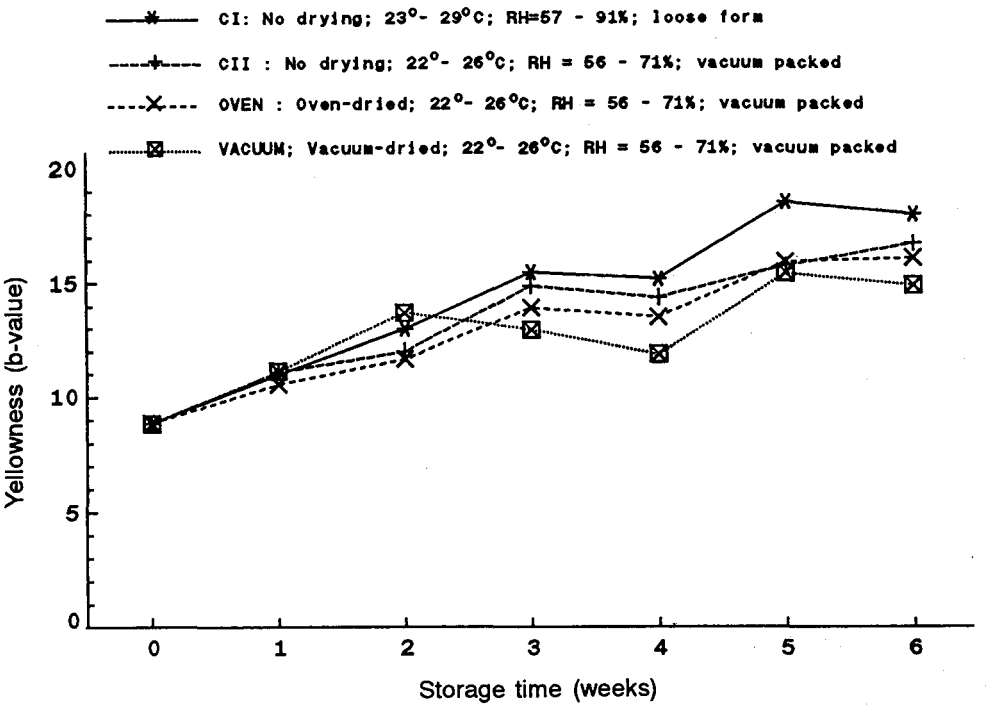

Fig. 3. Changes in the yellowness (b value) of boiled, dried anchovies with storage.

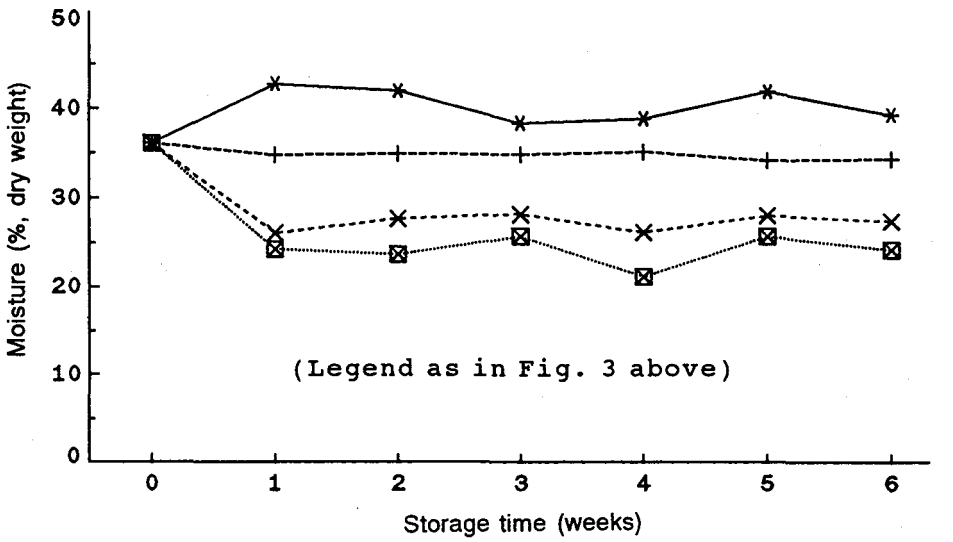

Fig. 4. Changes in the moisture content (%, dry weight) of boiled, dried anchovies under various conditions.

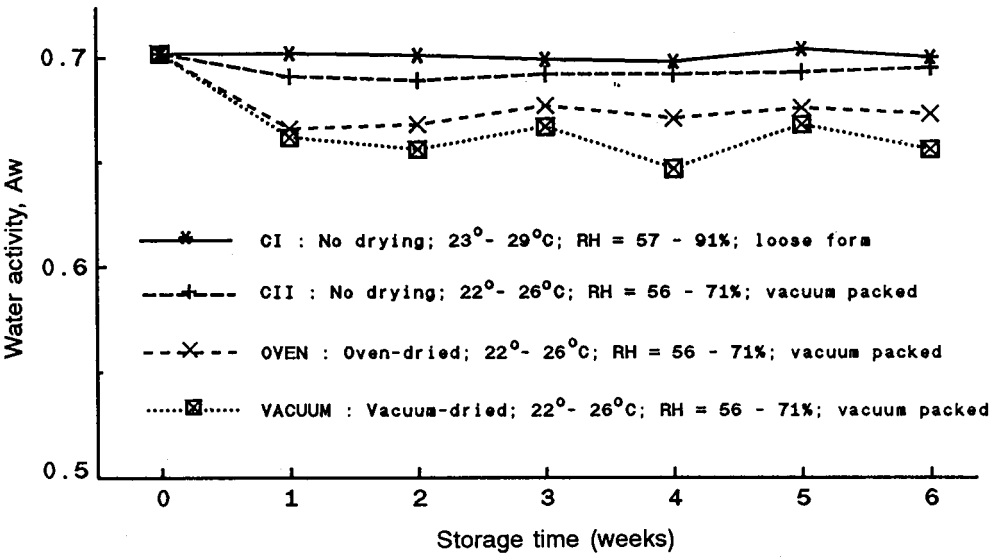

Fig. 5. Changes in water activity of boiled, dried anchovies under various conditions.

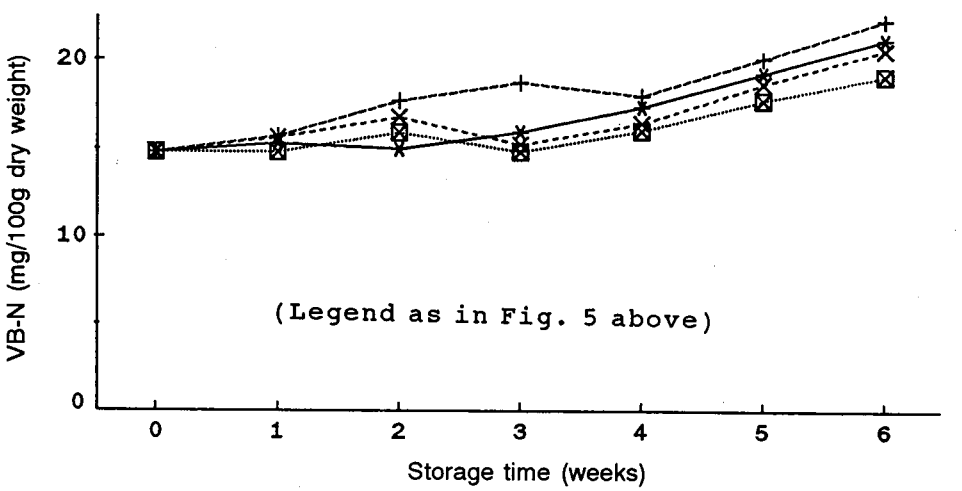

Fig. 6. Changes in the total volatile basic nitrogen (VBN) of boiled, dried anchovies under various conditions.

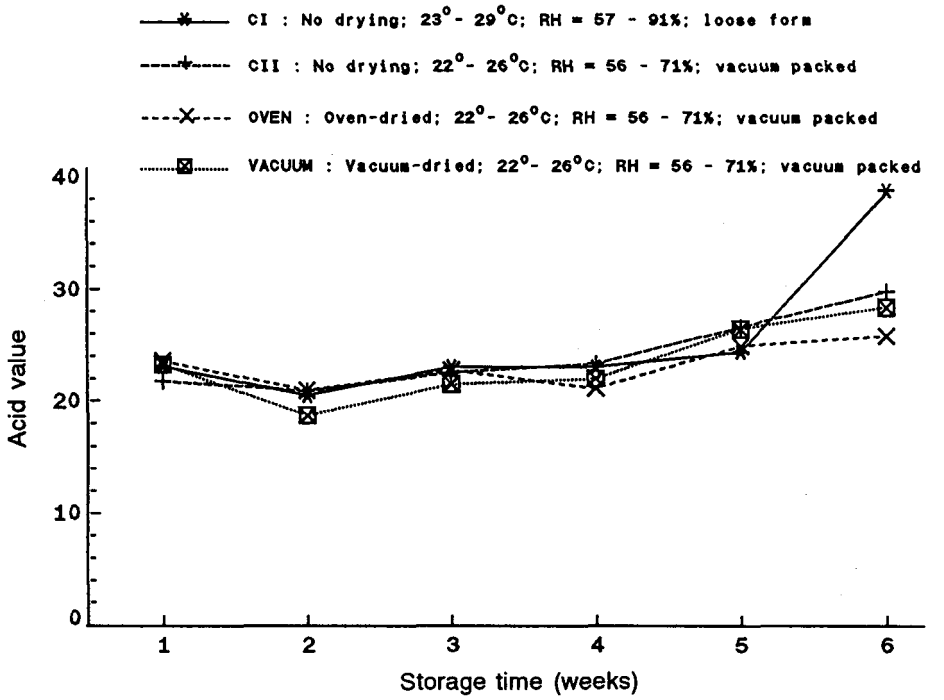

Fig. 7. Changes in acid value of boiled, dried anchovies with storage.

Table 3. Changes in peroxide value (PV) of boiled, dried anchovies under various storage conditions.

Treatment*	Storage time (weeks)					
	0	1	2	3	5	6
CI	23.76 ± 0.78	22.69 ± 4.45	36.15 ± 0.99	30.60 ± 3.64	32.60 ± 2.40	34.12 ± 1.26
CII	23.76 ± 0.78	36.06 ± 1.93	29.16 (n=1)	34.69 ± 2.22	18.68 ± 3.12	27.19 ± 0.72
OVEN	23.76 ± 0.78	39.15 ± 0.15	48.23 ± 3.42	20.95 (n=1)	21.98 ± 0.26	23.80 ± 0.94
VACUUM	23.76 ± 0.78	16.95 ± 0.91	25.90 ± 1.04	29.94 ± 1.57	17.62 ± 3.50	23.70 ± 0.79

* Legend as shown in Fig. 7 above

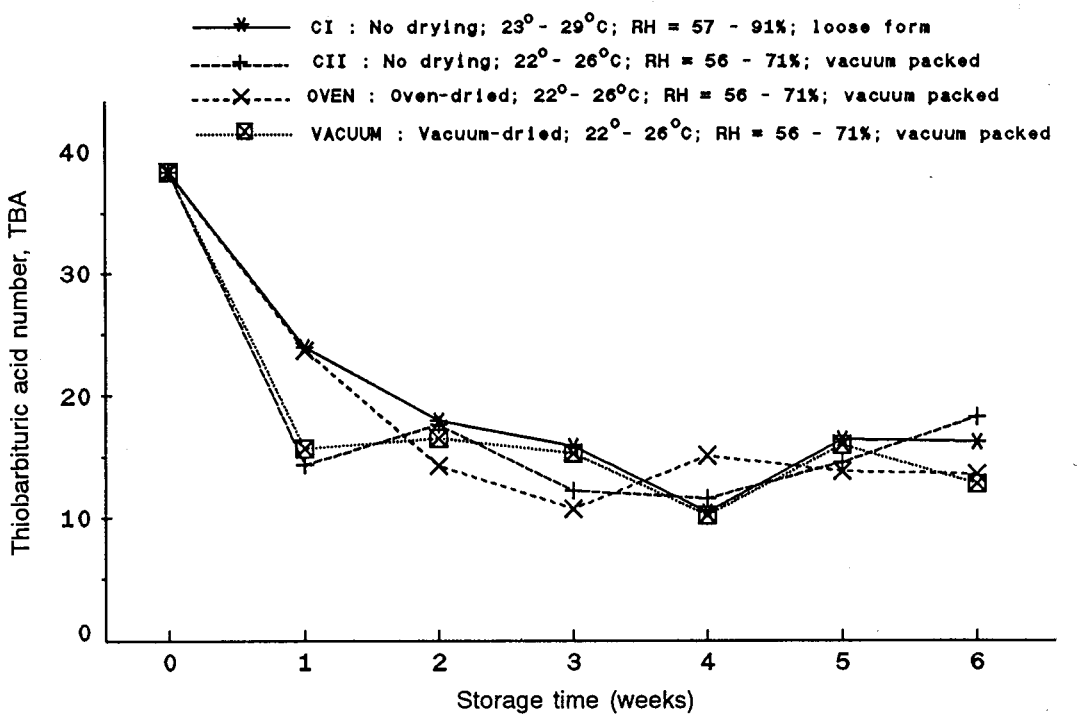

Fig. 8. Changes in thiobarbituric acid number (TBA) of boiled, dried anchovies under various conditions.

preventing insect infestation. Moulds managed to grow in CII samples because of the higher moisture content. CI samples were of borderline quality after five weeks of storage at room temperature. The better initial quality of the raw materials used in this study enabled the shelflife of this product under room temperature to be extended almost two-fold compared to those from Tanjong Pinang. The rest of the samples were still acceptable; as this study is still in progress, the shelflife limits for the various treatments will be reported later.

Conclusion

The results of this study showed that simple steps of further drying the boiled, dried anchovies and vacuum packing them were effective in maintaining its quality and extending shelflife. Samples that were vacuum dried under low temperatures yielded a better quality product.

In Singapore, boiled, dried anchovies are imported from our neighbours. Although, local packers have little influence on processing methods, however, further drying and vacuum packing are simple steps they can take in order to upgrade their products.

Since the South China Sea is an abundant anchovy resource and boiled, dried anchovy a popular food item of Southeast Asian countries, it is important to maximise anchovy utilization and reduce wastage due to spoilage as a result of poor processing and handling of the processed product. Results from this series of studies show that there can be much improvement in the processing methods and processing controls, re-processing and packaging of this commodity in this region.

The improved product does not only have the potential to fetch a higher price but is also a potential for export to Asian communities in America and Europe.

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Discussion

A query about the method used to analyse the presence of mould and how it was quantified was raised. In reply, Ms Low said that in the study, only organoleptic assessment and visual observations were conducted.

An explanation was sought as to why a decrease in the TMA-N after two weeks storage was not reflected in a corresponding decrease in the VB-N values. Ms Low replied that this fluctuation was also observed in other studies on the anchovy, and consequently she had recommended that the TMA-N is not a good quality index for the boiled-dried anchovy. There was no definite reason to explain this irregular fluctuation.

Asked why samples kept in the dark at room temperature deteriorated faster than those kept in the light. Ms Low replied that the samples kept in the dark trapped the VB-N within, and when assessed organoleptically, were of poorer odour and hence poorer organoleptic assessment grading. She added that the samples in the dark had more abundant mould growth.