FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

INTEGRATED GRADING AND SOLAR DRYING OF MEAT

THIRD PROGRESS REPORT

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BY

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ABSTRACT

Lean beef muscle (topside cut), was prepared into strips and cubes of approximately 10mm thickness. One half of these meat cuts were pre-treated by blanching in 1% hot brine (w/v) for 10 minutes, and the other half in 1% cold brine (w/v) containing 20% vinegar solution (v/v) for 10 minutes. One half each of these pre-treated meat cuts were dried in the tunnel and cabinet solar dryers respectively, over three drying cycles (three drying days).

Data monitored during the experimental period were temperature, RH, airflow rate and Aw. Moisture content and microbiological analysis were also monitored on the dried meat products after one week storage under room conditions.

Results of the work done indicated that the type of meat cut or pre-treatment applied did not adversely affect the overall quality of the stored dried meat product.

The marginal differences in temperature and RH recorded between the tunnel and cabinet solar dryers were attributed to poor weather experienced during the experimental period.

The inclination of the PV panel of the tunnel solar dryer permanently to the east suggested that solar radiation incident on the PV panel decreased gradually after about 14 hours GMT until sunset, thus reducing the amount of electrical energy generated and fan speed and consequently the airflow rate within the drying chamber of the tunnel dryer.

The quality of solar dried meat samples from both the tunnel and cabinet solar dryers deteriorated after about four weeks storage under ambient conditions, as a consequence of infestation from *Ascarus sirus* mites, reducing the dried meat into a powdery substance.

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LIST OF ABBREVIATIONS

w/w	:	weight for weight
w/v	:	weight for volume
v/v	:	volume for volume
Aw	:	water activity
RH	:	relative humidity
PV	:	photo voltaic
PE	:	polyethylene
TVC	:	Total viable count
Spp	:	Species
FAO	:	Food and Agriculture Organization
GMT	:	Greenwich Mean Time

1. INTRODUCTION

This report covers the second mission of my work schedule which was to be undertaken between 18/8/95 to 24/8/95. The mission was however, undertaken between 22/8/95 to 28/8/95, due to few administrative problems at the FAO Regional Headquarters in Accra.

2. MATERIALS AND METHODS

Work carried out involved meat preparation and treatment prior to solar dehydration, monitoring of weather parameters during drying, and microbiological analysis on the dehydrated meat product. These activities are elaborated below as follows:

2.1 Meat preparation and pre-treatment

About 6kg. of lean beef muscle (topside cut), was divided into two halves. One half was cut into strips of approximately 10mm. thickness and between 100 to 120mm. in length, and the other half cut into approximately 20mm. cubes of about 10mm thickness.

Each of the two meat cuts were treated differently as described below.

2.1.1 Fresh meat cubes

One-half of this meat cut was blanched at ca. 90^0C for 10 minutes in 1% brine (w/v) and then coated with 0.5% spice mix (w/w).

NB: Please refer to second progress report for the spice mix composition.

The other one-half meat cubes were soaked in 1% brine (w/v) containing 20% vinegar solution (v/v), for 10 minutes.

2.1.2 Fresh meat strips

This cut was also divided into two halves and each half treated separately as described above.

2.2 Solar drying of treated meat cuts

One-half of the treated meat cuts as described above, comprising of meat cubes and strips, were dried in the tunnel dryer on netted shelves, and the other half was dried similarly in the cabinet dryer. (Please refer to second progress report for the design types of solar dryers used)

2.3 Physical parameters monitored

The following below describes the physical parameters monitored during solar drying of meat.

2.3.1 Temperature and relative humidity

The above parameters were monitored and analyzed as described in the second progress report.

Solar radiation was not monitored in this experiment due to a technical problem with the software involved.

2.3.2 Airflow rate

Airflow rate was monitored with the Almemo 2290-8 logger using a vane-type anemometer at 30 minutes interval (courtesy of J.A. Teye, Anim. Sci. Dept., UST, Kumasi).

2.3.3 Water activity (Aw)

Aw was monitored on the freshly cut, pre-treated meat samples and then on the drying meat samples in both the cabinet and tunnel solar dryers, during three drying cycles between 26/8/95 to 28/8/95.

The two different meat cuts involved, ie. Cubes and strips, were sampled together at different drying time intervals, mixed and then sub-samples for the analysis.

The effect of meat cut on Aw was assumed to be zero since meat cubes and strips were approximately 10 mm in thickness, the latter being a critical factor in solar drying of meat. The effect of type of pre-treatment, ie. blanching versus vinegar application on meat Aw was however, not considered in this experiment.

2.3.4 Moisture content

Moisture content analysis was done as described in the second progress report, at the FRI laboratories in Accra.

2.4 Microbiological analysis

Samples of all pre-treated, solar dried meat cubes and strips, and spice mix were analyzed at the FRI laboratories in Accra after one week storage of samples under room temperature conditions in sealed polyethylene (PE) bags. Total viable counts on samples were analyzed as described in the second progress report.

Mould and yeast were enumerated on Malt Agar media at 30^0C for five days.

Microbial culture was identified on plates for all samples.

3. RESULTS AND DISCUSSIONS

3.1 Results on physical parameters monitored

3.1.1 Temperature

A temperature difference of 13.2^{0}C was recorded within the drying chamber of the tunnel solar dryer, over and above that of the ambient (FIG. 1). This is in contrast with a temperature difference of 10.4^{0}C recorded within the drying chamber of the cabinet solar dryer over and above the ambient (FIG. 2), and similarly, a temperature difference of 14.8^{0}C over the ambient on a different day (FIG. 3).

In previous experiments (second progress report), a temperature difference of 18.4^{0}C was recorded within the drying chamber of the tunnel dryer over that of the cabinet dryer but also on different days.

It was clearly established however, in that experiment that under similar ambient conditions, the tunnel dryer was by far more efficient in the ability to increase temperature within its drying chamber over that of the ambient and the cabinet solar dryer.

Results obtained in this work indicated partially the above trend, and this is attributed to data collected on different days with its associated different ambient conditions.

It is also recalled that intermittent rain intervention was experienced during the experiment.

3.1.2 Relative humidity (RH)

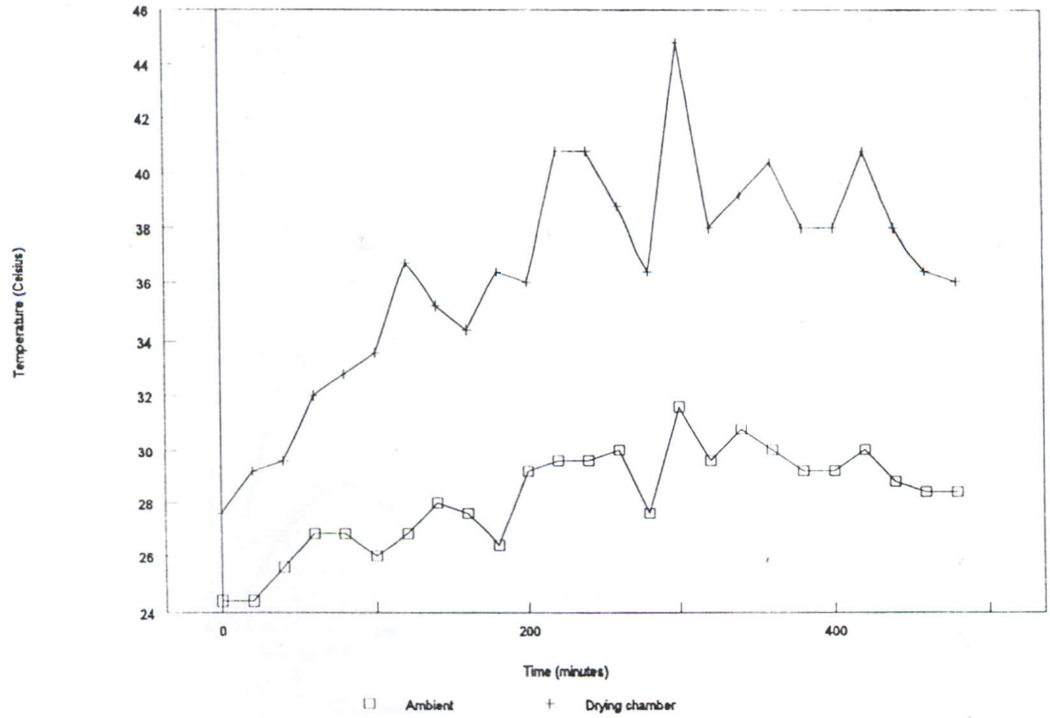
Comparison between RH conditions within the drying chambers of the tunnel and cabinet solar dryers (FIGS. 4 and 5), indicated a higher minimum (44%) for the tunnel than for the cabinet (38.5%), solar dryers.

Both minimum RH values recorded above (on different drying days), were above the optimum RH condition (ca. 30%) required for optimum meat drying (FAO, 1990).

The minimum RH obtained during a drying cycle in the day, is very important for meat drying. In contrast, night RH has been shown to be high, usually approaching saturation point and therefore not contributing to meat drying at all (Tettey, et. Al., 1992).

The difference in RGH data obtained in this experiment is attributed to poor weather conditions experienced intermittently during the experimental period as already stated above.

FIG. 1: <u>TEMPERATURE CONDITIONS OF AMBIENT AND WITHIN DRYING CHAMBER OF TUNNEL DRYER COMPARED (FIRST DRYING)</u>

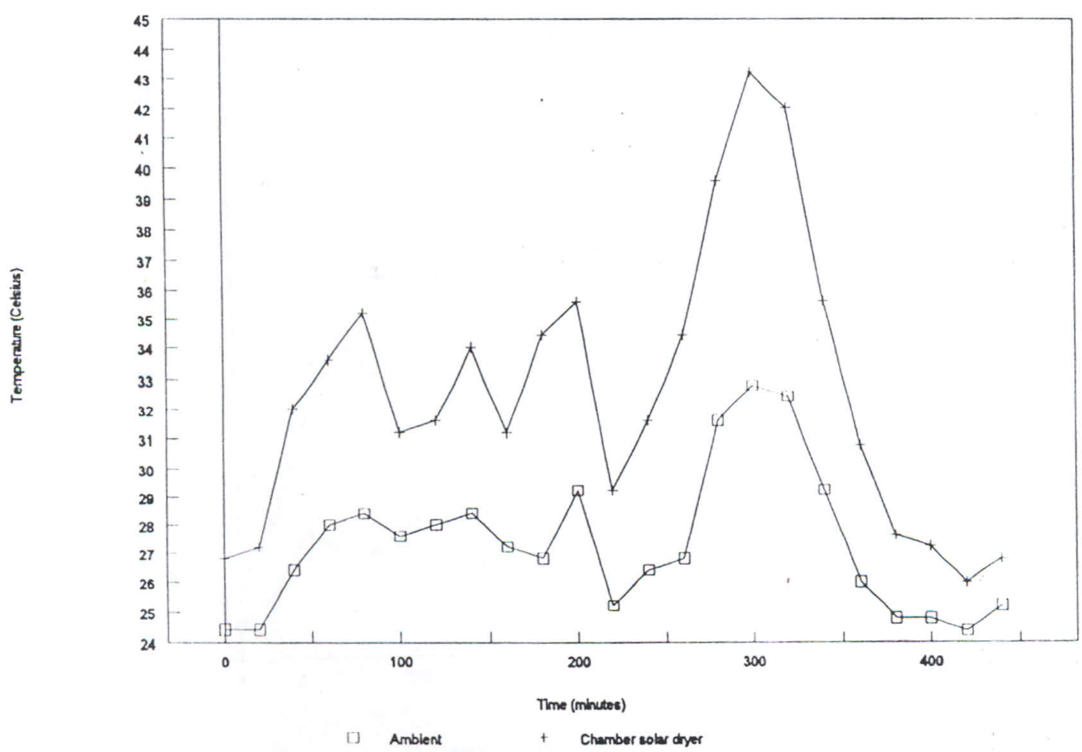


Starting time and date: 08:41 GMT (25/8/95)

Statistics on temperature data:

Ambient Temperature	Drying chamber of tunnel dryer
Max. = 31.6 ^{0}C	Max. = 44.8 ^{0}C
Min. = 24.4 ^{0}C	Min. = 27.6 ^{0}C
Mean = 28.169 ^{0}C	Mean = 36.292 ^{0}C
Standard deviation = 1.840	Standard deviation = 3.911
Variance = 3.387	Variance = 15.293

FIG. 2: TEMPERATURE CONDITIONS OF AMBIENT AND WITHIN DRYING CHAMBER OF CABINET SOLAR DRYER COMPARED (SECOND DRYING)

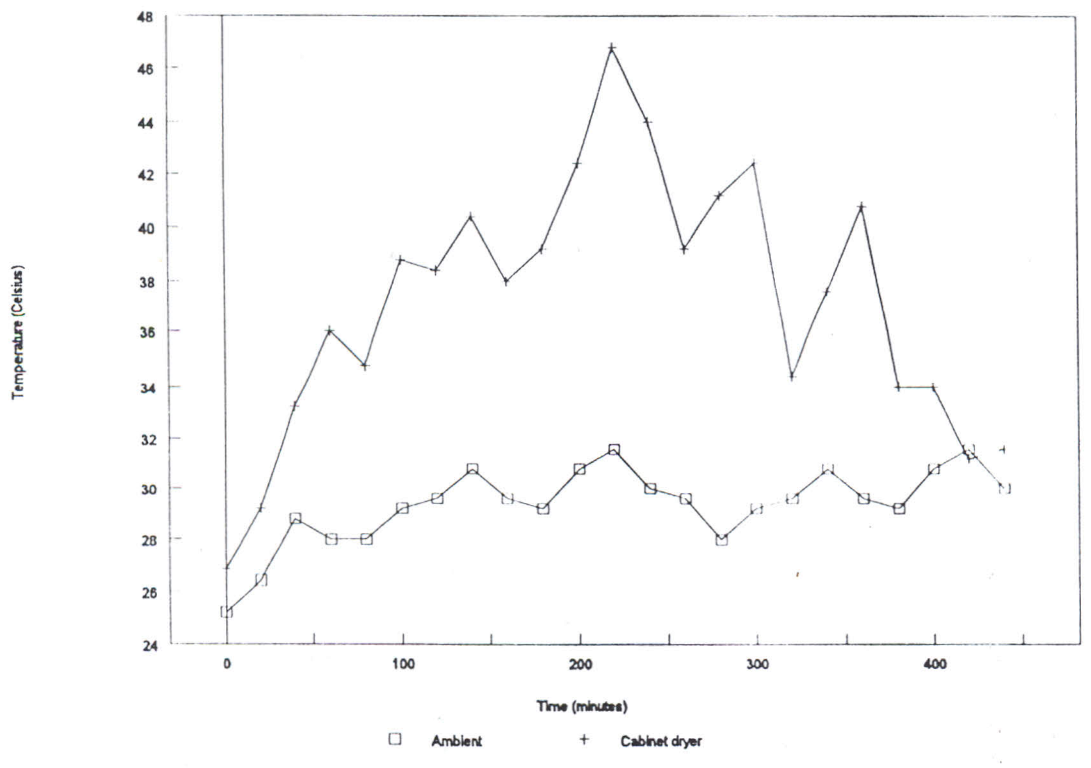


Starting time and date: 09:13 GMT (26/8/95)

Statistics on temperature data:

Ambient Temperature	Within cabinet solar dryer
Max. = 32.8 °C	Max. = 43.2 °C
Min. = 24.4 °C	Min. = 26.0 °C
Mean = 27.322 °C	Mean = 36.470 °C
Standard deviation = 2.43	Standard deviation = 4.654
Variance = 5.905	Variance = 21.686

FIG. 3: TEMPERATURE CONDITIONS OF AMBIENT AND WITHIN DRYING CHAMBER OF CABINET SOLAR DRYER COMPARED (THIRD DRYING)

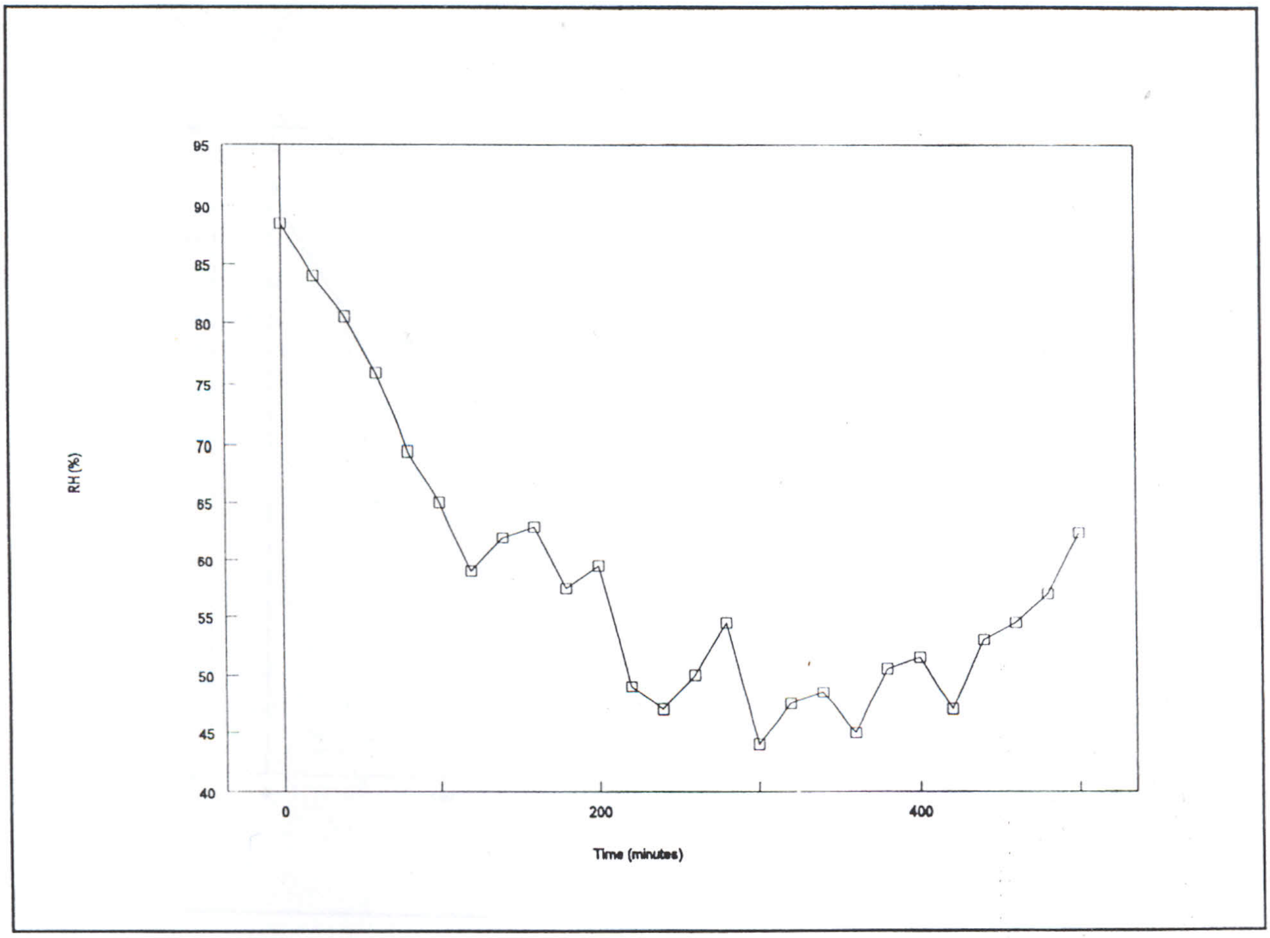


Starting time and date: 09:26 GMT (27/8/95)

Statistics on temperature data:

Ambient Temperature	Within cabinet drying chamber
Max. = 32.0 °C	Max. = 46.8 °C
Min. = 25.2 °C	Min. = 26.8 °C
Mean = 29.6 °C	Mean = 37.148 °C
Standard deviation = 1.591	Standard deviation = 4.825
Variance = 2.532	Variance = 23.281

FIG. 4: RELATIVE HUMIDITY CONDITIONS WITHIN THE TUNNEL SOLAR DRYER (FIRST DRYING)

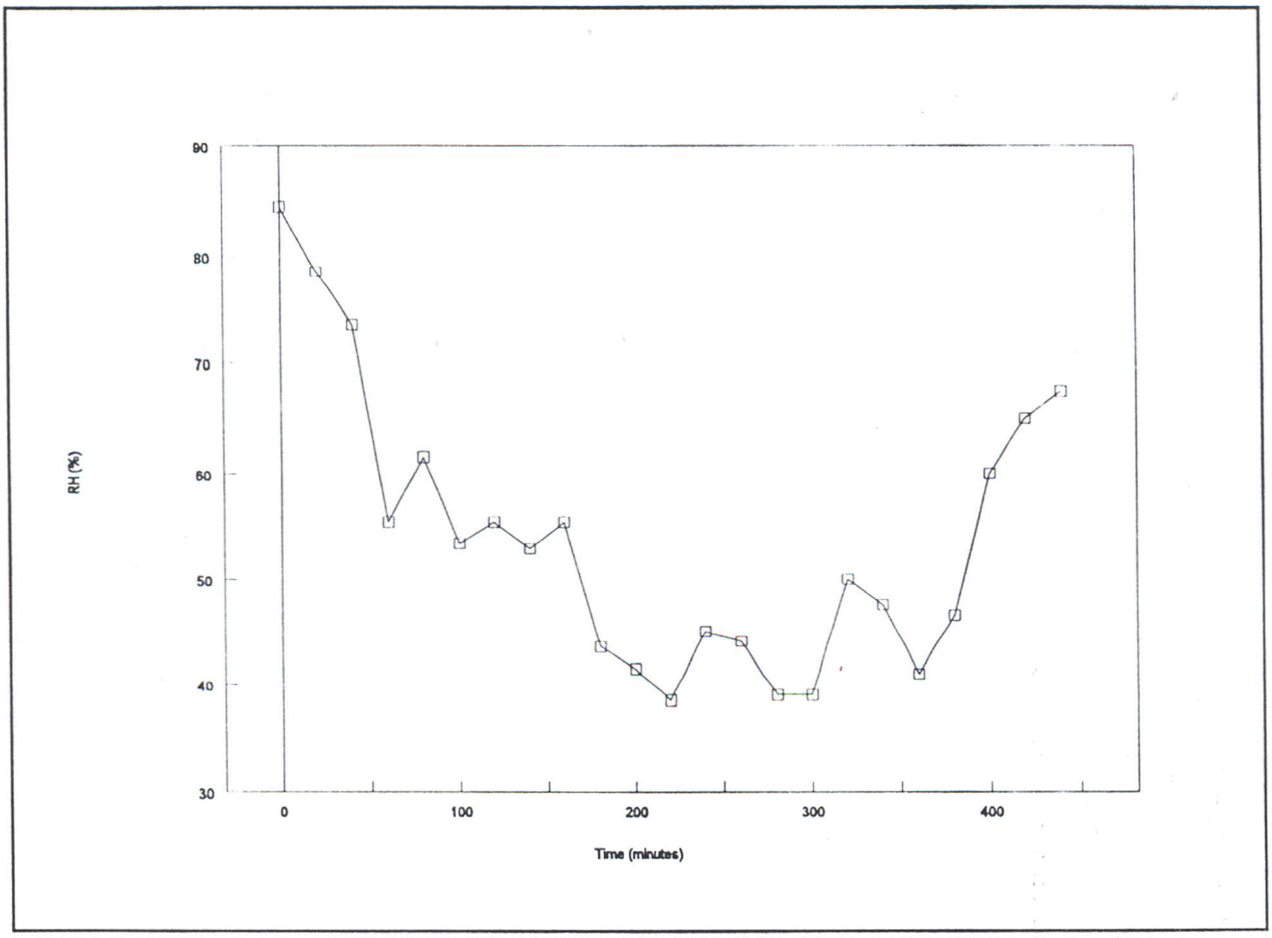


Starting time and date: 08:41 GMT (25/8/95)

Statistics on RH% data:

Max. = 88.5%
Min. = 44.0
Mean = 58.692
Standard deviation = 12.044
Variance = 145.059

FIG. 5: RELATIVE HUMIDITY CONDITIONS WITHIN THE CABINET SOLAR DRYER (THIRD DRYING)



Starting time and date: 09:26 GMT (27/8/95)

Statistics on RH% data:

Max. = 84.5%
Min. = 38.5
Mean = 53.870
Standard deviation = 12.743
Variance = 162.396

3.1.3 Airflow rate

Airflow rate recorded within the drying chamber of the tunnel solar dryer (FIG. 6), experienced intermittent rise and fall, possibly due to cloud overcast which obstructed solar radiation falling on the photo voltaic (PV) panel, responsible for the generation of electrical energy required to propel fans within the collector.

From approximately 14 hours GMT, airflow rate fell gradually to zero at about 15.30 hours GMT.

It was however, observed that the PV panel installed above the collector was permanently inclined towards he east thus, receiving maximum solar radiation during the first half of the day. After mid-day and beyond 14 hours GMT, the amount of solar radiation incident on the PV panel fell gradually as the sun moved towards the west, thus reducing the amount of electrical energy generated and consequently the fan speed and airflow rate within the drying chamber.

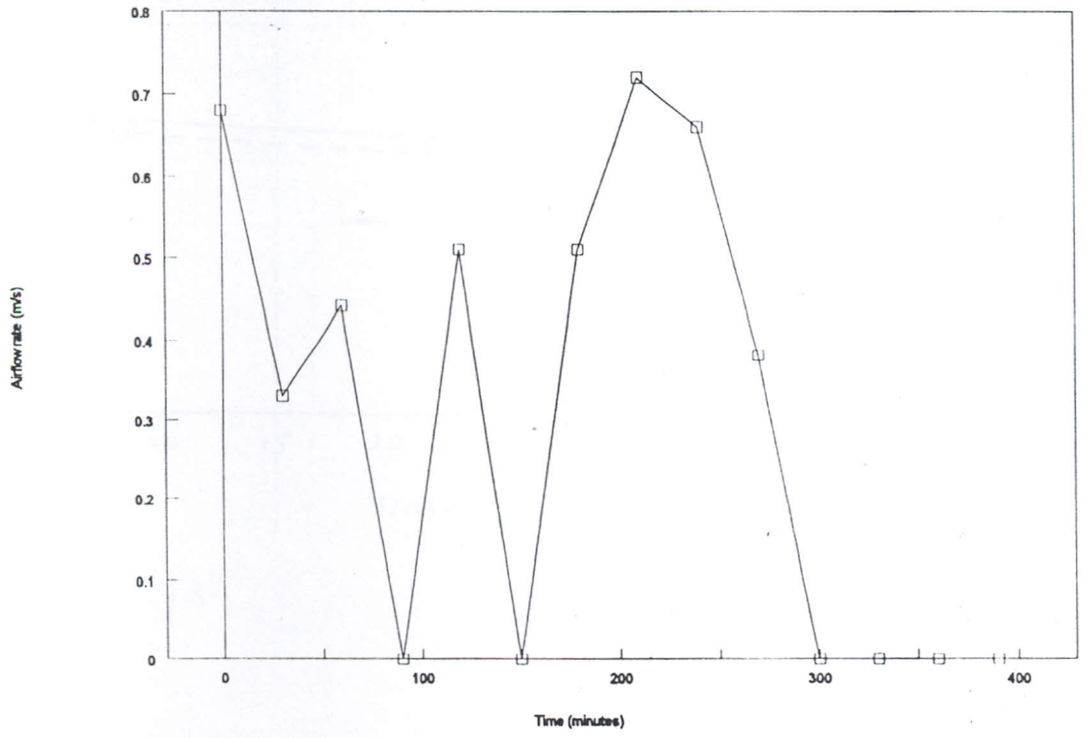
This phenomenon may have serious consequences for meat drying since the tunnel dryer was designed in such a way that airflow rate within the drying chamber was solely dependent upon the amount of electrical energy generated by the PV panel to propelfans.

This design is in contrast with natural convection solar dryers which are designed to receive adequate airflow within their drying chamber irrespective of the time of the day.

3.1.4 Aw

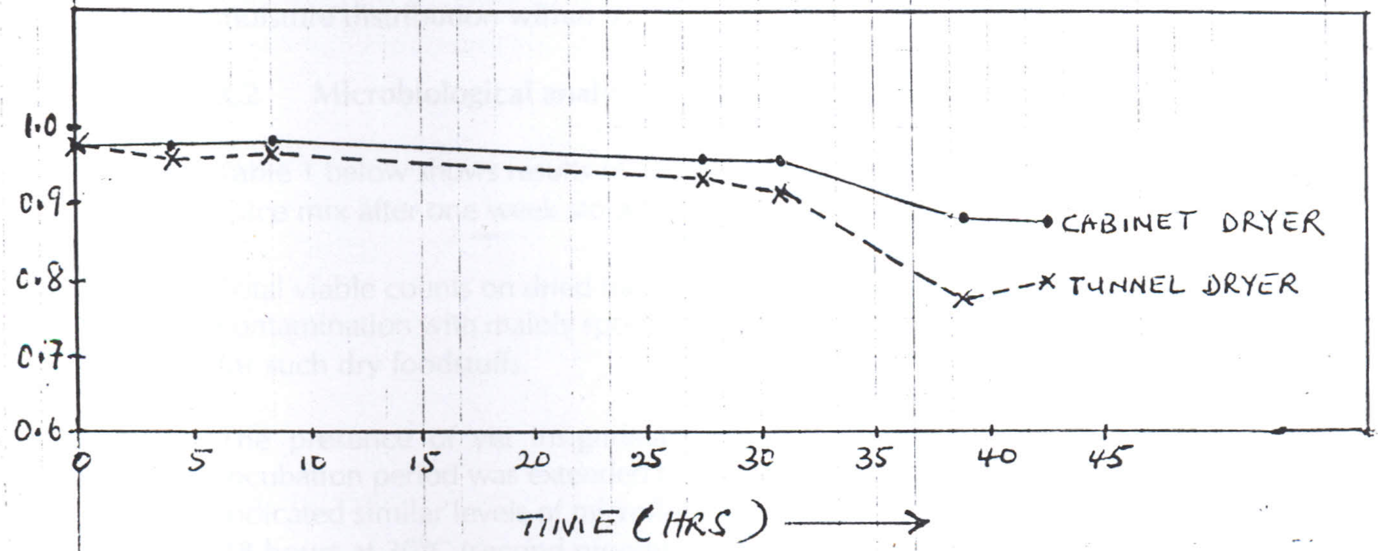
The first 30 hours or so of solar drying indicated only a gradual reduction in Aw for drying meat samples in both cabinet and tunnel solar dryers (FIG. 7). After this period however, a significant divergence in Aw reduction occurredbetween tunnel and cabinet dryer meat samples, with the tunnel dryer meat samples registering a lower Aw than those from the cabinet dryer, by a difference of approximately 0.075 Aw units.

FIG. 6: AIRFLOW RATE WITHIN THE DRYING CHAMBER OF TUNNEL DRYER



Starting time and date: 10:34 GMT (26/8/95)

FIG. 7: COMPARISON OF A_W MEASUREMENTS OF MEAT DURING SOLAR DRYING IN THE TUNNEL AND CABINET SOLAR DRYERS.



3.1.5 Moisture content

The mean moisture content value for sampled solar dried meat from both the tunnel and cabinet solar dryers indicated a value of 16.2%, after one week storage under ambient conditions.

This similarity in moisture content value was not consistent with the Aw values obtained earlier on, probably due to differences in time of analysis and also particularly to the non-homogeneity of the dried meat samples with respect to moisture distribution within its tissues (Tettey, et. Al., 1993).

3.2 Microbiological analysis on dried meat samples and spice mix

Table 1 below shows results of microbiological analysis on dried meat samples and spice mix after one week storage under ambient conditions.

Total viable counts on dried met samples and spice mix indicated low to moderate contamination with mainly spores forming spoilage microflora, which was expected for such dry foodstuffs.

The presence of yet insignificant amounts of microflora on spice mix when incubation period was extended to five days at 30^0C, confirms earlier results which indicated similar levels of microflora on spice mix when incubation period was for 48 hours at 30^0C (second progress report).

All dried meat samples remained shelf stable under ambient conditions for over four weeks. After this period however, product deterioration was observed in the form of *Ascarus sirus* infestation, a stored product mite which degraded meat samples into powdery end-products.

The source of contamination of this mite may be linked to the body materials used in the construction of the solar dryers. A similar mite infestation was reported in earlier work done on dehydrated beef strips (Tettey, et. Al., 1992).

Recently, a similar condition was again observed on solar dehydrated snail meat under ambient storage (unpublished work).

TABLE 1: **Microbiological analysis on dried meat and spcie mix samples**

Sample	TVC/g	Mould and Yeast Counts/g	Culture	Coliforms
Spice mix:	$1.2*10^6$	<10	Bacillus spp.	Nil
Tunnel dried meat:	$2.7*10^6$	$17*10^6$	Yeast and Bacillus spp.	Nil
Cabinet dried meat:	$3.3*10^7$	3.510^7	Yeast, Penicillium, Eurotium, Aspergillus, Bacillus spp.	Nil

4. CONCLUSIONS AND RECOMMENDATIONS

The following below summarizes conclusions and recommendations of the present work done.

i. The effect of meat cut ie., strips or cubes, and the effect of treatment ie., blanching or vinegar application, did not seem to affect the overall quality of dried meat samples under storage either from the tunnel or cabinet solar dryer. This is based on the similarity of results from microbiological and moisture content analysis on dried meat samples from both the tunnel and cabinet solar dryers.

   The difference in Aw data of dried meat samples from the tunnel and cabinet solar dryers however, may be attributed to the non-homogeneity of moisture distribution within the dried meat tissue.

ii. The marginal increase in temperature attained within the drying chamber of the cabinet solar dryer (FIG. 3) over that of the tunnel solar dryer (FIG. 1), may probably be due to data taken on different drying days with its associated different ambient conditions.

   Again, the marginal difference in RH conditions within the drying chambers of the tunnel and cabinet solar dryers may also be attributed to the above. It is recalled that intermittent rainfall was experienced during the experimental period.

iii. The pattern of airflow rate within the drying chamber of the tunnel solar dryer will be directly attributed to the amount of solar radiation incident on the PV panel. It was observed however, that due to the inclination of the PV panel towards the east, solar radiation incident on the PV panel reduced gradually from about 14 hours GMT until sunset, therefore resulting in reduced current generated and subsequently reduced fan speed and airflow rate within the drying chamber.

   It is recommended that to maximize the use of the available solar radition during the full day drying cycle, in terms of a more continuous airflow and efficient meat drying in the tunnel dryer, the PV panel must be fixed on adjustable hinges to enable its orientation towards the east or west depending on the position of the sun.

iv. The infestation of dried meat under storage with mites lowers the eating quality and acceptability of the meat product. Based on results of earlier work done, this problem can be prevented by dipping dried meat in hot gelatin suspension, then surface drying of the gelatin before meat packaging and storage. This application forms a protective layer over the dried meat surfaces thus preventing past attack during storage.

5. REFERENCES

FAO (1990)
Manual on simple methods of meat preservation. FAO Pub. # 79, FAO, Rome. Chpt. 2.

Tettey, E.C-T., Hodare-Okae, M., Osei-Yaw, A., and Dzidzo A. (1992)
Assessment of meat drying in hot humid climates using natural convection, closed-type solar dryers and investigation of practicable meat drying parameters.

Phase II, Final Report. FAO Reg. Hqts. for Africa, Accra.

Tettey, E.C-T., Jones, M.J., and Silverside, D.E. (1993)
Meat drying in a hot humid climate using convection type solar dryers. Trop. Sci, 33:401-410.

6. APPENDICES

6.1 Itinerary of activities carried out during the mission

Date	Activity
22/8/95	Departure: Accra - Kumasi
22/8/95	Arrival - Kumasi
23/8/95	Meat cutting and equipment setup
24/8/95	Meat pre-treatment and Aw measurements on pre-treated meat cuts
25/8/95	Unfavourable weather, thus meat drying in solar dryers postponed .
26-28/8/95	Meat drying and data collection
29/8/95	Departure: Kumasi - Accra
29/8/95	Arrival - Accra.