Salting, Drying and Smoking of Tilapia from Volta Lake, Ghana

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The effects of dressing methods, brining time, open-air drying time, smoking temperatures and storage time on the quality of salted, smoked and dried *Tilapia galilae* from Volta Lake were investigated. The data led us to establish an improved method of preparing dried fish acceptable to Ghanaians. The method includes scaling, dressing in split-open form, thorough cleansing and washing, brining in a saturated brine to give a finished product containing about 10% salt on a wet basis and a water content of 40 to 45%, open-air drying before smoking down to 75 to 80% yield, and warm smoking at 40 to 60°C (down to 40% yield) followed by open-air drying. The whole process at Volta Lake was completed in 24 to 36 hr during the dry season and 30 to 70 hr during the rainy season. The larger the fish the longer the processing time. The products prepared by this method proved to have an organoleptic quality superior to the locally dried fish and remained in good condition for at least a month when stored in polythene bags (gauge 400).

The author proposed in Zambia an improved method of preparing salted, dried and smoked fish¹⁾. The procedure developed proved suitable for almost all species of fish of various sizes under dry climatic conditions (RH 40–80%) in Central Africa.

On Volta Lake in Ghana, it is rather humid year round, with the RH ranging from 65 to 95% at Akosombo*². This condition makes the fish drying process more difficult than in Zambia.

Tilapia galilae formed about 50% of the commercial catch from the lake in 1969*³, although the percentage seems to have declined to 25 in 1972.

Most of the tilapia are preserved in salted-dried form, and only 0.3% of the total dried tilapia are prepared in smoke-dried*⁴ or rather "grilled" form³⁾. The eating quality of the products available at local markets was fair for the former and fair to good for the latter*⁵. The main defects of the local salted products are a pungent fermenting off-odor and too high salt content. As for the grilled fish, charred surface, extreme brittleness of the meat, and the frequent heavy infestation in the meat by larvae deposited by blow flies pose major problems. The local processing methods generally require up to one week.

To rectify these defects, a method combining salting, drying and smoking seemed promising.

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*² Volta River Authority (Meteorological Section), Job No. CIV/OP/DS/4, Akosombo, Ghana (1972).

*³ W. A. Evans and J. Vanderpuye: Early development of the fish and fisheries of Volta Lake, Internal Report, Volta Lake Research Project, Akosombo, Ghana (1970).

*⁴ E. M. Mensah: Methods used in fish processing on Volta Lake, Internal Report, Volta Lake Research Project, Akosombo, Ghana (1970).

*⁵ K. Watanabe and E. M. Mensah: Unpublished data.

In this paper, the applicability of the improved method developed under conditions in Central Africa for processing Volta Lake tilapia, as well as the acceptability of the products by local people, were determined.

Materials and Methods

Preparation of smoked tilapia *Tilapia galilae* of commercially available sizes, e.g. small (ca 200 g, so called 1/2 lb fish), medium (ca 450 g, so called 1 lb fish), and large (ca 700 g, so called 1 and 1/2 lb fish), were collected directly from fishermen at Pawnpawn River. Only very fresh fish were sampled. The fish were packed in ice in an insulated box and brought back to the experimental fish drying plant* of the Volta Lake Research Project (VLRP) at the Marine in Akosombo where the fish were processed by essentially the same method as described earlier¹⁾. The method includes the steps, in the order, of washing, opening, scaling, salting by brining in a saturated salt solution, sun-drying before smoking, warm smoking and sun-drying after smoking. During the processing changes in the weight of individual fish were recorded.

A series of experiments designed in multiple-way layout was conducted to assess the effect of the following factors on the quality of the finished product: 1. Dressing methods of gutting and splitting. 2. Brining time in a saturated brine. 3. Drying time in dry and wet season. 4. Smoking temperatures. 5. Storage in polythene bags. After fixing the optimum conditions of the above factors, the products prepared by the best combination were directly compared with the locally prepared gilled *T. galilae*.

The data were subjected to the analysis of variance according to the main effects only, assuming that interactions are technically negligible. Also, the statistical analysis was applied considering that the whole series was randomly performed, although the data were basically to be treated as a split plot design.

Commercial products of unsalted-grilled tilapia The local products purchased at market were normally prepared by the following traditional method. Fresh fish are first scaled and cutted sideway starting from anus to upper end of pectoral fin base showing somewhat a logarithmic curve, then gutted by pulling out entrails by fingers through the opening. After gutting, the fish are placed on the shelves of ovens and covered by metal sheetings. Grilling of fish are carried out at 60°C to 125°C and lasts from overnight to 7 days depending on the size of fish and season.

Evaluation of the samples Specimens were taken from the thickest part of the body, e.g. anterior dorsal part of the trunk, and analysed for water content by drying to constant weight at 105°C, salt content³⁾, total viable counts on nutrient agar⁴⁾ and pH by a glass

* K. Watanabe: Experimental fish drying plant on Volta Lake, Ghana: design, construction and economic consideration, Internal Report, Volta Lake Research Project, Akosombo, Ghana (1973).

electrode pH meter. Appearance and smell of non-cooked fish were examined organoleptically according to WATANABE and DZEKEDZEKE's scheme⁶⁾ and scored on a ten point hedonic scale (excellent-10, good-8, fair-6, half rotten-2, rotten-0). Eating quality of the cooked fish (boiling for 30 minutes in distilled water) was determined for smell and taste by a taste panel formed by 4 members of VLRP laboratory staff, and scored into the same ten point hedonic scale as described for appearance and smell of non-cooked fish. The 4 members were, following the method of WATANABE⁶⁾, trained and selected out of 6 members who were first invited to participate in the tests. After several trials for familiarizing them to the tasting methods and statistically checking the individual performance, 2 members who revealed inconsistent flavor sensitivity were omitted. The remaining 4 members formed a panel which showed insignificant variation in members.

Results and Discussion

Effect of dressing and salting on quality Locally prepared salted or grilled tilapia are only gutted and never split opened except for those landed spoiled. The salted fish are made of smaller fish, whereas the smoked fish are normally processed from larger fish. The reason for this traditional practice is that only smaller gutted fish can absorb enough salt to keep the fish unspoiled during drying. For larger fish, as salt penetrates into the meat too slowly to protect it at the early stage of the sun-drying, hot smoking or rather grilling is the only way to preserve them.

Splitting fish evidently quickens the salt penetration and drying process by increasing the surface which produces better water evaporation and salt absorption than skin surface.

An experiment was carried out during the dry season to compare the effect of different brining times on split or gutted fish of various sizes. The results of chemical, bacteriological and organoleptic analysis of the finished products are tabulated in Table 1 and the drying curves shown in Fig. 1.

Loss in fish weight after brining was less than 5% in all cases. In some the weight increased by 1%.

Little difference in the drying speed was observed between shorter brined and longer brined fish for all sizes. Split fish obviously dried much faster than the gutted, except for the small tilapia. Overall split fish of the medium and large size completed the process about 12 hours faster than the gutted fish.

With regard to the quality of the finished products, 1/2 hour brining was sufficient to prepare a product of fair quality for the small split fish while 1 hour brined small gutted fish were of poor to rotten quality. For the medium fish, at least 1 hour brining was essential for both split and gutted fish. Large split fish need over 1 hour brining but the same length of brining time was not sufficient for the gutted ones. Split fish, especially of

Table 1. Chemical, bacteriological and organoleptic analysis of salted, dried, smoked Tilapia comparison by dressing method, brining time and fish size

Dressing method	Fish size *1	Brining time (min)	Storage time (days)	Water %	Salt % wet basis	pH	Total viable count/ cm ² skin	Cooked fish score *2	Appearance score	Mould growth *3	Blow fly larvae *3	Off odour *3
Split	S.	15	70	31.8	10.8	6.8	10	5.3	8	—	—	—
		30	60	34.1	12.8	6.8	35,000	7.0	8	—	—	—
		60	60	32.7	13.7	6.8	180,000	7.0	8	—	—	—
	M.	15	60	34.3	9.5	7.5	10	0	4	+	—	+
		30	60	33.0	13.6	6.8	450,000	6.8	8	—	—	—
		60	60	38.1	15.4	6.7	300	7.5	8	—	—	—
	L.	15	60	38.6	7.2	7.6	1,600,000	0	4	+	—	+
		30	60	37.0	8.4	7.6	48,000	0	4	+	—	+
		60	60	44.1	8.9	7.2	8,200,000	6.8	8	—	—	—
Gutted	S.	15	60	38.0	7.6	7.8	300,000	0	6	—	—	+
		30	60	25.5	8.5	6.8	2,300,000	6.3	8	—	—	—
		60	70	34.2	10.5	6.9	10	3.3	6	—	—	—
	M.	15	50	36.7	5.9	7.4	550,000	0	4	+	—	+
		30	50	44.5	10.1	7.0	2,100	4.5	4	—	—	—
		60	50	26.0	9.1	6.8	8,500	7.2	8	±	—	+
	L.	15	10	61.6	2.3	7.9	3,200,000	0	0	+	+	+
		30	10	44.4	4.5	8.0	—	0	0	+	+	+
		60	10	49.1	5.2	7.4	1,500,000	0	4	+	+	+

*1 S: Small 200 g, M: Medium 450 g, L: Large 700 g. *2 Average of smell and taste for 4 scores.

*3 — none, + some, ± slight.

Each value is the average of 4 fish except for cooked fish and appearance score.

Table 2. Analysis of variance of panel scores for palatability of meat of smoked Tilapia comparison by dressing methods, brining time and sizes of fish

Source of variation	D.F.	Smell		Taste	
		M.S.	F.	M.S.	F.
Split vs. Gutted	1	111.89	35.2*	40.50	12.4*
Sizes	2	109.89	34.6*	105.68	32.3*
Brining times	2	157.39	49.6*	126.43	38.6*
Members of taste panel	3	1.89	0.59	1.20	0.37
Error	63	3.18		3.27	

* indicates a significant difference at $P < 0.01$.

D.F.: Degree of freedom. M.S.: Mean square. F.: Variance ratio.

Table 3. Proposed brining time for different sizes of Tilapia to prepare a finished product containing 10% salt on wet basis of 40–45% water

		Very small*1	Small*2	Medium*2	Large*2	Very large*2
Weight	(g)	< 200	200	450	700	1,000~1,500
	(lb)	< 1/2	1/2	1	1 and 1/2	2 3
Brining time	(hr)	1/2	1/2	1	1 and 1/2	2 6

*1 gutted

*2 split

Fig. 1. Drying curves of tilapia from Volta Lake, comparison by dressing method, brining time and fish size. Each point is the average of 4 fish.

Meteorological conditions on the days of the trials:

Temperature mean 31°C, range 29–33°C; RH mean 75%, range 68–94%

*1 Small: 200 g (1/2 lb), Medium: 450 g (1 lb), Large: 700 g (1 and 1/2 lb).

*2 In a saturated brine.

medium to large size, were apparently superior not only in keeping quality but also in ease and speed of the processing.

The results of the taste panel test showed that the score of split fish is significantly ($P < 0.01$) higher than that of the gutted, the score of small fish higher than that of large, and the score of longer brined fish higher than that of fish brined for a shorter time (Tables 1 and 2).

The data indicate that fish dried to a level of 45% of their dressed weight (35 to 40% water content) will keep well if the salt content is over 10% wet basis.

To establish the brining time required to increase the salt content up to this level additional trials were conducted by dipping split fish of the three sizes in a saturated brine for 15, 30, 60 and 120 minutes, respectively. Each lot was composed of 6 fish. After being dried and smoked, the fish were analysed for salt content (Fig. 2). This test

Fig. 2. Salt penetration into the meat of split tilapia from Volta Lake, by brining method. Each point is the average of 6 fish.

*1 Small: 200 g (1/2 lb), Medium: 450 g (1 lb), Large: 700 g (1 and 1/2 lb).

*2 In a saturated brine.

*3 Water content in the finished products varied from 32 to 45%.

was repeated several times in 1972 but the reproducibility of the salt penetration curves was rather poor, apparently due to seasonal variation in physiological changes of the texture and oil content of the fish. Mixing of fish in the brine helped to make the brining uniform. Roughly, however, "a one pound fish" required 1 hour of brining, while "a one and a half pound fish" required one and a half hours. Small fish which were brined for two hours showed salt spotting and a very rough surface. Quick washing in fresh water for 15 to 30 seconds improved the appearance. For very large "fish of 3 to 4 pounds", although data were few and inconclusive, 6 to 8 hours of brining were necessary to give the right salt concentration because of the high oil content. In conclusion, proper brining time for the whole range of commercially available sizes of *T. galilae* were derived as shown in Table 3.

Effects of season on drying time In the Akosombo area the months of the major rainy season are May, June and July, the minor rainy season being September and October. During these months the relative humidity ranges from 70% at 3.00 p.m. to 100% early in the morning. During the dry months the relative humidity drops as low as 35% at 3.00 p.m. but early in the morning it still goes up to 90%. These conditions are less

Fig. 3. Drying curves of split tilapia from Volta Lake, comparison by season and fish size. Each point is the average of 6 fish.

Meteorological conditions:

Dry season, Temperature	28–35°C	Rainy season, Temperature	25–32°C
RH	35–90%	RH	70–100%

*1 Small: 200 g (1/2 lb), Medium: (1 lb), Large: 700 g (1 and 1/2 lb).

favourable for open-air drying of fish than in Central Africa. Fig. 3 shows the comparison in the drying curves between the wet and dry seasons. The fish were all split and brined for the time as established in Table 3.

Total processing time in the dry season varied from 24 hours for small fish to 36 hours for large fish whereas in the rainy season it varied from 30 to 70 hours. The processing of small fish could be completed in 12 hours in the dry season if smoking was started at 6.00 p.m. when the fish was dry enough to begin smoking and continued till 10.00 to 12.00 p.m. The small fish were in fact overdried down to 60% yield in the pre-drying. Whenever this overdrying happened, the smoke deposited on the fish more slowly during the smoking process than when they were dried up to 80% yield. At this dryness the fish texture was also resistant to the smoking heat. Except for small fish in the dry season, the fish dried very little at night. Occasionally during the rainy season a smoker-dryer* was used as a dryer at night and this shortened the process to such an extent that the time required for the whole process became as short as in dry season. The consumption of firewood, however, was almost triple that for simple smoking.

At Akosombo, when rain is falling no drying of the fish occurs but as soon as the sun comes out the relative humidity drops and the fish weight starts to decrease. Fortunately

* K. Watanabe: Experimental fish drying plant on Volta Lake, Ghana; design, construction and economic consideration, Internal Report, Volta Lake Research Project, Akosombo, Ghana (1973).

most of the rain in Ghana takes the form of showers of short duration.

Yield after 2 days of drying in the rainy season was usually 5 to 10% higher than that in the dry season.

Tables 4 and 5 show the results of chemical, bacteriological and organoleptic examinations of the fish and statistical analysis of the taste panel scores.

Table 4. Chemical, bacteriological and organoleptic analysis of salted, dried, smoked, Tilapia, comparison by season and fish size

Season	Fish size * ₁	Storage time (hr)	Water %	Salt % wet basis	pH	Total viable count/ cm ² skin	Cooked fish score * ₂	Appearance score	Mould growth * ₃	Blow Fly larvae * ₃	Off odour * ₃
Dry	S	20	24.6	8.5	6.8	80	6.8	6	—	—	—
	M	30	23.5	9.2	6.6	50	7.0	8	+	—	—
	L	30	40.7	11.7	6.6	80,000	7.0	8	—	—	—
Rainy	S	28	24.3	12.5	6.6	1,200	8.0	8	—	—	—
	M	13	36.7	11.8	6.9	1,400	7.5	6	—	—	—
	L	13	40.5	10.8	6.8	1,000	7.5	8	—	—	—

*₁ S: small 200 g, M: medium, 450 g, L: large 700 g.

*₂ Average of smell and taste for 4 scores.

*₃ — none, + some.

Each value is the average of 4 fish except for cooked fish and appearance score.

Table 5. Analysis of variance for panel scores, for palatability of the meat of smoked Tilapia, comparison by season and fish size

Source of variation	D.F.	Smell		Taste	
		M.S.	F.	M.S.	F.
Dry vs. Rainy season	1	9.83	8.57*	6.00	4.43
Sizes	2	4.33	3.69*	0.19	0.12
Members of taste panel	3	4.72	4.12*	0.67	0.49
Error	17	1.15		1.35	

* indicates a significant difference at $P < 0.05$.

D.F.: Degree of freedom. M.S.: Mean square. F.: Variance ratio.

Table 6. Minimum hours necessary for open-air drying to prepare split, salted, smoked, dried Tilapia at Akosombo by season and size

Season	Drying stages	Fish Size				
		Very small < 200 g	Small 200 g	Medium 450 g	Large 700 g	Very large > 700 g
Dry	Pre-smoking	5	5	10	15	25
	Post-smoking	0	0	5	10	30
	Total including brining and warm smoking	12	12	25	35	65
Rainy	Pre-smoking	20	20	25	30	50
	Post-smoking	0	0	20	30	55
	Total including brining and warm smoking	30	30	55	70	120

The finished products in both seasons were similar in water and salt content, which were well within the desirable percentages as shown in the previous section. However, mould grew on the medium fish processed during the rainy season, due to surface absorption of moisture from the air by the salt which created a condition suitable for the mould growth. This suggests the need to protect the dried fish from reabsorbing moisture in the rainy season.

Seasonal variations in smell, in sizes of fish and in panel members were significant ($P < 0.05$) whereas those in taste were not. The products had a better smell during the rainy season which could be due to the difference in firewood used.

It is now clear that the method can produce year round dried fish of acceptable and storable quality. Minimum drying time required for the preparation of salted, dried smoked *T. galilae* at Akosombo is summarized in Table 6.

Effect of smoking temperature and storage time on quality The local products are non-salted and processed at high temperatures of over 100°C, which results in a highly brittle texture with a shelf life of only two days unless the fish are re-grilled every day. The improved method includes brining which gives a firm texture even at relatively high smoking temperatures, although a warm temperatures of 40 to 60°C is recommended. In Zambia hot smoked fish were preferred to warm smoked ones⁵¹. This is generally considered to be also true in Ghana because of local tradition. Another possible explanation for the use of hot smoking (grilling) in this country could be the relatively wet climate under which warm smoking would take too long a time to prepare the products of good quality and unless they were salted the fish would be spoiled during the warm smoking.

Bearing in mind these facts, the advantages and disadvantages of hot and warm smoking and the effect of storage time on quality were investigated. Fish were grouped into two lots and both were dressed, brined and pre-dried in exactly the same manner. After pre-drying one lot was smoked warm at 40 to 60°C for 6 hours and the other lot was processed hot at 90 to 100°C for 4 hours. These smoking times in the VLRP smoker-dryer produced fish with an attractive yellowish brown colour. The analysis of the quality of the end products were done after 10 and 30 days storage in polythene bags (gauge 400) at room temperatures.

The results of quality estimation are shown in Table 7, with those of statistical analysis of taste panel scores for the palatability of cooked meat (Table 8).

Contrary to what was anticipated there was no significant difference in preference of taste and smell between hot and warm smoked tilapia. Both products remained without noticeable deterioration in flavour up to 30 days of storage. The texture of the hot smoked fish was somewhat brittle and although it was much less so than non-salted local products, there might be breakage of the fish if they were handled roughly and transported on rough roads.

Table 7. Chemical, bacteriological and organoleptic analysis of salted, dried, smoked Tilapia, comparison by smoking temperatures and storage time

Method of smoking	Storage days	Fish size* ¹	Water %	Salt % wet basis	pH	Total viable count/cm ² skin	Cooked fish score* ²	Appearance score	Mould growth* ³	Blow fly larvae* ³	Off odour* ³	Brittleness* ³
Hot	10	S.	25.7	12.9	6.8	—	6.2	8	—	—	+	+
		M.	49.0	14.1	6.8	—	6.2	6	—	—	—	+
		L.	37.7	9.4	6.9	—	7.3	9	—	—	—	+
	30	S.	19.4	12.0	6.5	3,300	7.8	8	—	—	—	—
		M.	29.0	8.1	6.9	23,000	5.0	6	+	—	—	+
		L.	34.3	11.3	6.8	1,400	8.5	8	—	—	—	—
Warm	10	S.	38.4	8.5	6.3	4,500	7.0	8	—	—	—	—
		M.	53.8	6.7	6.5	700	7.6	8	—	—	—	—
		L.	46.0	12.3	6.8	2,800	7.5	6	—	—	—	—
	30	S.	36.5	12.6	6.8	—	8.0	8	—	—	—	—
		M.	1.5	14.1	6.5	80	7.0	8	—	—	—	—
		L.	8.8	13.2	6.6	7,000	7.0	8	—	—	—	—

*¹ S: Small, 200 g. M: Medium, 450 g. L: Large 700 g.

*² Average of smell and taste for 4 scores.

*³ — none, + some, ± slight.

Each value is the average of 4 fish except for cooked fish and appearance score.

Table 8. Analysis of variance of panel scores for palatability of the meat of smoked Tilapia comparison by smoking temperature and storage time

Source of variance	D.F.	Smell		Taste	
		M.S.	F.	M.S.	F.
Hot vs. Warm smoking	1	0.75	0.32	2.08	1.05
Storage time	1	0.08	0.04	0.08	0.04
Sizes	2	1.27	0.54	9.77	4.94*
Members	3	2.08	0.88	1.67	0.84
Error	40	2.36		1.98	

* indicates a significant difference at $P < 0.05$.

D.F.: Degree of freedom. M.S.: Mean square. F.: Variance ratio.

Water content generally became constant after a few days of storage. Fish with a higher salt content usually maintained a higher constant level of moisture than those with a low salt content which tended to lose considerable weight even in polythene bags.

The pH of the warm smoked fish was somewhat lower than that of the hot smoked fish and water content of the former higher than that of the latter.

The main advantages of hot smoking are that it shortens the time needed for drying and that it is sterilizing the products. It is well known that the resistance of fish flesh to heat increases as the fish become dryer. Thus, to avoid the problem of brittleness in hot smoking as well as of slow drying in warm smoking, the fish can be smoked by a combination of warm temperatures at first and increased temperatures of 110°C towards the end of the process. This method was tested several times and enabled us to prepare

non-brittled products in a shorter time than by warm smoking only. This technique was found most useful during the rainy season.

Firewood of the species *Talbotialla gentii* produced fish of the most attractive colour and good flavour. The trees are abundant on the lake.

At present the local people tend to prefer darkly smoked products because of long familiarity with the charred or grilled type.

Comparison in flavour between local and VLRP (Volta Lake Research Project) products

From the above data, a method which prepares products of an improved quality was established. Described briefly, this VLRP method of producing dried *T. galilae* involves the following steps: 1. Scaling. 2. Dressing in split-open form. 3. Cleaning and washing. 4. Brining in a saturated brine for the time shown in Table 3 and quick washing after brining. 5. Open-air drying before smoking down to 75 to 80% yield. 6. Warm smoking at 40 to 60°C. 7. Open-air drying after smoking down to 40 to 45% yield (35 to 40% water content). These steps are basically similar to those developed in Zambia.¹¹

To ascertain whether the product prepared by the VLRP method is preferred by local people to the traditional products, medium size *T. galilae* from Pawnpawn River were processed according to the improved procedure and two fish were subjected to the taste panel test with another two grilled fish prepared locally by the traditional method. The local dried tilapia from the same river were purchased at Akosombo market and were of normal quality judged for appearance and smell by the members of VLRP laboratory staff. They were boiled in a 5% brine in order that the final product would have a salt content of approximately 2%, similar to the VLRP products cooked in distilled water. This experiment was repeated 4 times. All the fish were analysed for chemical, bacteriological and organoleptic quality, the results of which are given in Table 9. Table 10 gives the results of analysis of variance of the taste panel scores for smell and taste.

The locally prepared grilled tilapia were significantly ($P < 0.01$) inferior in taste but not in smell to those prepared by the VLRP method even though the former had been in storage only for less than 4 days, ordinary lapse between processors and retailers, whereas the latter had been stored for at least 1 week. The repetition of the tests using different members of the taste panel produced similar results.

When packaged in plastic bags and stored under closed conditions the local products usually became infested heavily with blow fly larvae and turned inedible within two days, except for those which had unusually been dried to less than 15% water content. The highly dried fish, however, imply low yield percentage and consequently less profit if the transaction is made on weight basis.

JOHNSON⁷⁾ attempted in 1941 to promote in Ghana an improved method of drying marine fish. The method was similar to the present one of combined salting, smoking and drying. He stated that there had been little apparent desire among local fish traders

Table 9. Chemical, bacteriological and organoleptic analysis of salted, dried, smoked Tilapia, comparison between local and VLRP products

Product	Repetition	Fish *3	Water %	Salt % wet basis	pH	Total viable count/ cm ² skin	Cook- ed fish score *4	Ap- pear- ance score	Mould growth *5	Blow fly larvae *5	Off odour *5	Brit- tleness *5
Local*1 (Grilled)	1	a	50.8	—	7.4	800	7.1	8	—	—	—	+
		b	69.0	—	7.2	18,000	7.5	8	—	—	—	+
	2	a	37.5	—	7.0	140,000	4.9	8	—	—	—	+
		b	50.1	—	6.8	200	7.5	8	—	—	—	+
	3	a	50.0	—	7.2	1,300	7.8	8	—	—	—	+
		b	50.9	—	6.8	600	7.3	8	—	—	—	+
	4	a	50.5	—	6.5	3,600	4.0	8	—	—	—	+
		b	18.3	—	6.3	1,700	7.4	6	—	—	—	+
	VLRP*2 (salted & smoked)	a	41.21	8.3	7.0	1,000	8.3	8	—	—	—	—
		b	29.8	9.0	6.7	110	7.5	8	—	—	—	—
		a	30.4	10.1	6.5	75	7.5	8	—	—	—	—
		b	31.5	10.9	6.6	15	6.6	8	—	—	—	—
		a	34.7	7.7	6.8	43	7.1	8	—	—	—	—
		b	24.6	8.2	6.5	49	7.3	8	—	—	—	—
		a	27.8	11.0	6.2	1,500	7.0	8	—	—	—	—
		b	28.1	11.4	6.4	1,700	8.1	8	—	—	—	—

*1 Salt content for local grilled product was not determined, since they were not salted.

*2 Volta Lake Research Project.

*3 All the fish were of medium size (450 g).

*4 Average of smell and taste for 4 scores.

*5 — none, + some.

Each value is the average of 4 fish except for cooked fish and appearance score.

Table 10. Analysis of variance of panel scores for palatability of the meat of smoked Tilapia comparison between local and VLRP products

Source of variance	D.F.	Smell		Taste	
		M.S.	F.	M.S.	F.
Local vs. VLRP products	1	14.99	3.99	25.00	9.56*
Repetitions	3	9.40	2.51	0.19	0.07
Members of taste panel	3	3.89	1.04	0.56	0.21
Error	56	3.75		2.62	

* indicates a significant difference at $P < 0.01$.

D.F.: Degree of freedom. M.S.: Mean square. F.: Variance ratio.

to adopt this method. Since then the situation has remained almost unchanged without much improvement in the drying technique*1. There has been a lack of determined effort by the Government extension service to promulgate new methods*1,8). In this connection, WATANABE⁹⁾ demonstrated that local fish traders in Zambia have adopted in the relatively short span of 2 to 3 years the new fish processing method and attributed the cause of the change to the steady effort of the Zambian Fisheries Department Development Section which conducted a number of training courses and field demonstrations.

*1 B. Kagan and A. Trenning: Report on visits to traditional processing sites in greater Accra, Report No. 5, Food Research Institute, Accra, Ghana (1968).

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