FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

"INTEGRATED GRADING AND SOLAR DRYING OF MEAT" TCP/GHA/4452(C).

SECOND PROGRESS REPORT

SUBMITTED: AUGUST, 1995

E. C-T. TETTEY
(NATIONAL CONSULTANT)

ABSTRACT

Beef strips of approximately 20 mm. thicknesses were prepared and pre-treated in three different ways prior to solar drying in a cabinet and tunnel types solar dryers over a period of three drying cycles.

Weather data monitored during the drying period indicated poor drying conditions prevailing during this period of the experiment (early August).

As a direct consequence of this, dried meat samples stored for only a period of four days under ambient conditions became heavily contaminated with spoilage microflora, and moisture content and water activity (Aw) values were also too high to afford shelf stability under ambient storage.

Under the same ambient conditions the tunnel solar dryer had by far better drying conditions within its drying chamber than that of the cabinet solar dryer, due to its ability to generate sufficient heat for drying purposes and the presence propels the heat generated towards the insulated drying chamber.

However, the overall performance of the solar dryers was directly related to the prevailing ambient conditions during the experiment, in the terms of relative humidity and temperature of the air and the air flow rate.

The spice mix used for meat pre-treatment was surprisingly devoid or microflora to any significant extent, indication the presence of some inherent antimicrobial factors, bit his condition was no manifested in the dried meat products due to the prevailing poor ambient conditions and high moisture content and water activity values obtained for the dried meat products.

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1.0 INTRODUCTION

Following the signing of an official contract for this project for the National Consultant, a meeting was held between the Project Leader, Project co-coordinator and National Consultant on the 11/8/95 at the U.S.T., Kumasi (Pleas refer to Appendix I showing a copy of the signed letter of agreement on that meeting

The first mission of the proposed work schedule for the National Consultant was undertaken between the period 28/7/95 to 3/8/95, and this report is the summary of work carried out during the mission.

2.0 MATERIALS AND METHODS

Work carried out during this mission involved the preparation and solar dehydration of three difference types of pre-treated meat strips.

2.1 Meat preparation and pre-treatment

Fresh lean beef was cut into strips to approximately the following dimensions: length=100mm., breadth=20mm. and thickness= 15mm.

About 1.5kg. each of the cut meat strips were pre-treated according to the following procedure:

a. Raw fresh beef strips coated with a slurry of 0.5% spice mix and 1% finely ground salt per meat weight.
b. Raw beef strips soaked in 10% vinegar solution (weight for volume), containing 0.5% spice mix and 1% salt per meat weight.
c. Raw beef strips blanched in 90oC hot water (Weight for volume, containing 0.5% spice mix and 1% salt per meat weight.

NB: The finely ground spice mix comprised of the following spices: Melegueta pepper (Afromuma), caraway seeds (Anisin), xylopia aethiopica (Ethiopian pepper). and Allim sativum (Garlic) in the following respective ratios in the mix (1:1:1:0.5).

The pre-treated meat strips were then dried over three drying cycles (between 1/8/95 to 3/8/95) in the cabinet and tunnel solar dryers as follows: About 1.5kg each of the three different pre-treated meat strips were skewed onto a long twine and hanged in the cabinet solar dryer on the same level, but separated and labeled for identification.

Only on type of the pre-treated meat strips (about 1.5kg.) was dried in the tunnel solar dryer i.e. Meat strips per-treated with a slurry of 0.5% spice mix and 1% salt per meat weight. The meat strips were dried lying horizontally on the drying tray in the tunnel dryer.

2.2 Weather parameters monitored

The following were monitored during drying of meat strips:

2.2.1 Temperature

Temperature at different points was monitored using the CT-U-V5-I temperature probes for ambient air temperature and air temperature within the cabinet and tunnel solar dryer chambers.

2.2.2. Relative humidity

Ambient relative humidity was monitored using the Vaisala VH-L-ZI relative humidity probe (Helsinki, Finland).

2.2.3. Air flow rate

Ambient air flow rate was monitored using the WS401A wind Velocity Sensor.

2.2.4. Solar radiation

Solar radiation was monitored using the Quantum solar Radiation (Skye Instruments Ltd., Llandridod, Wells Powys, Wales).

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3.0 RESULTS AND DISCUSSION

3.1 Results on weather parameters monitored

3.1.1 Temperature

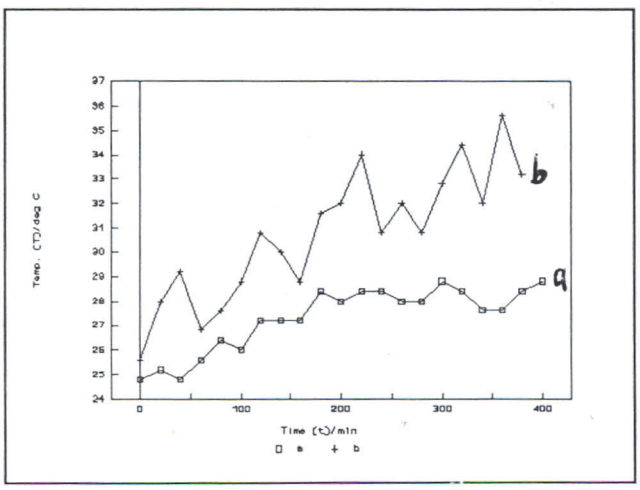
Figure 1 shows ambient temperature conditions monitored during the second and third drying cycles of meat drying. The results indicate that incident solar radiation was comparatively higher during the third drying cycle (03/8/95) than for the second (02/8/95).

When Fig.1 results are compared with that of Figs. 3 and 4, there was a correspondingly higher heat increment in the tunnel dryer (16.4^0C) than in the cabinet dryer (4.8^0C), over the corresponding ambient temperatures.

Referring to Table 1 below of solar dryer dimensions, the tunnel dryer has a total collector area about six times bigger than that of the cabinet dryer. The heat increment or temperature elevation that can be attained within the solar dryer is directly proportional to the collector surface area, therefore, under the same ambient conditions as it were, the tunnel dryer will generate far more heat than the cabinet dryer per total area of collector surface.
Figs. 6 and 7 below show sketch drawings of the tunnel and cabinet solar dryers, respectively. (Drawings not to scale).

Referring back to Figs. 3 and 4, it can again be shown that despite the lower temperature conditions prevailing during the second drying cycle (Fig. 1, graph a), than in the third (Fig 1 graph b), it seems heat retentions was better in the insulated drying chamber of the cabinet dryer (Fig.4), than in the insulated drying chamber of the tunnel dryer (Fig.3). This result may be attributed to the relatively smaller exhaust vent of the cabinet solar dryer as opposed to the rather large and open exhaust vent of the tunnel dryer. This latter condition may lead to inefficient use of the large amount of heat generated by the collector of the tunnel dryer.

FIGURE 1 : Ambient Air Temperature (°C)



Key:

(a) = Ambient temp. for 02-8-95

(b) = Ambient temp. for 03-8-95

STATISTICS ON DATA

(a) Ambient air temp. (2/8/95)

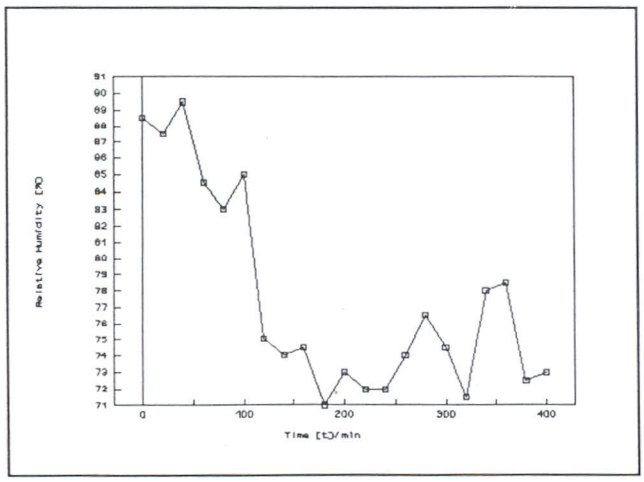
Max. = 28.8°C
Min. = 24.8°C
Mean = 27.295°C
Standard Deviation = 1.282
Variance = 1.644

(b) Ambient air temp. (3/8/95)

Max. = 35.6°C
Min. = 25.6°C
Mean = 30.8°C
Standard Deviation = 2.533
Variance = 6.415

NB:
Starting Time: 9:50am
Time recorded at 20 minutes interval.

FIGURE 2 : Ambient Air Relative Humidity (%)

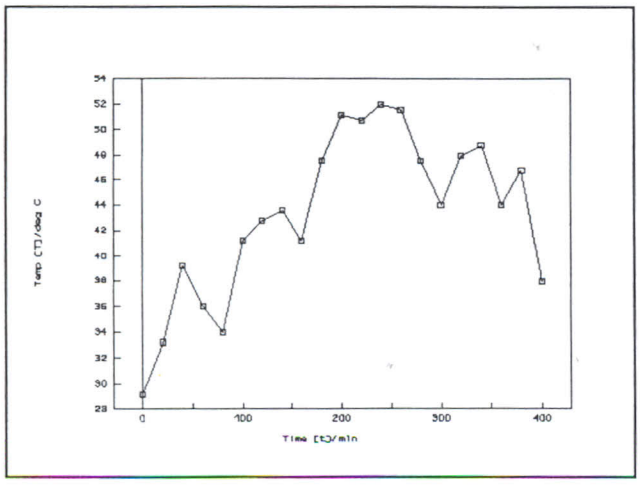


NB:
Starting Time 9:16am (02/8/95)

STATISTICS ON DATA

Min. R.H = 71%
Max. R.H = 89.5%
Mean R.H = 77.524%
Standard Deviation = 5.999
Variance = 35.988

FIGURE 3: Tunnel Solar Dryer Drying Chamber
Air Temperature (°C)

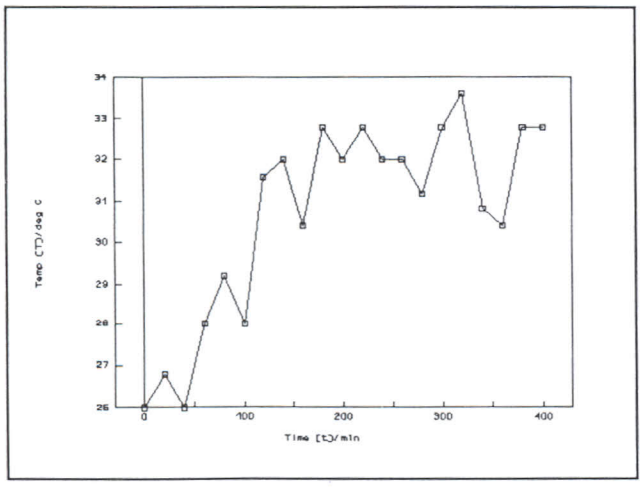


Starting Time: 9:24am (03-8-95)

STATISTICS ON DATA

Min. Temp. = 29.2 °C
Max. Temp. = 52.0 °C
Mean Temp. = 43.371 °C
Standard Deviation = 6.401
Variance = 40.969

FIGURE 4: Cabinet Solar Dryer Drying Chamber Air Temperature (°C)



Starting time: 9:16am (02/8/95)

STATISTICS ON DATA

Max. Temp. = 33.6 °C
Min. Temp. = 26.0 °C
Mean Temp. = 30.667 °C
Standard Deviation = 2.337
Variance = 5.460

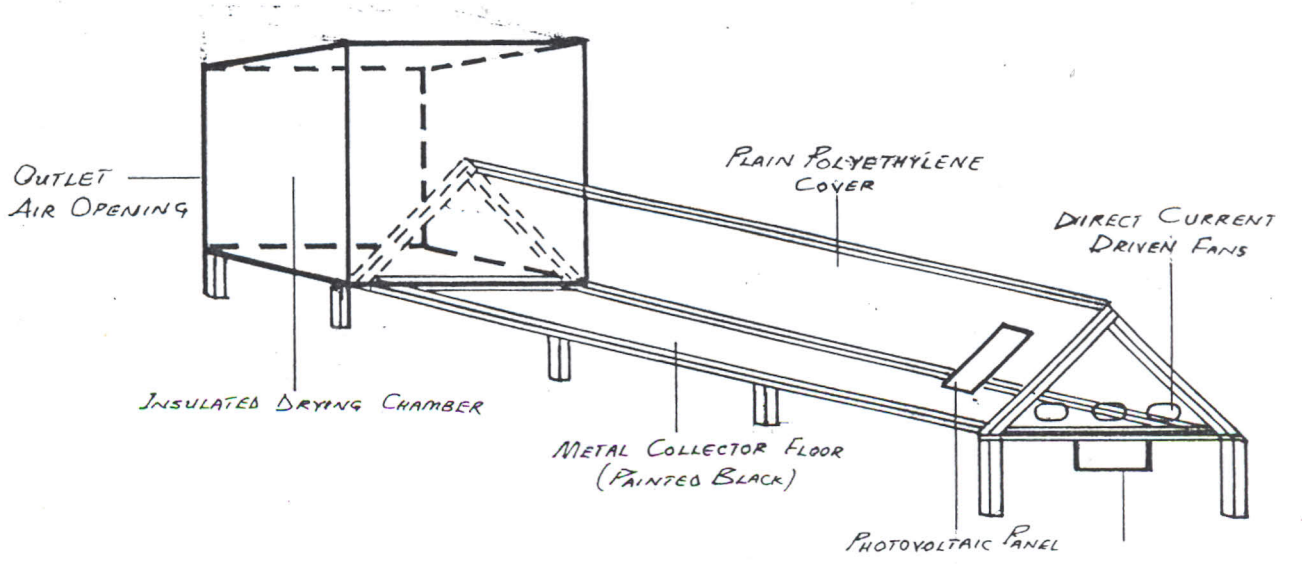


Fig 6 TUNNEL SOLAR DRYER

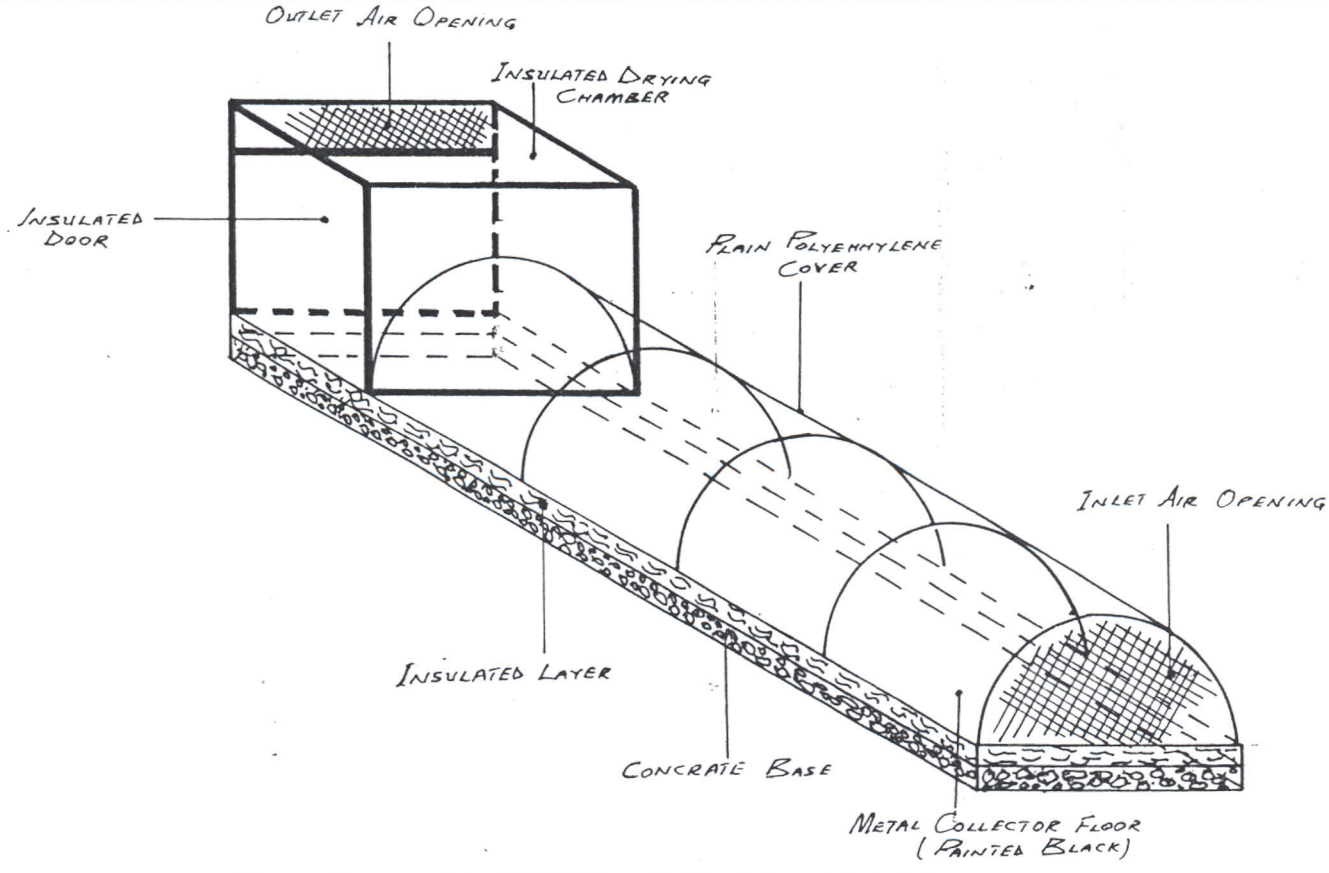


Fig 7 CABINET SOLAR DRYER

Table 1 Comparative Dimension of the Cabinet and Tunnel Solar Dryers

Parameter	Tunnel solar dryer	Cabinet solar dryer
1. Collector length	15m.	3.97m.
2. Collector width	1.85m.	1.24m
3. Collector Surface area	27.8m*m	4.9m*m
4. Collector drying chamber (Internal volume)	2.97m*m*m	1.58m*m*m

3.1.2. Ambient relative humidity

Results of ambient relative humidity (Fig. 2 above) shows very high ambient relative humidity condition during the second drying cycles, with the minimum value (obtained in the afternoon) to be 71%.

Warm, dry air of low humidity of about 30%, and relatively small temperature differences between day and night are optimal conditions for meat drying (FAO, 1990).

The minimum relative humidity of 71% obtained during the afternoon of the second drying cycles (Fig. 2), and in addition to the lower ambient temperature condition monitored during the same period (Fig.1, graph a), indicate poor conditions for drying meat during the experimental period.

3.1.3. Solar radiation and air flow rate

Figure 5 shows the graph of solar radiation scores (volts) monitored during the second drying cycle (02/8/95).

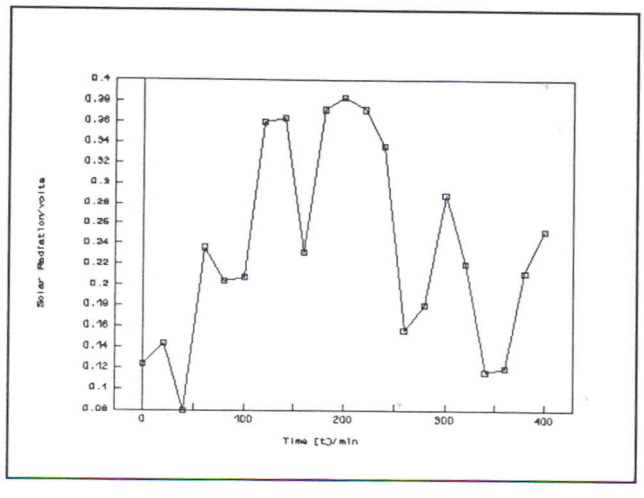
The graph shows the pattern of solar radiation intensity as monitored over the period.

Conversion of radiation scores (volts) into radiation values (watts/m*m) however, was not successful when tried on the squirrel wise software, due to unidentified technical problem

The same situation occurred with conversion of wind speed scores (volts) into wind speed values (m/s).

The problem is however being attended to for rectification.

FIGURE 5 : Solar Radiation Distribution Pattern for 02-8-95



Starting Time :9.16am (02-8-95)

STATISTICS ON DATA

Min. radiation score = 0.080 volts
Max. = 0.384 volts
Mean = 0.236 volts
Standard deviation = 0.095
Variance = 0.009

3.2 Microbiological Analyses

Table 2 Results of Microbiological Analysis

Sample description	TVC/g (PCA)	Mould/yeast counts/g (MA)	Culture	Coliforms in 0.1g	E.coli
Spice mix	N/A	<10	No growth	Nil	Nil
Tunnel dried meat	$1.3*10^9$	$1.3*10^8$	Micrococci, Bacillus spp., yeast	Present	Nil
Cabinet dried meat	$4.3*10^9$	$7.2*10^7$	-do-	-do-	Nil

Results of microbiological analysis (Table 2 above), shows that after four days storage of dried meat samples under ambient conditions in aerobically sealed polyethylene packs, both tunnel and cabinet dried meat samples were heavily contaminated with micro-organisms, both by visual evaluation and by analysis. Mould and yeast counts also indicated high contamination for tunnel and cabinet dried meat samples. These results were irrespective of the pre-treatment given before solar drying, thus indicating zero effect of type of treatment on meat strips.

The culture was made up of common spoilage microflora and coliforms were present in 0.1g sample solutions. Incidentally, the spice mix was devoid of viable counts and antimicrobial factors present in some spices, some of which may be represented in the spice mix formulated. This is an area for further investigation.

Generally, it can be acknowledged that the weather condition prevailing during the experimental period was very poor with respect to drying of meat (refer to Figs. 1 and 2). The above conditions explain the poor quality dried meat product obtained. This is further justified by high moisture content and water activity values obtained for the dried meat products (refer to Table 3 below).

In the absence of suitably high concentrations of salt or other humectants in the dried meat products, a moisture content of 23.3% and Aw of 0.69, as obtained for the tunnel dried meat product, for example, will not afford shelf suitability for the product under ambient storage conditions. Dried meat samples from the cabinet dryer was therefore even less shelf stable under ambient storage conditions. Salt level of 1% was used during meat pre-treatment.

Table 3 Moisture content and water activity values obtained for tunnel and cabinet dried meat strips

			Time monitored	
1.	**Cabinet dryer meat samples**	**Parameter monitored**	**2nd drying cycle (2/8/95)**	**3rd cycle (3/8/95)**
a.	Vinegar treated meat strips	Aw	0.96	0.94
b.	Hot blanched meat strips	Aw	0.95	0.95
c.	Slurry coated meat strips	Aw	0.95	0.92
2.	Tunnel dryer meat sample			
d.	Slurry coated meat strips	Aw	0.92	0.91
3.	Meat sample	Aw (4 days storage)		Moisture content (4 days storage)
e.	Cabinet dried	0.73		41.7%
f.	Tunnel dried	0.69		23.3%

4.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are summarized based on the present results of work carried out.

i. The effect of different pre-treatments on raw meat strips prior to solar drying was nullified due to poor drying conditions which prevailed during the experimental period of early August.

The exceptionally good microbiological quality of the spice mix eliminates its effect as a contaminant on meat strips. The microbiological quality of fresh meat used in this experiment was however, not established.

ii. Under the same ambient conditions of temperature, solar radiation, relative humidity and air flow rate, the tunnel solar dryer will comparatively generate much higher temperature and provide better drying conditions than the cabinet solar dryer as they were used in this experiment. This is due to the large solar collecting surface of the tunnel dryer coupled with the photovoltaic powered fans which provide forced draft to propel hot air towards the drying chamber end.

The efficiency of drying in the tunnel dryer can be further improved by reducing the exhaust air opening of the drying chamber to slightly increase heat retention time.

iii. Alternatively, the rather small solar collecting surface of the cabinet solar dryer limits its ability to generate the necessary heat required to sufficiently warm its insulated drying chamber for drying purposes. This limitation can be corrected by increasing the collector surface areas of the cabinet dryer to at least twice its present size.

iv. Comparatively, under similar ambient conditions, the cabinet solar dryer with polyethylene cover on its drying chamber (refer to first progress report on this project), will be capable of generating more heat for drying than the present one with insulated drying chamber.

The total collector area of the latter is 4.9 mm, compared with the total collector area of the former which is the sum total of the drying chamber collector floor area (1.44m*m) plus collector floor area (4.6m*m), giving a total of 6.04 m*m.

Furthermore, director solar radiation entering the drying chamber through the plain polyethylene will cause further surface warming of the drying material and air within the drying chamber.

Further work is required to uncover any potential antimicrobial qualities that may exist in the spice mix used due to the good microbiological results obtained in this experiment.

5.0 REFERENCES

FAO (1990) Manual on Simple Methods of Meat Preservation. FAO Publication, No. 79. FAO, Rome, Chapter 2.

6 APPENDICES

APPENDIX I
ASD.73/95

12th July, 1995

FAO REPRESENTATION IN GHANA
FAO, OFFICE FOR AFRICA
P.O. BOX 1628
ACCRA

TCP/GHA/4452(C)
PROPOSED WORK SCHEDULE FOR
MR. E. C-T. TETTEY - CONSULTANT

At a meeting held on 11th July, 1995 at the Department of Animal Science, U.S.T., we the undersigned agreed that the following should be the U.S.T. - Kumasi work schedule for Mr. E. C-T. Tettey a Consultant for the above-mentioned Project to enable him collect data and carry out the other duties specified in his terms of reference.

	Date of Visit	Duration, days
i)	28th July - 3rd August, 1995	7
ii)	18th - 24th August, 1995	7
iii)	24th - 30th November, 1995 (Tentative)	7

Our understanding based on an earlier meeting held in Kumasi between Mr. Frederich, the International Consultant, Mr. A. Nessel, the Project Leader and Dr. Heinz (FAO, Rome), is that the total cost to the Project of Mr. E. C-T. Tettey's entire consultancy including any payments made earlier and costs of analytical work would not exceed $4,000.00 US.

We trust that you will endeavour to assist him to enable him complete his assignments on schedule.

Thanks in anticipation.

We remain.

Yours sincerely,

.....
MR. A. NESSEL (PROJECT LEADER)

.....
DR. D.B. OKAI (CO-ORDINATOR/CONSULTANT)

.....
MR. E. C-T. TETTEY (CONSULTANT)

DBO/gan.

cc: Dr. G. Heinz, FAO Rome
Dr. M.P. Touade, FAO, Accra
Mr. E. C-T. Tettey - FRI, Accra ✓
Dr. D.B. Okai - U.S.T., Kumasi

APPENDIX II **Itinerary of Activities carried out during the mission**

Date	Activity
28/7/95	Departure: Accra-Kumasi
28/7/95	Arrival: Kumasi
29/7/95	Visit to project site to meet project team members and site preparation for work
30/7/95	Assembling and testing of weather monitoring equipment in readiness for use
31/7/95	Mounting of equipment, weather data monitoring and meat strips cutting
1/8/95 to 31/8/95	Pre-treatment of meat strips, solar drying of pre-treated meat strips and weather data monitoring
4/8/95	Departure: Kumasi – Accra
4/8/95	Arrival: Accra