SOLAR DRYING OF MEAT STRIPS USING CLOSED-TYPE, NATURAL CONVECTION TENT AND CABINET SOLAR DRYERS.

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ABSTRACT

Two types of solar dryers were examined for use in the drying of meat strips under hot-humid climatic conditions.

10 x 10mm. meat strips dried faster and stored better than 20 x 20mm. meat strips when stored under room conditions in aerobically sealed plain low-density polyethylene bags during a 6 week storage period.

The solar cabinet dryer (SCD) proved marginally better than the solar tent dryer (STD) in the rate of moisture reduction in meat strips. Pre-immersion of meat strips in 5 per cent sodium chloride solution prior to drying adversely affected the overall moisture reduction in drying meat strips over a 70 hour drying period, and subsequently resulted in a shortened storage life of the dried product during storage.

Gelatine solution coating and hot wood smoking treatment of solar dried meat strips resulted in extended shelf life of the dried meat strips over a 6-month storage period under room storage conditions.

Sensory evaluation on dried meat strips cooked in a traditional Ghanaian light soup indicated better flavour and acceptability than when cooked in ordinary water.

KEYWORDS

Meat drying, sun drying, solar cabinet dryer, solar tent dryer, solar dryers.

Cattle 1.3 million, sheep 2.5 million, goats 2.6 million. pigs 620,000 and chicken 11 million. The estimated indigenous carcass meat production for the year 1991 accounted for the following: beef 22,000 Metric tons (MT), sheep and goats 14,000 MT and pig meat 14,000 MT.

The per caput protein intake per day from animal products between 1988 to 1990 accounted for 13.7 grams.

Ghana is basically an agricultural country, often described as mainly fish-eating in habit, with over 60 per cent of the fish catch being contributed by artisanal marine fishing.

This trend in the consumption of animal products may be changing in recent years.

Of late, the country has withnessed the establishment of many frozen meat shops and freezing facilities to hold and retail imported frozen raw meat sources from beef, mutton, turkey, chicken and even cow feet.

The increasing demand of these frozen meat products in the country attests the importance and increased consumption of animal products in recent years, against the background of a relatively slowly developing livestock production sector.

Sun drying and other traditional meat preservation technologies such as hot wood smoking and salting still account for the main methods employed in the preservation of meat in Ghana, especially among rural populations where the lack of electric power supply demands the use of these simple preservation technologies to extend the shelf life of available fresh meat and fishery products in excess of immediate requirement.

The most popular traditional preservation method applied mainly to game meat and fishery products in the country still remains as hot wood smoking. This is followed by sun drying and salting methods or their combination.

In comparison, traditionally preserved including sun dried meat products are also very popular in most African countries.

In the sub-saharan and sahelian zones of Africa can be found a variety of sun dried and other traditionally preserved meat products such as follows; Banda, Kilishie and Suya products (from Nigeria), Shermute, Nanitete, Basterme, Lonchon and Miris (from Egypt and Sudan), Qwanta (from Ethiopia) and Biltong, Barunfudle, Solay, Kumbis and Odka from the horn of Africa stretching down to southern Africa.

The use of solar dryers as against open-air sun drying in the drying and preservation of meat is not a common practise in Ghana, and indeed insignificant with regards to the drying of agricultural produce.

Little research work has however, been carried out in this area by research institutions notably the Food Research Institute (Lartey, 1985, 1986, and Abbey, 1987) and in the universities.

The problem associated with solar drying of meat under the natural conditions in hot humid climates such as occurs in Accra, Ghana, is the relatively large differences in environmental parameters between day and night. For example, the presence of mean relative humidity of about 76 per cent associated with mean ambient temperature of about 28°C, which occurs sometimes in this area inhibit the capacity of air to pick up and evaporate moisture from meat during drying cycles.
It has been stated (FAO, 1990), that the optimal conditions for meat drying are warm, dry air of low relative humidity of about 30 per cent and relatively small temperature differences between day and night.

The objective of this study was to assess all parameters associated with, and the optimal conditions in the use of closed-type, natural convection solar dryers for the drying of meat under hot humid conditions.

Portion of the prepared meat strips were pre-treated by immersion in 5 per cent sodium chloride solution at 1:2 (meat to brine) infusion ratio at 25°C for 2 hours. Ten to fifteen meat strips were hung on hooks welded to a single 1m. long rod. Eight rods were fitted in layers in each dryer giving a meat weight ratio to collector area ratio of 0.25 kilogram per m^2.

Drying runs

Drying runs were carried out in the open between November to February, 1991 in Accra, Ghana.

Daytime temperatures were typically at maximum 33°C (unshaded) with a relatively low relative humidity (minimum 35 per cent). During darkness however, temperature fell to about 23°C with relative humidity increasing to almost 100 per cent.

Air flow rates (ms^{-1}) over the trial period ranged between 0.17 to 1.69 and insolation (Wm^{-2}) ranged between 1.9 to 924 during the night and day cycles respectively.

Conditions within solar dryers during the drying cycles are shown in Figures 1 and 2.

Dryers were loaded approximately four hours after sunrise and drying was continued over a three day period. Weight loss was recorded by weighing whole rods at 4 to 8 hours intervals.

Moisture content was determined on one-third of the total whole strips held on separate rods (20 grams sample dried at 105°C for 8 hours), and water activity was determined on the same samples (1 gram chopped sample measured on a Decagon X1, Decagon, USA, water activity meter).

Measurement of isolation was done with Kipp and Zonen type CMII solarimeter. Ambient humidity, ambient and internal dryer temperatures were recorded on a Grant Squirrel data logger.

Preparation of gelatine treated dried meat strips

10 per cent (w/v) gelatine solution in water was prepared at a temperature of about 40°C and solar dried meat strips were dipped into this solution. The gelatine coated meat strips were then surface dried in an open tray in the sun.

Preparation of hot smoked dried meat strips

Solar dried meat strips were hot smoked in a locally constructed smoke oven at a temperature of about 70°C for 30 minutes.

Chemical and microbiological analysis

Proximate composition of solar dried meat strips were estimated according to AOAC (14th Edn). procedures.

Bacteria counts were estimated on serial dilution preparations of meat samples on Plate Count Agar using the Pour Plate technique and incubated at 30°C for 72 hours.

Sensory evaluation

Sensory analysis on representative samples of solar dried meat strips were carried out on ten experienced panellists. Meat samples were offered in a traditional Ghanaian light soup preparation.

RESULTS AND DISCUSSIONS

Weight loss for meat strips dried under ambient conditions is given in Figure 3. 10 x 10 mm. meat strips would be expected to complete drying (ie. to /30% of original weight) in about 35 hours. This would be expected to extend to at least 70 hours in the larger 20 x 20mm. meat strips.

Salt pre-immersion accelerated the initial rate of weight loss in both sizes of meat strips, but this advantage was not sustained thus, leading to a reduction in the overall weight loss of salted strips over the drying period.

Weight losses and associated changes were recorded for meat strips in both solar dryers for the 10 x 10mm. (Figure 4) and 20 x 20mm strips (Figure 5).

70% of the original weight was lost in the 10 x 10mm. raw meat strips in both the SCD and the STD (Fig. 4). More divergent results for weight losses were obtained for the larger 20 x 20mm. strips (Fig. 5), where the rate and extent of weight loss was generally lower in the SCD. Pretreatment of 20 x 20mm. meat strips in brine resulted in a further reduction in overall weight loss although this was not equivalent to strips dried under ambient condition (Fig. 3). The performance of both dryers was similar to that recorded for these units with brined or salted fish (xenomugil thoburni), giving 35% of original weight after 35 hours (Trim and Curran, 1983), although the comparative effect of not salting was not reported.

Results on moisture loss suggested that the drying process could be divided into four distinct phases reflecting in part changes in ambient conditions as follows:

the initial rate of moisture loss was rapid over the first six hour period in all treatments, although the reduction in moisture in raw material sample dried in the STD was noticeably slower.

Rates of moisture removal over the 6 to 24 hour period were reduced in all treatments irrespective of dryer type as the samples equilibrated with the higher relative humidity overnight.

Brine pre-immersion appeared to accelerate the drying rate (Figures 6 and 7), but had a limited effect under the higher temperature conditions in the SCD.

The reduction in water activity over these early drying stages was in agreement with the steady decline anticipated from moisture loss (Figures 8 and 9).

Treatments diverged over the 29 to 32 hour drying period, equivalent to the high temperature low humidity conditions of the second drying cycle. The increase in the rate of moisture loss in the STD raw material and brined 10 x 10mm. strips was minimal as opposed to a higher rate of moisture loss observed in both solar dryers for the 20 x 20mm. raw material. Brined samples generally showed a relative reduction in rate of moisture loss in both dryers.

Drying over the third drying phase (from 32 hours onwards), showed a consistent limited moisture loss over the period, irrespective of dryer type or brine pre-immersion.

Reduction in water activity was not consistent with moisture content, reflecting a decrease in the homogeneity of the drying sample with respect to moisture distribution within the tissues.

End-product analysis (Table 2) confired the advantage of small diameter meat strips in producing a more stable end-product after 70 hours drying irrespective of the dryer type used.

The SCD was however, marginally better than the STD in drying the 10 x 10mm. meat strips, whilst the STD showed a marginal superiority over the SCD in the overall moisture reduction of 20 x 20mm. meat strips. This is also evidenced by the similarity of the SCD and the STD in their system Drying Efficiencies (Table I).

Trim and Curran (1983), reported a similar limited difference in dryer performance for fish. Pre-immersion in brine treatment of meat strips generally resulted in a product with higher ultimate moisture content.

10 x 10mm. dried meat strips generally stored better than 20 x 20mm. meat strips when aerobically sealed in low density polyethylene bags at room temperature during a 6 week storage period.

Some of the raw and brined 20 x 20mm. meat strips developed off-odour and mould growth during this storage period, leading to high bacterial counts (Ca. $> 10^8$) in those affected. Galetine coated and hot smoke treated dried meat strips stored similarly under ambient conditions had greatly extended shelf life during a 6 month storage period.

Sensory evaluation on dried meat strips cooked in a traditional Ghanaian light soup indicated acceptable meat flavour than when cooked in ordinary water.

CONCLUSIONS

The conditions of high relative humidity prevailing in hot humid climates will result in extended drying times during solar drying of meat strips. This condition may affect the quality of dried meat product during prolonged storage.

The risk of spoilage of dried meat product during storage may be reduced by the use of narrow diameter meat strips and the SCD type dryer.

Pre-immersion of meat strips in brine, even though assists in faster rate of moisture reduction initially, has inhibitory effects over a 70 hour drying process. The effect of other pre-treatments prior to drying which will afford protection of the meat strips during the first two cycles of drying and further modifications of the dryers to dry more efficiently needs to be investigated.

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Table 1: Physical dimensions and characteristics of solar dryers

Dryer characteristic	STD	SCD
Height from ground level	2.66m.	3.22m
Height from dryer chamber floor	1.52m.	3.07m
Total volume	$3.34m^3$	$2.11m^3$
Useable volume (from dryer chamber floor to topmost brace for supporting hanging meat)	$2.61m^3$	$1.66m^3$
Surface area of lower vent	$1.51m^2$	-
Collector-absorber surface area	-	$2.013m^2$
Drying chamber floor surface area	$4.47m^2$	$1.44m^2$
Surface area of upper vent	$0.096m^2$	-
Surface area of dryer chimney	-	$1m^2$
Surface area of collector air duct	-	$0.173m^2$
Height of dryer chimney	-	1m.
Collector absorber slope to ground level	-	3°
Number of hanging meat strips to fill drying chamber to capacity	400	260
Per cent total volume of dryer used for drying	75.0	78.7
Equivalent cost of construction (in US Dollars)	139.3	155.4
Stability and durability	wooden frame work structurally stronger and more stable than the SCD.	Wooden framework structurally weak especially at the upper section embodying dryer chimney.
Mean System Drying Efficiency	2.19	2.20

Footnotes:
mm. denotes millimetres
m^2 " metre squared
m^3 " metre cubed

Figure 1: Environmental conditions in the SCD

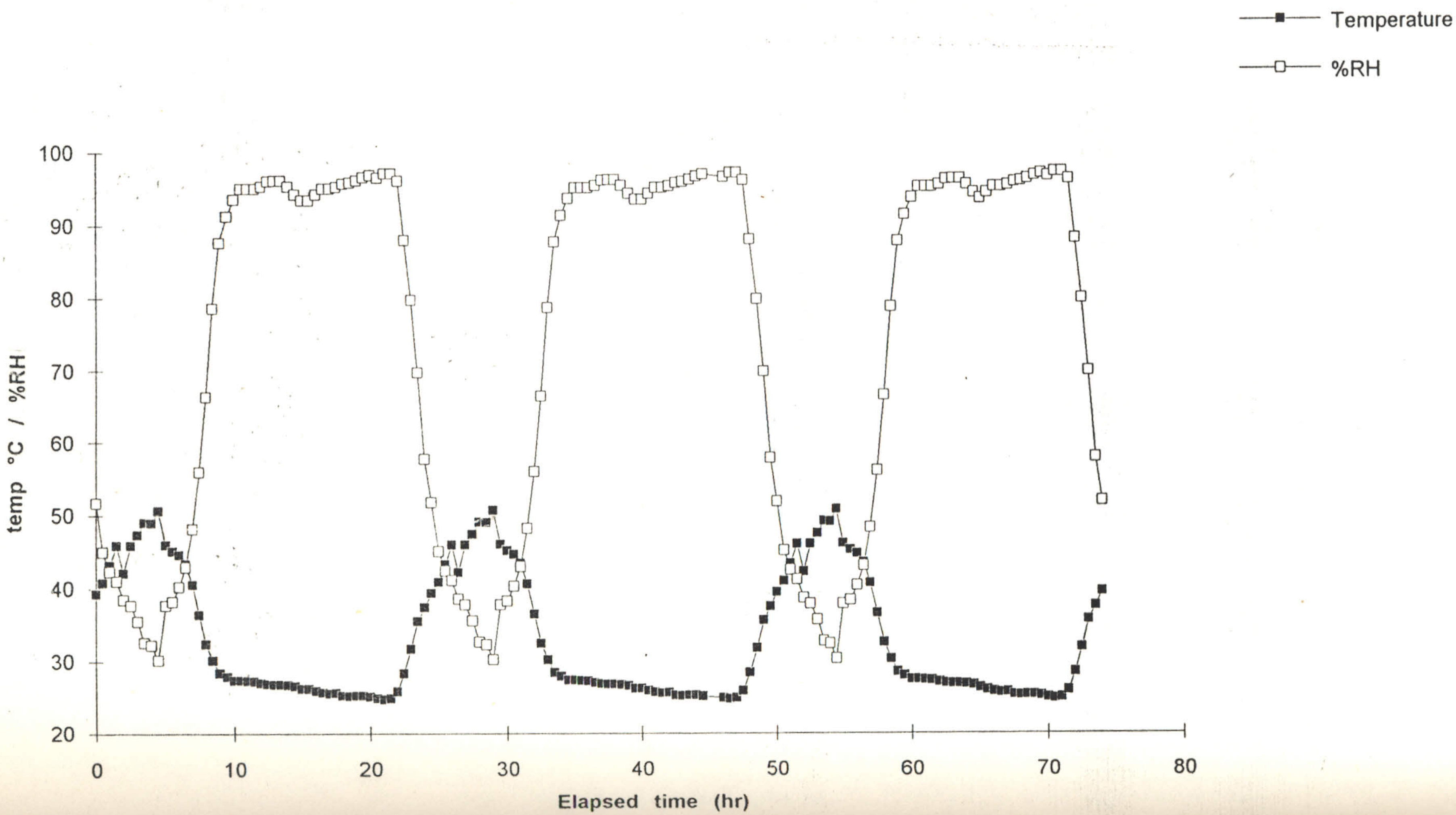

Figure 2: Environmental conditions in the STD

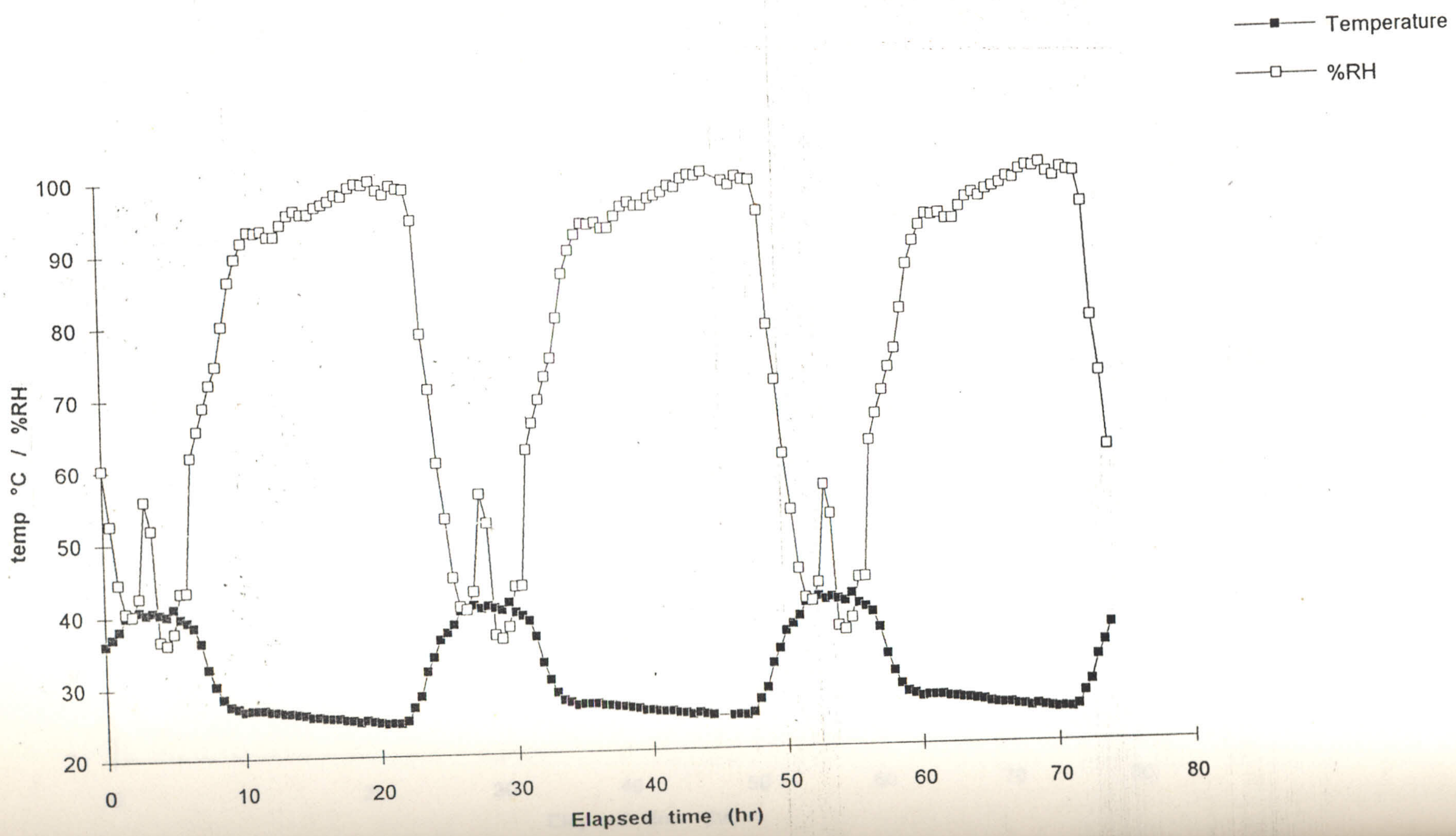

Figure 3. Weight loss of 10 x 10mm and 20 x 20mm meat strips dried under ambient conditions.

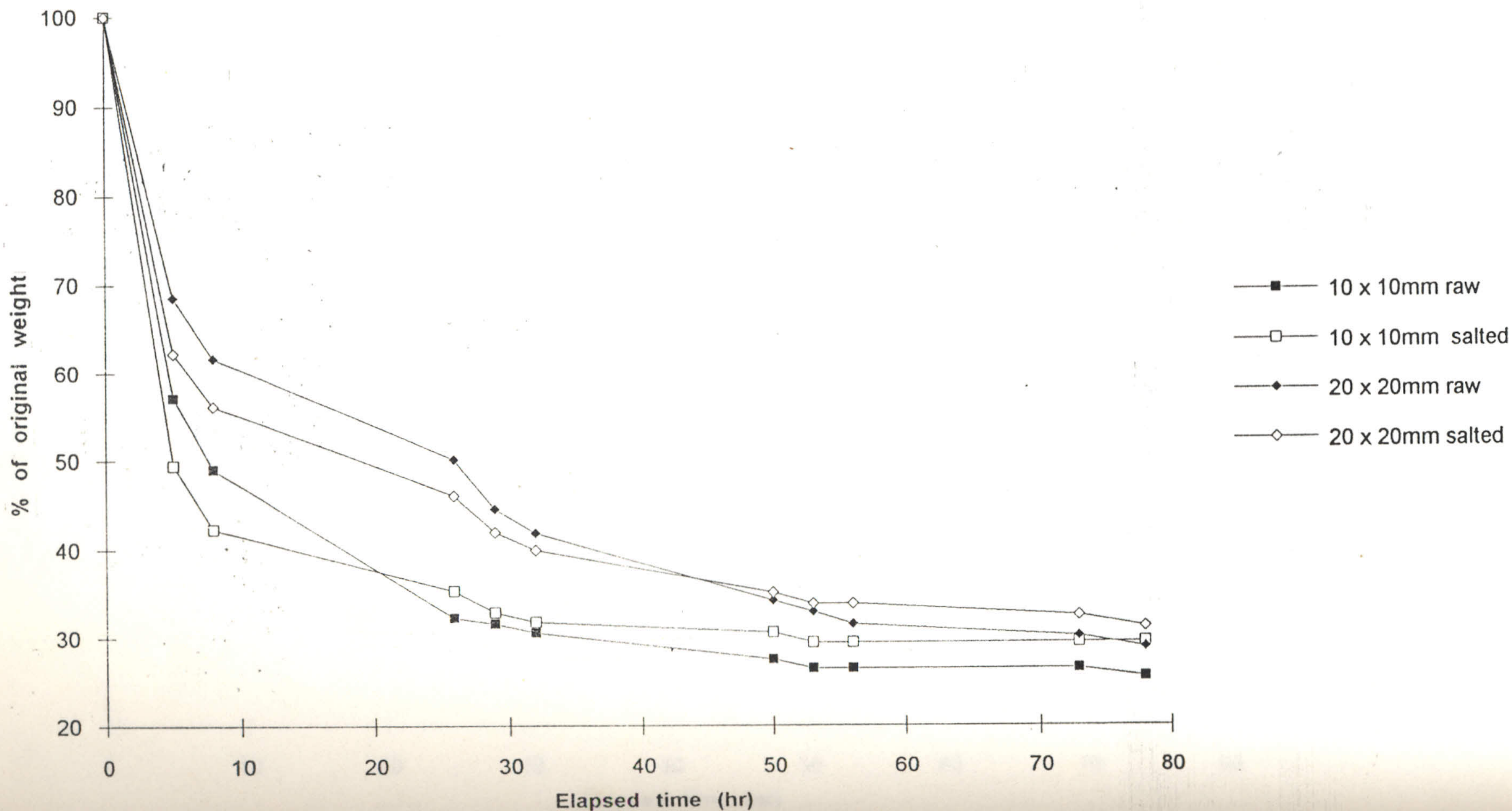

Figure 4: Weight loss (as % of original weight)

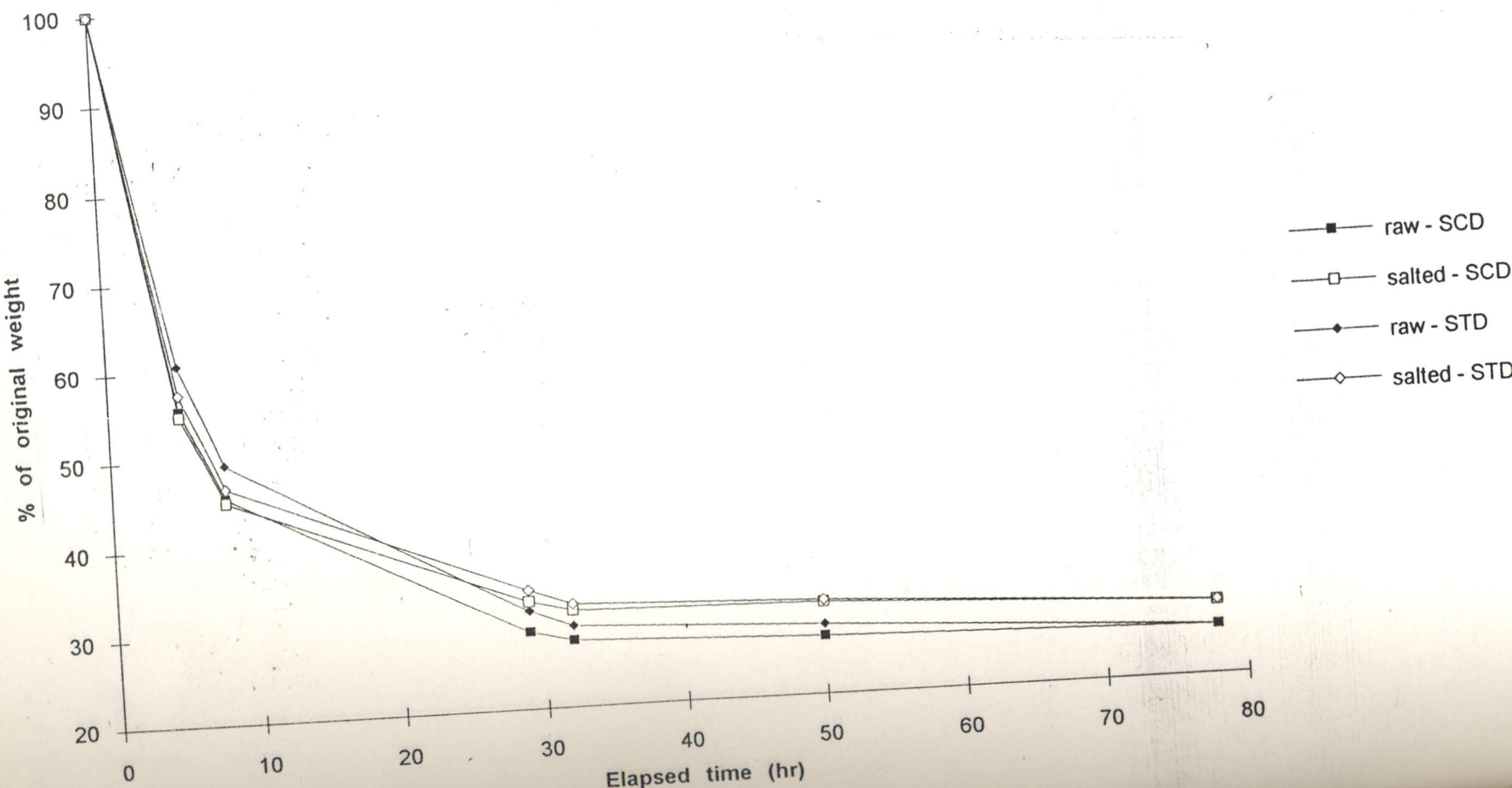

Figure 5: Weight loss (as % of original weight)

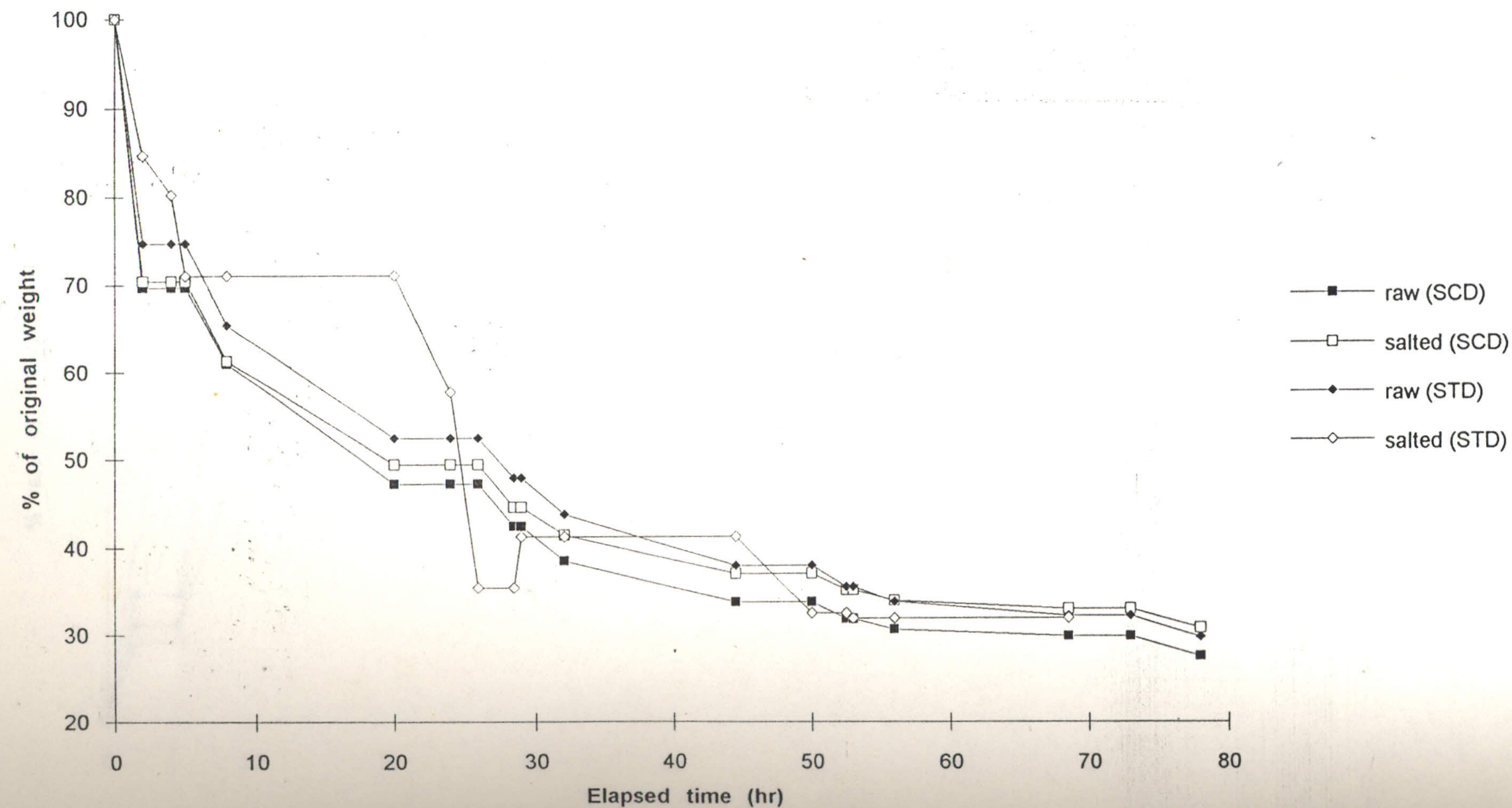

Figure 6: Cumulative rate of moisture loss (as % of preceding weight) - 10 x 10mm. meat strips

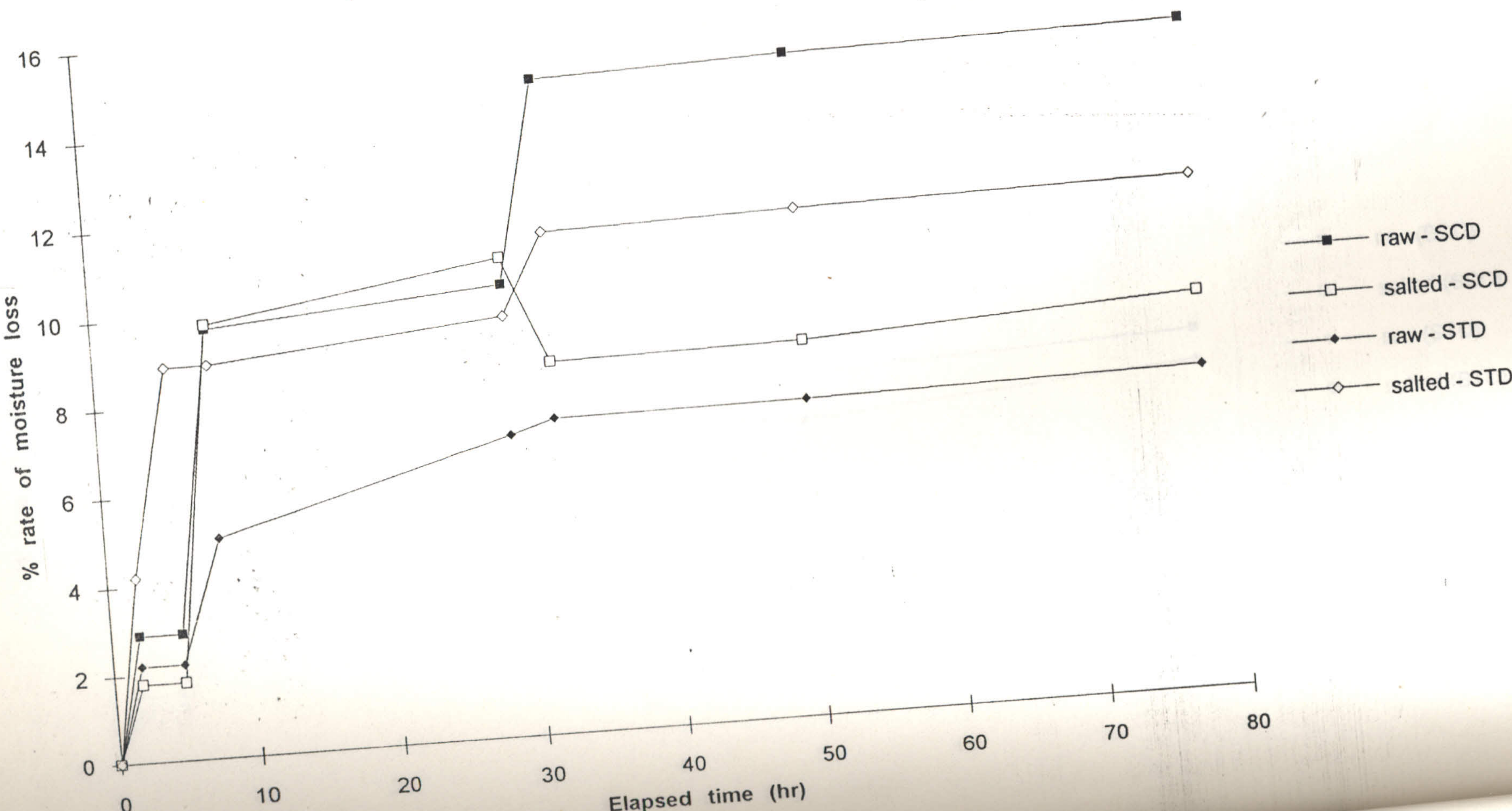

Figure 7: Cumulative rate of moisture loss (as % of preceding weight) - 20x20mm. meat strips

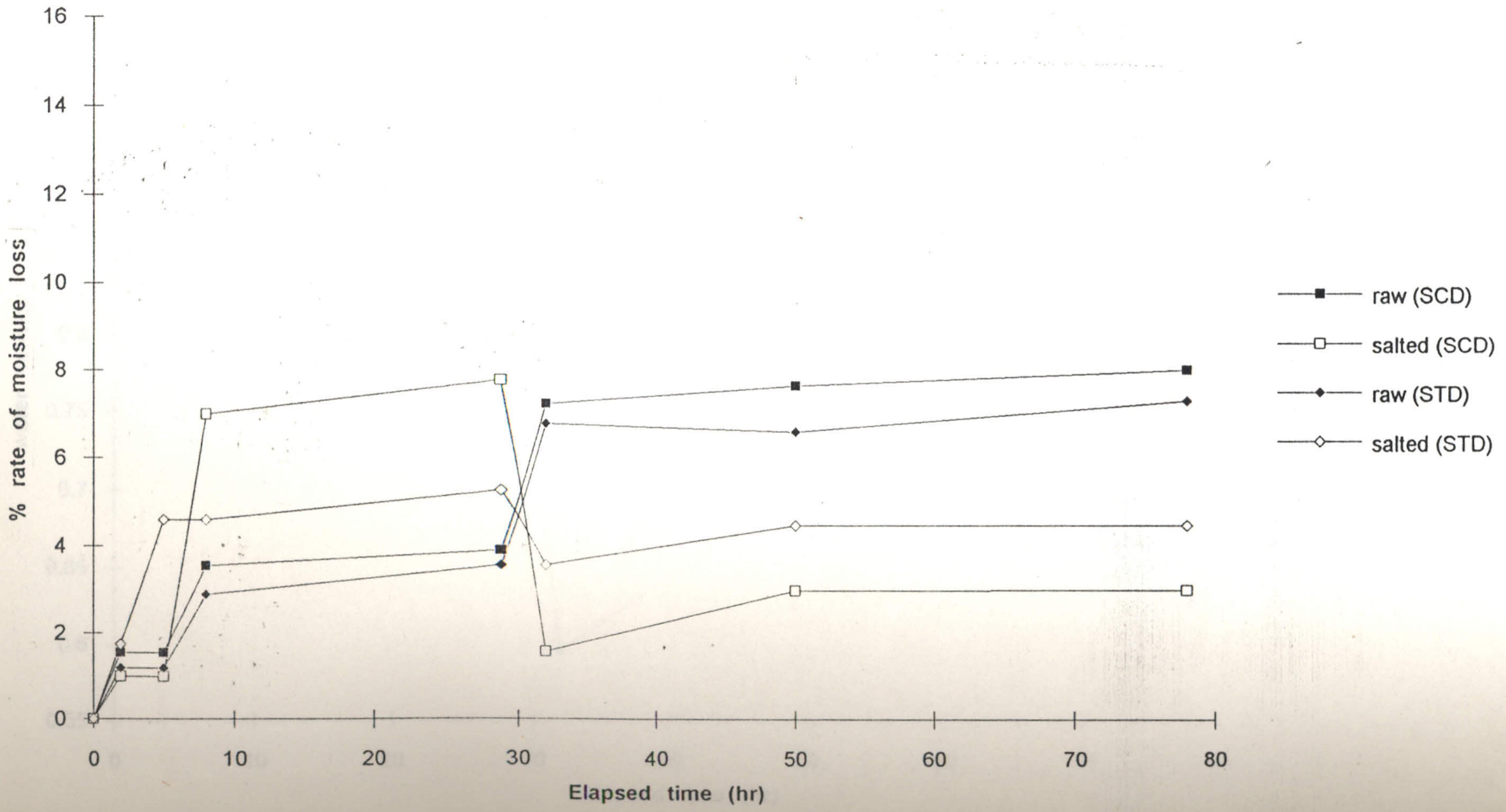

Figure 8: Water activity changes in solar dried (10 x 10mm) meat strips.

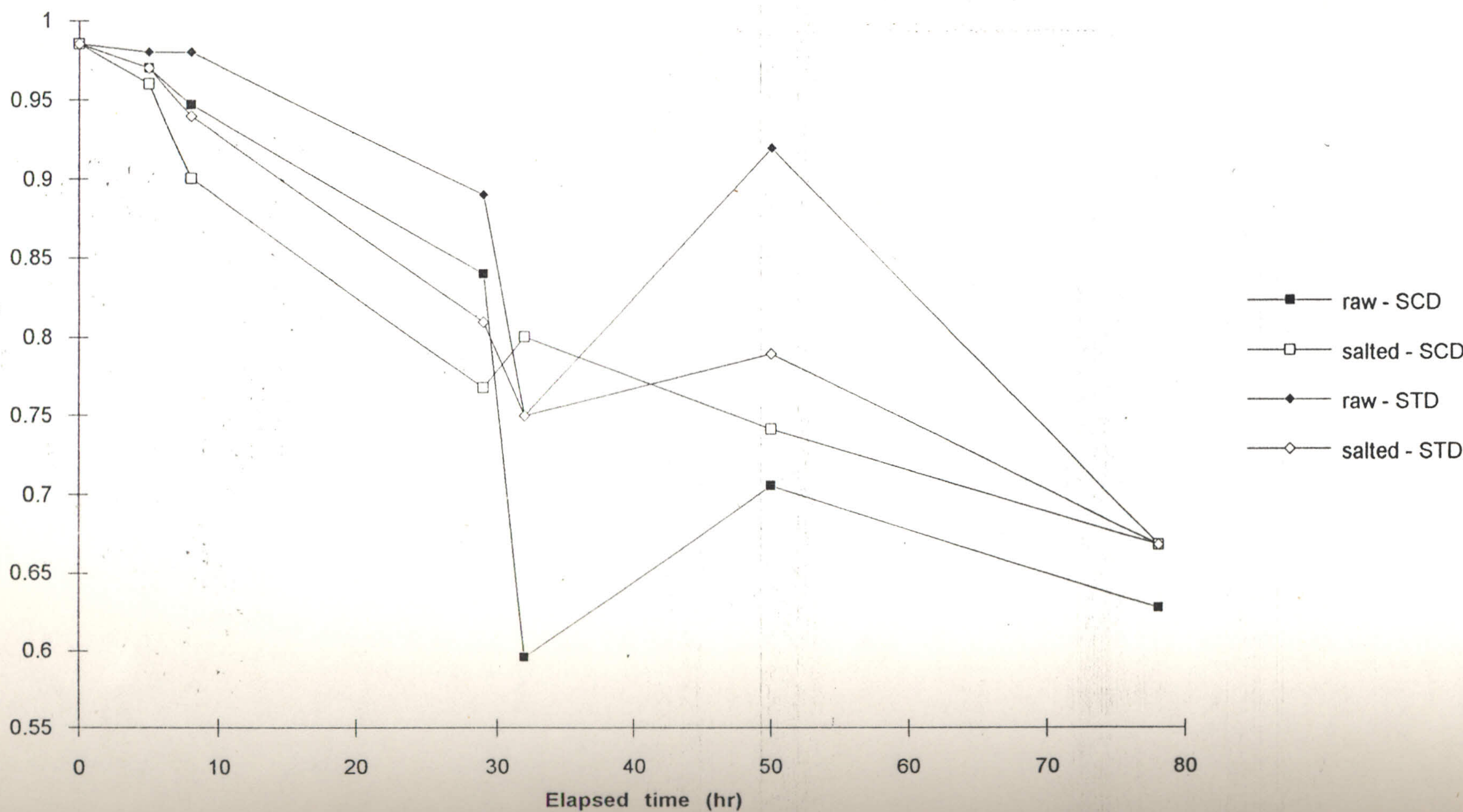

Figure 9: Water activity changes in solar dried (20 x 20mm) meat strips

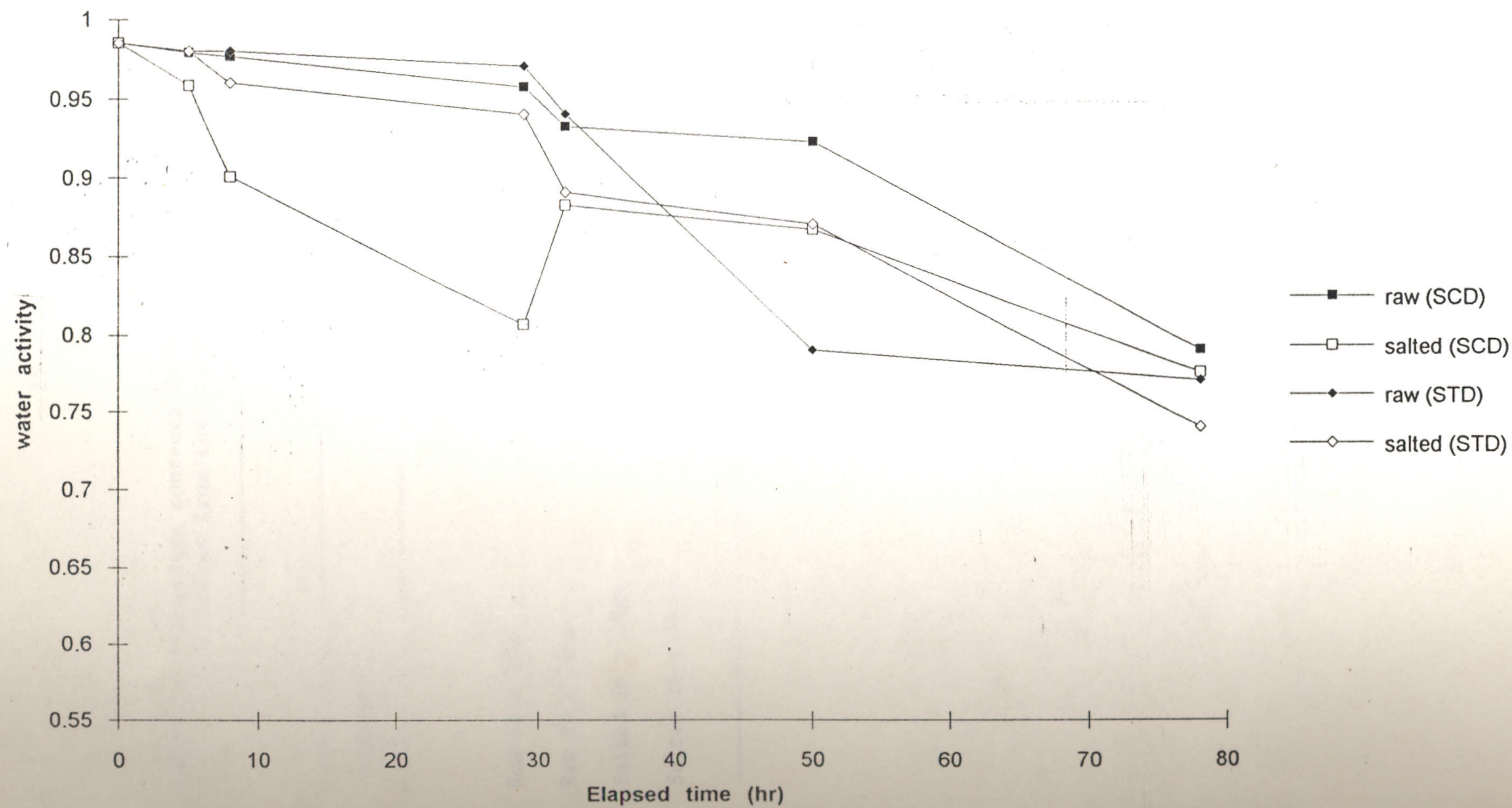

Table 2: Moisture contents (per cent) of end products removed from the SCD and STD after 70 hours drying

Treatment	Dryer Type	
	SCD	STD
Raw 10 x 10mm.	16.2	18.4
Raw 20 x 20mm.	28.5	24.8
Salted 10 x 10mm.	19.1	20.4
Salted 20 x 20mm.	33.1	28.9