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Improving hot air processing of fish using the Chokor smoker-Development of an Improved Smoking Oven "AFRISMO-150"

Food Research Institute/AgSSIP Technical Report for Agro-Processing Programme (FRI-AGP-2).

BY

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IMPROVING HOT AIR PROCESSING OF FISH USING THE CHORKOR SMOKER - DEVELOPMENT OF AN IMPROVED SMOKING OVEN "AFRISMO – 150"

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(2005)

Summary

The need for an efficient, cost effective smoking oven that eliminates the interchanging of tray positions, reduces heat loss and makes fish smoking less laborious as well as addresses the reduction / elimination of tar deposits usually associated with fish processed by the chorkor smoker has resulted in the design and construction of an improved smoking oven at the Food Research Institute (FRI) of the Council for Scientific and Industrial Research (CSIR). The oven, AgSSIP/FRI Smoking Oven (AFRISMO), model AFRISMO-150 was developed under the Agro-Processing Programme of the Agricultural Services Subsector Investment Project (AgSSIP). AFRISMO - 150 is an improvement to the popular chorkor smoker. It is an enclosed rectangular shaped structure consisting of three basic components: two firing sections, cooking/smoking chamber and a chimney. It can be fired by firewood only or Liquified Petroleum Gas (LPG) only or a combination of LPG and firewood.

This report covers the design, construction and test run of the AFRISMO - 150 using firewood only for the smoking of Mackerel fish. Temperature distribution tests conducted during smoking within the oven recorded highest temperature difference of 29°C at 90th minute and maximum operating temperature of 195°C at 110th minute of operation as presented in Table 1 and Figure 5. The test run also established a smoking capacity of 150kg of fresh fish per batch of 3 hours, fuel consumptions of 39.5 kg of firewood (i.e. unit fuel consumption rate of 0.33 kg of firewood per kg of smoked fish). Yield of 80.6% and moisture loss of 19.4% were also recorded as presented in Table 2.

Microbiological analyses carried out on the smoked fish showed absence of faecal coliforms, spoilage and food poisoning microorganisms proving that the smoked fish is safe for human consumption and would not pose any health hazard when consumed.

The total cost of construction of the AFRISMO-150 is ¢2,500,000 (~$280).

Background Information

Among the various traditional processing methods employed in Ghana to preserve fish, smoking is the most widely used. About 70% of the total fresh fish catch is consumed in the smoked state. Even though fish smoking has been practiced for a long time, the methods used are still at the traditional level. Round mud or metal and rectangular mud or metal types of smoking ovens are used in Ghana. The chorkor smoker is an improvement on the original rectangular mud ovens (UNICEF, 1983).

Even though the chorkor smoker is one of the most cost effective means of smoking fish, there are a few aspects of its operation that need attention and improvement. These include the interchanging of tray positions during smoking so as to prevent the burning of fish on the lower trays, thus making smoking laborious. Direct application of heat during smoking tends to increase the deposition of tar on the smoked product. Heat is also lost during the interchanging process. The need to address the above-mentioned concerns gave birth to the development of FRI Improved Smoking Oven (AFSMO).

The objective of this project is therefore to develop an improved oven which eliminates the interchanging of tray positions during smoking, reduces heat loss and makes fish smoking less laborious. The improved oven also targets the reduction / elimination of tar deposits usually associated with fish processed by the original chorkor smoker.

MATERIALS AND METHODS

Design features

The new design was created with the concept of eliminating the laborious process of interchanging tray positions during smoking and its associated heat loss as well as the elimination of tar deposits during smoking. The firing chambers are therefore located at the two sides of the smoking chamber where the trays are stacked. The curved nature of the side walls of the oven, coupled with the central positions of the shelf structure that carries the trays and the exhaust guarantee uniform smoking in the oven.

The height of the exhaust/chimney is such that smoke is always directed above the immediate surroundings of the smoking area, thus preventing the processors from smoke pollution. Figure 1 shows the front and side elevation as well as the plan of the oven.

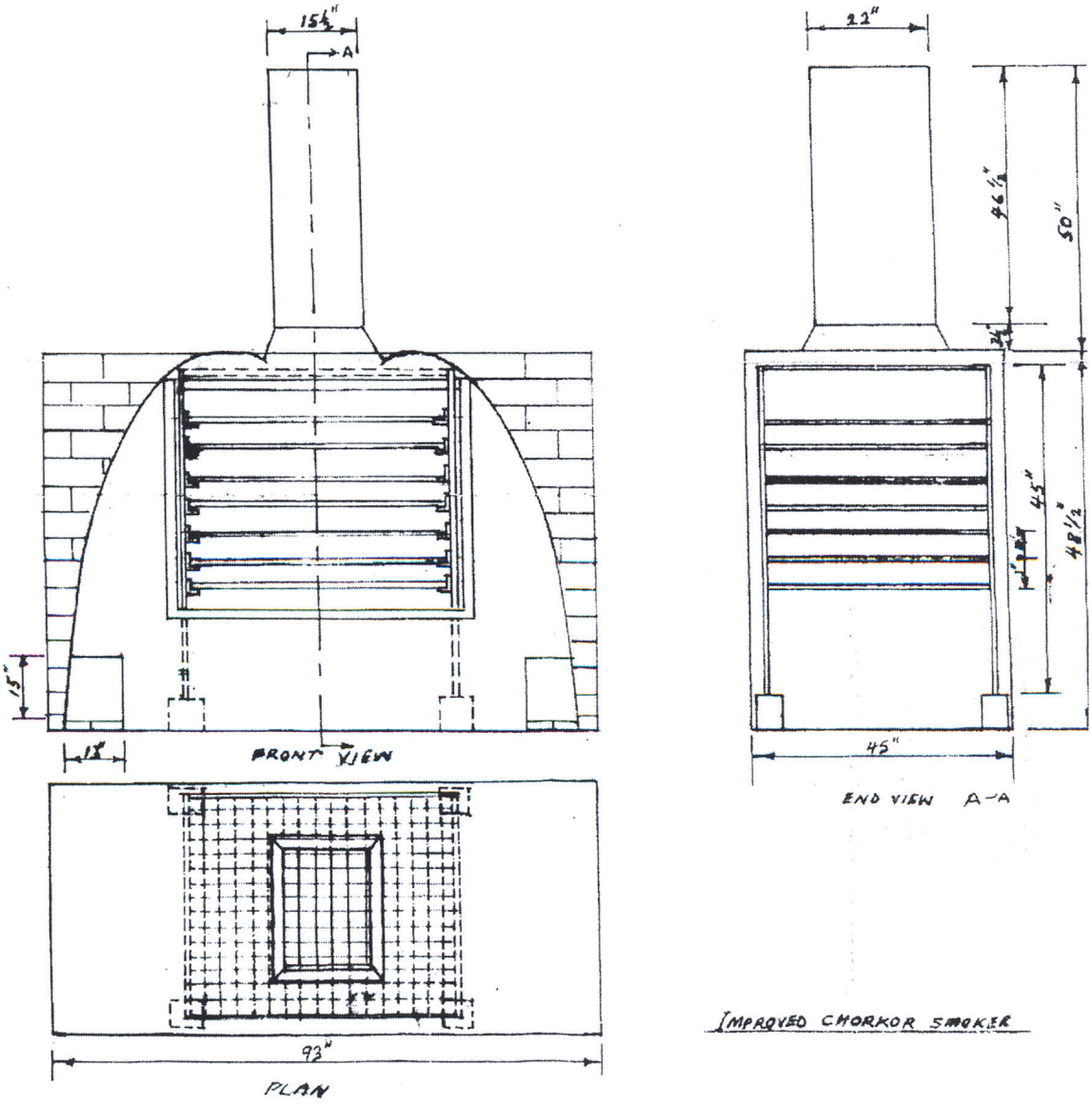

Figure 1: Front and side elevation and Plan of the AFRISMO-150

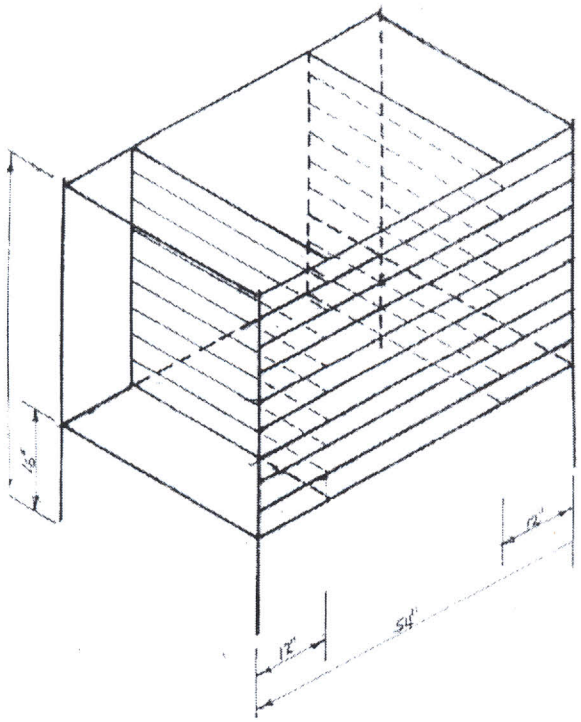

Figure 2: Shelf

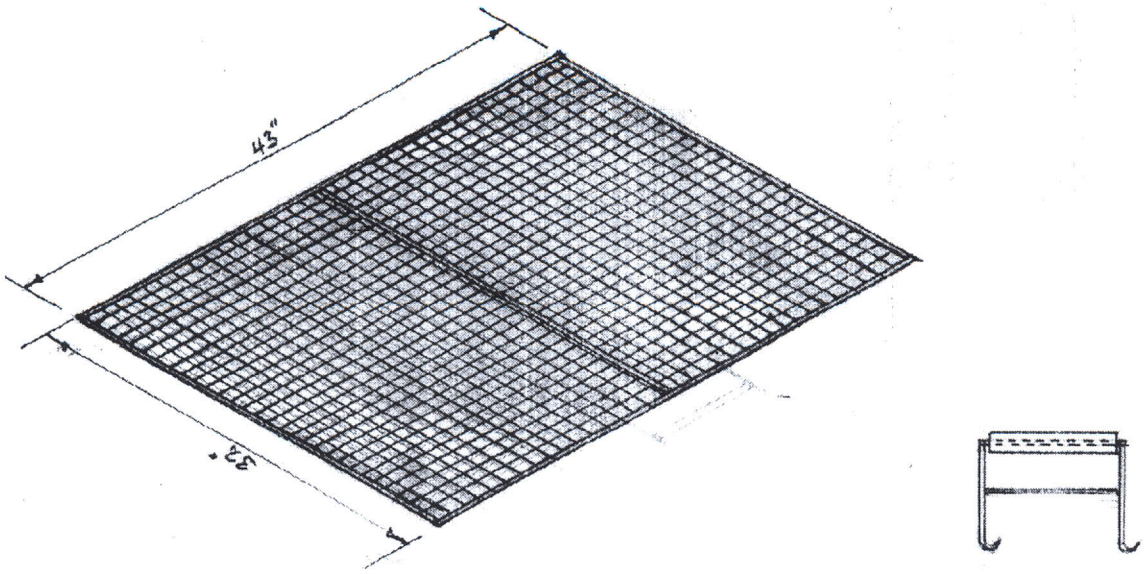

Figure 3: Tray and handle

The shelf is made from 5/8" steel rods and designed to allow easy "push-in and pull-out" of trays. The trays are made from 5/8" - steel rod frames and 3mm welded mesh. A hook with wooden handle has also been made to pull out the trays, one after the other after the smoking process. Drawings of the shelf, a tray and the hook are presented in Figures 2 and 3.

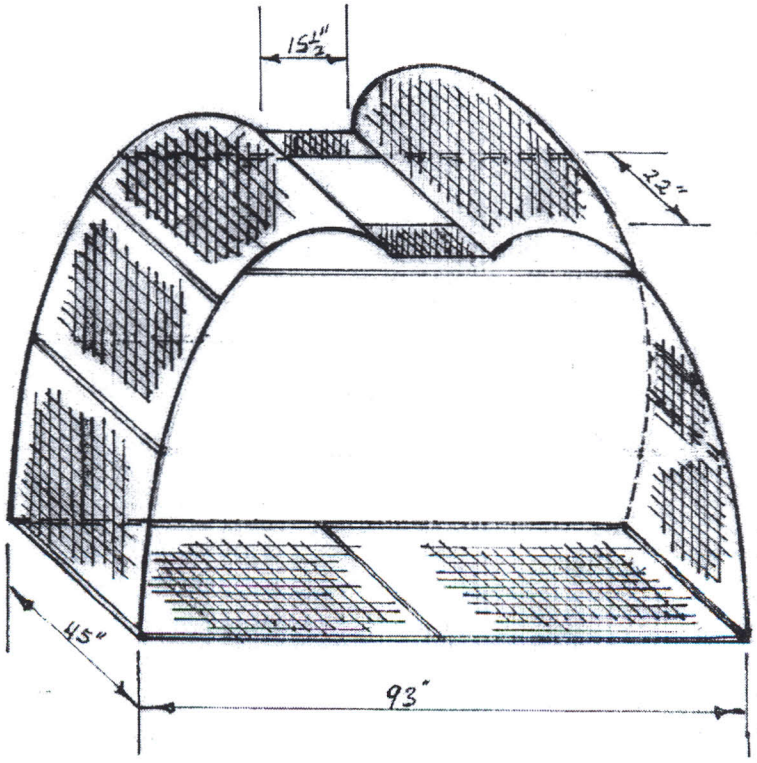

Figure 4: Structural frame of the improved oven

TEST RUN OF OVEN

Test run of the oven was conducted using firewood as source of fuel and mackerel fish to determine its performance characteristics. The mackerel fish was obtained in frozen state from a Cold Store facility at the Tema Fishing Harbour. The firewood used is called "Osha" and was obtained from the market at Shiashi, near Okponglo in Accra.

Temperature distribution test

Test on temperature distribution in the oven was conducted to find out how uniform heat is distributed in the oven. Three temperature probes were inserted in the oven from the back and positioned on the top, middle and bottom trays to record temperatures. Readings were taken every 10 minutes.

The smoking process

The fish was allowed to thaw, washed, drained of water, weighed and spread as uniformly as possible on the ten trays with each tray carrying a tenth of the total quantity of fish to be smoked, i.e. 15kg of the mackerel. Firewood for the smoking was weighed and about 5 or 6 sticks were arranged in each of the stockholes and lit. The trays were then slided onto the shelves and the door closed. Three stages of smoking process were employed. The first stage (slow firing) covers a period of about thirty (30) minutes during which the fire was manipulated such that temperature in the oven increased slowly and steadily but did not exceed 100^0C to prevent case hardening. The second stage (increased firing) lasted for about two (2) hours during which temperature was raised to record a maximum of about 195^0C. The third stage (cooling) saw the partial withdrawal of the firewood from the stockholes and allowing the fish to slowly reduce its temperature for about thirty minutes. After the third stage, the firewood was completely withdrawn and the door was opened and the fish allowed to cool. The trays were then pulled out of the shelves and the smoked fish weighed. The remaining firewood was also weighed and recorded. Samples were taken from the top, middle and the bottom trays for microbiological analysis.

PAH and chemical/texture analyses would be carried out during subsequent smoking tests.

RESULTS AND DISCUSSIONS

Tables 1 represents the temperature readings at the top, middle and bottom trays recorded during smoking. The results give a maximum temperature difference of 29^oC representing 15% of the maximum working temperature of 195^oC and falls within the

Table 1: TEMPERATURE PROFILE IN OVEN

TIME	TOP	MIDDLE	BOTTOM	TEMP. DIFFERENCE
0	30	30	30	0
10	61	58	55	6
20	70	70	67	3
30	87	82	77	10
40	95	92	89	6
50	102	98	95	7
60	133	128	116	17
70	160	142	134	33
80	143	135	127	16
90	171	152	149	29
100	190	186	175	15
110	195	184	179	16
120	165	150	148	17
130	150	135	132	18
140	159	146	144	15
150	126	123	110	16
160	117	110	105	12
170	89	84	78	11
180	77	72	69	8

smoking temperature range. It must be noted that same temperatures cannot be attained during every smoking process for the obvious reasons that temperatures in the oven will depend on how the processor manipulates the firewood which depends on experience and instincts.

Table 2 shows data recorded before, during and after the fish smoking process. It can be deduced from the results that the oven has a smoking capacity of 150kg per batch of 3 hours and firewood consumption of 39.5 kg.

TABLE 2: FISH SMOKING DATA

Type of fish	Mackerel
Type of firewood	"Osha"
Weight of firewood before smoking, kg	46.0
Weight of firewood after smoking, kg	7.5
Weight of firewood used, kg	39.5
Process time, hr	3.0
Consumption rate of firewood, kg/hr	13.2
Cost of wood per kg	¢952.38
Cost of firewood used	¢37,620
Weight of fresh fish, kg	150.0
Weight of smoked fish, kg	120.9
Weight of loss, kg	29.1
Percentage weight loss, %	19.4
Yield, %	80.6
Firewood consumption rate, kg/kg smoked fish	0.33
Firewood consumption rate, kg wood/kg fresh fish	0.26
Unit energy cost of smoking, ¢/kg smoked fish	¢314.28
Unit energy cost of smoking, ¢/kg fresh fish	¢247.19

Results of the microbiological analyses presented in Table 3 indicated that the aerobic plate counts at 30°C ranged between 3.0×10^1 and 2.6×10^3 cfu/g. The Ghana Standards Board Microbiological Standards (GSBMS) for food samples (1988) and the International Commission on Microbiological specifications for Foods (ICMSF, 1982) indicated a limit of acceptability as less than 1.0×10^6 cfu/g for the total viable count in any food to be safe for consumption. Such counts recorded in the smoked Salmon were therefore within the limits of acceptability.

The mould and yeast counts were between 0 and 9.0×10^2 cfu/g in the smoked mackerel (Table 3). The ICMSF (1982) and GSBMS (1988) has a specification of less than 1.0 x

10^4 cfu/g which indicated that the smoked fish met the specified standard requirement for safe food.

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Coliforms were absent in all the samples (Table 1); and further indications showed that *Escherichia coli* (*E. coli*) were also not detected. While ICMSF (1982) specified the levels of *E. coli* to be less than 1.0 x 10^1 cfu/g, the GSBMS (1988) indicated levels of zero cfu/g. the non detection of these food poisoning organisms indicated that the fish was safe for consumption.

Salmonella species were not detected in 25 grams of any of the samples (Table 1). Both ICMSF (1982) and GSBMS (1988) stipulated levels of zero cfu/g of these organisms in the food to be considered safe for human consumption.

Staphylococcus aureus and *Bacillus cereus* were absent in the smoked fish samples (Table 1). For *S. aureus*, both ICMSF (1982) and GSBMS (1988) indicated safe levels of less than 1.0 x 10^2 cfu/g and zero cfu/g respectively; while *Bacillus cereus* levels should not exceed 1.0 x 10^4 cfu/g.

Dominant flora observed were Gram-positive rods, yeasts and *Mucor* species.

The absence of faecal coliforms, spoilage and food poisoning microorganisms in the smoked Salmon showed that the fish was microbiologically safe for human consumption and would not pose any health hazard when consumed.

Table 3: Population of microorganisms in smoked Salmon processed with improved smoker.

Smoked Salmon	Aerobic microorganisms at 30°C (cfu/g)	Moulds & Yeasts (cfu/g)	Coliform organisms (cfu/g)	*E. coli* (cfu/g)	*Salmonella* species (/25g)	*Bacillus cereus* (cfu/g)	***Staphylococcus aureus*** (cfu/g)	Dominant Flora
1	1.3×10^3	8.0×10^1	0	0	Absent	0	0	*Mucor* spp., Yeasts, Gram +ve rods
2	2.6×10^3	9.0×10^2	0	0	Absent	0	0	Yeasts, Gram +ve rods
3	7.7×10^2	6.0×10^1	0	0	Absent	0	0	Gram +ve rods and Yeasts
4	3.0×10^1	0	0	0	Absent	0	0	Gram +ve rods

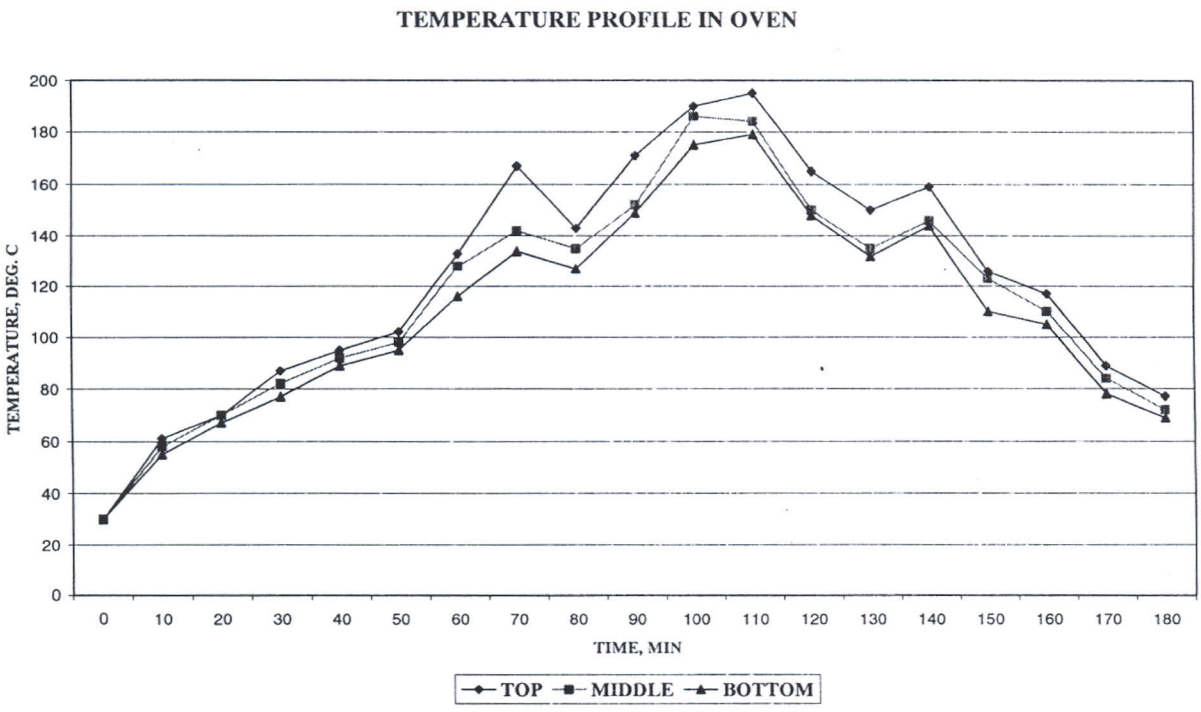

Figure 5: Temperature profile in oven during smoking of mackerel fish

CONLUSION

A 150kg capacity smoking oven AFRISMO – 150 has been designed, constructed and tested at the Food Research Institute (FRI) of the Council for Scientific and Industrial Research (CSIR). The oven is working satisfactorily and has actually eliminated the process of interchanging trays during smoking with the chorkor smoker thus reducing the amount of labour expended. Series of trials are being conducted to determine the tar deposits on the products i.e. polycyclic aromatic hydrocarbons (PAH) content, texture and shelf life properties of smoked fish with AFRISMO - 150.

The total cost of construction of the AFRISMO – 150 is ¢2,500,000 (~$280).

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