SOLAR DRYING OF GROUNDNUT PODS: BETTER ALTERNATIVE TO TRADITIONAL DRYING METHOD

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ABSTRACT

The traditional methods for groundnut pods viz., drying of plant with pods in the field, direct exposure of groundnut pods in the sun light, windrows methods leads the post harvest losses due to its several drawbacks. These drawbacks can be inhibited by adopting mechanical drying of groundnut pods immediately after threshing. An experiment on drying of groundnut pods (GG 20) immediate after threshing was carried out by solar dryer and sun drying method. The biochemical parameters of groundnut kernels, viz., moisture content (% (wb)), protein content (%), carbohydrate content and fat content were determined before and after drying. physical parameters of freshly harvested groundnut pods (GG 20) with kernel viz., weight of 100 grains, maximum diameter, minimum diameter, bulk density, true density and porosity were found 616.10 ± 52.04 g, 11.69 ± 1.17 mm, 10.69 ± 0.85 mm, 239.80 ± 21.60 kg/m^3, 432.10 ± 44.96 kg/m^3 and 43.80 ± 7.75 %, respectively. However, the physical parameters of groundnut pods with kernel at threshing time viz., weight of 100 grains, maximum diameter, minimum diameter, bulk density, true density and porosity were found 117.37 ± 9.95 g, 13.03± 1.21 mm, 11.87± 0.93 mm, 247.05±7.45 kg/m^3, 439.64 ± 48.72 kg/m^3 and 43.02 ± 6.78 %, respectively. The highest value of drying constant (0.30 /h) was found in treatment T_4 (i.e., 50^{0}C temperature & 1.0 m/s air velocity) among all the treatments. The drying time required for drying of threshed groundnut pods by solar dryer was 7 to 8 hours, whereas sun drying took five days (50 hour). Higher retention of biochemical parameters viz., protein content (6 %), carbohydrate content (7.5 %) and fat content (9.90 %) in groundnut kernels dried by solar dryer as compared to that of traditional sun drying method.

KEY WORDS: Groundnut, solar dryer, sun drying

INTRODUCTION

India produces 6 to 7 million tons of groundnut with an average yield of 1400 kg/ha. About 80 per cent of total production is used for oil extraction, 11 per cent as seed, 8 per cent direct food uses and 1 per cent for export as HPS kernel. Gujarat cultivates about 16.25 lakh hectare, which shares almost 39.13 per cent of the total groundnut area in India. Saurashtra region contributes to 55 per cent and 65 per cent of area and production, respectively (Chavda, 2010). In Gujarat, the cultivated area under groundnut was 1625 thousand hectares producing 3054 thousand metric tons with a

productivity of 1879 kg/ha during 2016-17 (Anonymous, 2017).

The correct drying or curing of the harvested groundnuts is very important as poor curing can induce fungal growth (producing aflatoxin contamination) and reduce seed quality for consumption, marketing and germination for the following seasons planting. For good storage and germination, the moisture content of the pods should be reduced to 6 to 8 per cent. There are different ways of drying the pods, some of which are better than other. It is particularly important to note that, if the pods are exposed to the sun for too long, the seed quality can deteriorate considerably and germination can be affected.

Mada *et al.* (2014) reported 30 per cent post harvest loss of groundnut during various post harvest operations *viz*., drying, storage, threshing, transportation, packaging and marketing. Presently, the farmers of Saurashtra region followed the traditional open air sun drying method for drying of groundnut pods. Over the last two decades, open air drying has gradually become more and more limited because of the requirement for a large area, limitation of time, the possibilities of quality degradation, high level of dust and atmospheric pollution from the air, cloudiness and rain, intrusion from animals and man, infestation caused by birds and insects, losses due to rodents and inherent difficulties in controlling the drying process.

The present investigation was carried out by looking to the demand to develop a proper drying method using low cost dryer to dry the groundnut pods uniformly in 8 to 10 hours (i.e., 1 day) to a safe moisture content (7 to 8 % (wb)) as well as minimizes the post harvest losses occurs during drying, for better storability of groundnut pods during storage. The investigation was also concentrated to eliminate the drawbacks of traditional sun drying method for groundnut pods.

MATERIALS AND METHODS

The experiment on drying of groundnut pods (GG 20) was carried out in the Department of Processing and Food Engineering, College of Agricultural Engineering and Technology, JAU, Junagadh. The experimental procedures and materials used in the experiment are reported as per following details.

Selection of variety

There are different variety of groundnut *viz*., GG 2, GG 3, GG 5, GG 6, GG 7, GG 8, GG 11, GG 13, GG 14, GG 16, GG 20, GG 21, GAUG 10, etc. Among these local cultivars, GG 20 is most commonly used for confectionery purposes. The shelling efficiency as well as yield of kernel is higher as compared to other varieties of groundnut. In addition to this, GG 20 variety of groundnut was found very well with respect to germination, moisture content, oil recovery, physical purity, insect damage and field emergence percentage. Looking to the above features of groundnut cultivar GG 20 was selected for the present investigation (Plate 1). The groundnut pods (GG 20) were procured from village Kanadipur (Ta : Mendarada, Dist.: Junagadh) immediately after threshing.

Biochemical parameters of groundnut kernels

The biochemical parameters *viz*., moisture content, protein content, fat content and carbohydrate of groundnut kernels were determined using standard analytical methods (Plate 2) as mentioned in Table 1.

Drying of groundnut pods using solar dryer

The well cleaned and graded groundnut pods were weighed using digital weight balance. The drying of groundnut pods was carried out by solar dryer (120 kg capacity) developed by AICRP on Post Harvest Engineering and Technology,

Processing and Food Engineering Department, CAET, JAU, Junagadh (Plate 3). After weighing of 10 kg of groundnut pods in drying tray, it was loaded in the drying cabinet as per its sequence. Total 12 trays were arranged in 6 tiers (i.e., 2 trays per tier). After loading of all the trays (120 kg), the main doors were closed. It was observed that 45 to 50 ^{0}C temperature was obtained after 10.00 hours in the morning. The drying of groundnut pods was during 10.00 to 17.00 hours (i.e., 8 hours). After of loading of trays as per their order in the drying cabinet, first blower was started at 9.50 hours, then after, air velocity of 0.50 m/s was maintained by adjusting the wheel valve. The first experiment was carried out at 45^{0}C drying air temperature and 0.50 m/s air velocity (Treatment T_1). The drying air temperature of 45 ^{0}C ± 1 ^{0}C was maintained by blanking the solar collector as required. Similar kinds of experiments were carried out for Treatment T_2, T_3 and T_4 as per treatment combinations shown in Table 2. However, sun drying of groundnut pod (GG 20) is considered as a control treatment (T_5).

Moisture content of groundnut pods during the drying process was measured by recording the weight loss at an interval of one hour. The drying of groundnut pods using developed dryer was continue until the initial moisture contents of groundnut pods, i.e., 11.00 to 11.25 per cent (wb) was reduced up to safe storage moisture level, i.e., 6.0 to 7.0 per cent (wb). Similar drying process was carried out for other 3 treatments too (i.e., T_2, T_3, T_4).

The drying characteristics of groundnut pods using developed dryer was determined in terms of drying curves *viz*., moisture content *vs*. drying time, drying rate *vs*. drying time, and moisture ratio (MR) *vs*. drying time. The values of moisture ratio (MR) and drying rates were determined as per the methods suggested in Table 3.

Sun drying of groundnut pod

The experiment on sun drying of groundnut pods was carried out immediate after threshing as per the methods followed by local farmers of Saurashtra region at Village Kanadipur (Ta. : Mendarda, Dist. Junagadh). At least three labours were required for sun drying of groundnut pods for spreading the groundnut in 5 to 6 layers (bed thickness of about 8 to 10 cm) on the open field under direct sun light from 9:00 AM to 6:00 PM (i.e., 10 hour / day). Then after, groundnut pods were heaped and covered with plastic cover to protect groundnut pods against dew and rain.

Statistical design

The observations taken for various treatment combinations for groundnut kernels were subjected to analysis of variance technique considering two factors using Completely Randomized Design. The experiments were replicated four times as per the different treatment combinations. All the treatments were compared at 5 per cent level of significance using the Critical Difference test. The analysis of variance (ANOVA), standard error of mean (SEM), critical difference (CD), coefficient of variance (CV) and mean values for dependent parameters were tabulated and the level of significance was reported as suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Biochemical parameters

The biochemical parameters *viz*., moisture content, protein content, fat content, carbohydrate of groundnut kernels were evaluated after threshing by standard methods as mentioned above.

Moisture content of groundnut pods along with kernel after threshing was ranged from 11.02 to 11.30 per cent (wb) (Table 4). The results revealed that the mean value of moisture content with their standard deviation was found as 11.17 ± 0.10 per cent (wb). Protein content, carbohydrate content

and fat content of groundnut kernel after threshing was ranged from 23.95 to 25.02 per cent, 22.12 to 23.14 per cent and 45.27 to 47.11 per cent, respectively. However, it was observed that the mean value of protein content, carbohydrate content and fat content with their standard deviation was found to be 24.48 ± 0.39 per cent, 22.70 ± 0.45 per cent and 46.16 ± 0.71 per cent, respectively. The results revealed that the groundnut kernels of GG 20 are rich in oil (fat) content.

Drying characteristics of groundnut pods using solar dryer

The drying characteristics of groundnut pods immediate after threshing using the developed dryer (Plate 3) was determined for different drying air temperature (i.e., 45^0C and 50 ^{0}C) and air velocity (i.e., 0.50 m/s and 1.0 m/s). The mean values of moisture contents, drying rates and moisture ratio at an interval of 1.00 hour were measured and reported in Table 5, Table 6, Table 7 and Table 8 for treatment T_1, T_2, T_3 and T_4, respectively. The values of drying rate and moisture ratio were calculated as the formula mentioned Table 2. The drying curves, i.e., drying time *vs*. moisture content, drying time *vs*. drying rate and drying time *vs*. moisture ratio for different treatments were illustrated graphically in Figure 1, 2 and 3, respectively.

Effect of drying time on moisture content

It was observed (Figure 1) that moisture content of groundnut pods was decreased with increase in drying time for all the treatments. During the initial stage of drying process, the rate of reduction of moisture content was higher and it decreased with increase in drying time. At the later stage of drying process, rate of removal of moisture becomes very slower for all the treatments.

Effect of drying time on drying rate

It was observed (Figure 2) that drying of groundnut pods was found higher during noon hour (i.e., during 13.00 to 15.00 hours), as the temperature increased, the drying rate increased and in addition to this, relative humidity during noon hours was also lower for all the treatments.

Effect of drying time on moisture ratio

The efficiency of the drying process could be judged on the basis of value of drying constant, i.e., higher the value of drying constant, faster the drying and *vice versa*. The mean values of moisture content and moisture ratio were plotted on semi log paper and the value of drying constant was obtained on the slope of curve.

The highest value of drying constant (0.30 /h) was found in treatment T_4 (i.e., 50^0C temperature & 1.0 m/s air velocity), whereas the lowest value of drying constant (0.25 h^{-1}) was found in treatment T_1 (i.e., 45^0C temperature & 0.50 m/s air velocity). It shows that at higher temperature (50^0C) and higher air velocity (1.0 m/s) resulted in higher rate of drying. It might be due to increased in air temperature and air velocity accelerates the drying process results in faster evaporation process.

It was also observed (Figure 3) that at same drying temperature increase in air velocity from 0.50 m/s to 1.0 m/s, air velocity increases the value of drying constant, i.e., 0.25 /h and 0.26 /h for treatment T_1 (i.e., 45^0C temperature & 0.50 m/s air velocity) and T_2 (i.e., 45^0C temperature & 1.0 m/s air velocity), respectively. Similarly, at same drying air velocity, increase in drying temperature increased the value of drying constant.

Quality evaluation of groundnut kernel dried by solar dryer and sun drying

The quality evaluation of ground kernel dried by solar dryer and sun drying was carried out on the basis of biochemical parameters *viz*., protein content,

carbohydrate content and fat content as per standard methods mentioned in Table 1.

It was observed (Table 9) that mean values with their standard deviation of protein content (23.75 ± 0.38 %), carbohydrate content (22.25 ± 0.45 %) and fat content (45.70 ± 0.71 %) were obtained in the samples of groundnut kernels dried by solar dryer, whereas, that of sun drying (Table 10) were obtained 22.56 ± 0.32 per cent, 20.69± 0.37 per cent and 41.59 ± 0.58 per cent, respectively.

In the tune of per cent retention, higher retention of biochemical parameters i.e., protein content (6 %), carbohydrate content (7.5 %) and fat content (9.90 %) in groundnut kernels dried by solar dryer as compared to that of traditional sun drying method.

The drying of groundnut pods was carried out by solar dryer at full load condition (120 kg). The final weight of groundnut pods after drying was found 114 kg. The solar dryer required only 7 to 8 hours (i.e., 10.00 AM to 5.00 PM) to reduce the initial moisture contents of threshed groundnut pods (i.e., 11.00 to 11.25 % (wb)).

The drying of groundnut pods by traditional sun drying method took five days to reduce the moisture content of threshed groundnut pods from 11.00 to 11.50 % (wb) to about 7.30 to 8.85 % (wb). The total hours under sun rays during sun drying of groundnut pods were from 8.00 AM to 6.00 PM (i.e., 10 hour).

CONCLUSIONS

1. The highest value of drying constant (0.30 /h) was found in treatment T_4 (i.e., 50^0C temperature & 1.0 m/s air velocity), whereas the lowest value of drying constant (0.25 /h) was found in treatment T_1 (i.e., 45^0C temperature & 0.50 m/s air velocity).
2. The drying time required for drying of threshed groundnut pods by solar dryer was 7 to 8 hours, whereas sun drying took five days (50 hour).
3. Higher retention of biochemical parameters i.e., protein content (6 %), carbohydrate content (7.5 %) and fat content (9.90 %) in groundnut kernels dried by solar dryer as compared to that of traditional sun drying method.
4. Finally, it was concluded that the drying of groundnut pods using solar dryer saved drying time (4 days), higher retention of biochemical parameters (protein, carbohydrate and fat) and minimized post harvest losses as compared to sun drying.

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Table 1: Methods for determination of biochemical parameters of groundnut pods after threshing

Sr. No.	Biochemical Parameter	Method	Equation / Formula Used
1	Moisture content, % (wb)	AOAC (1990)	MC % (wb) = $\frac{(W_2-W_1)-(W_3-W_1)}{(W_2-W_1)} \times 100$
2	Protein content, %	Lowry *et al*. (1951)	Protein (%) = $\frac{graph\ factor \times OD \times total\ buffer volume\ \ (ml)}{volume\ extracted(ml) \times weight\ of\ sample\ (g)} \times 100$
3	Carbohydrate, %	Phenol Sulphuric Acid method	Total carbohydrate, % = $\frac{x}{0.1} \times 100$ mg of glucose
4	Fat content, %	AOAC (1990) using soxhlet	Fat Content, % = $\frac{Wt.of\ Extraction - Wt,of\ extraction\ with\ fat}{Weight\ of\ sample} \times 100$

Table 2: Treatment combinations used for drying experiment

Sr. No.	Treatments	Temperature (°C)	Air Velocity (m/s)
1	T_1	45	0.5
2	T_2	45	1.0
3	T_3	50	0.5
4	T_4	50	1.0

Table 3: Methods used for determination of drying characters of groundnut pods

Sr. No.	Drying Character	Formula / Equation Used
1	Drying rate, %	Drying rate=$\frac{dm}{dt}$ % *where, dm = Moisture removed per hour, % (wb)* *dt = drying time, h*
2	Moisture Ratio (MR)	Moisture Ratio = $\frac{Mt-Me}{Mo-Me}$ *Where, M_t= Moisture content at time t, % (wb)* *M_e=Equilibrium moisture content, % (wb)* *M_o=Moisture content after threshing, % (wb)*

Table 4: Mean values of biochemical parameters of groundnut pods after threshing

Sr. No.	Moisture Content (%(w.b.))	Protein Content (%)	Carbohydrate Content (%)	Fat/Oil Content (%)
1	11.02	24.51	22.82	46.5
2	11.14	25.02	22.12	45.69
3	11.13	24.32	23.14	47.11
4	11.25	24.62	23.09	45.27
5	11.30	23.95	22.34	46.25
Mean	**11.17**	**24.48**	**22.70**	**46.16**
SD	**0.10**	**0.39**	**0.45**	**0.71**

Table 5: Mean values of drying rate and moisture ratio at different drying time for different trays at 45 0C drying air temperature and 0.50 m/s air velocity (Treatment T_1)

Sr. No.	Drying Time (IST), h	Tray 1			Tray 2			Tray 3			Tray 4			Tray 5			Tray 6		
		M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR
1	10:00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00
2	11:00	10.58	0.42	0.93	10.54	0.46	0.92	10.49	0.51	0.91	10.50	0.50	0.91	10.45	0.55	0.90	10.39	0.61	0.89
3	12:00	9.90	0.68	0.81	9.86	0.69	0.80	9.82	0.67	0.79	9.77	0.73	0.78	9.74	0.72	0.78	9.70	0.69	0.77
4	13:00	9.17	0.74	0.68	9.07	0.78	0.66	9.01	0.81	0.65	8.95	0.82	0.64	8.92	0.81	0.64	8.90	0.81	0.63
5	14:00	8.14	1.02	0.50	8.07	1.01	0.49	8.05	0.96	0.48	7.98	0.97	0.47	7.97	0.95	0.47	7.95	0.94	0.47
6	15:00	7.40	0.75	0.37	7.30	0.77	0.35	7.23	0.81	0.34	7.17	0.82	0.33	7.07	0.90	0.31	7.02	0.93	0.30
7	16:00	6.88	0.52	0.28	6.83	0.48	0.27	6.81	0.43	0.26	6.78	0.39	0.26	6.76	0.31	0.26	6.66	0.36	0.24
8	17:00	6.22	0.66	0.16	6.20	0.63	0.16	6.14	0.67	0.15	6.12	0.66	0.14	6.11	0.65	0.14	6.08	0.58	0.14

Tray 7			Tray 8			Tray 9			Tray 10			Tray 11			Tray 12			Mean		
M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR
11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00
10.41	0.59	0.90	10.45	0.56	0.90	10.49	0.51	0.91	10.54	0.46	0.92	10.56	0.44	0.92	10.59	0.41	0.93	10.50	0.50	0.91
9.68	0.73	0.77	9.75	0.70	0.78	9.80	0.69	0.79	9.85	0.70	0.80	9.89	0.67	0.81	9.92	0.67	0.81	9.81	0.69	0.79
8.91	0.77	0.63	8.96	0.78	0.64	9.02	0.78	0.65	9.08	0.76	0.66	9.12	0.77	0.67	9.18	0.74	0.68	9.02	0.78	0.65
7.96	0.95	0.47	7.99	0.97	0.47	8.05	0.97	0.48	8.09	1.00	0.49	8.12	0.99	0.50	8.23	0.96	0.51	8.05	0.97	0.48
7.06	0.90	0.31	7.09	0.90	0.31	7.13	0.92	0.32	7.17	0.92	0.33	7.23	0.89	0.34	7.31	0.92	0.35	7.18	0.87	0.33
6.68	0.38	0.24	6.74	0.35	0.25	6.79	0.34	0.26	6.83	0.34	0.27	6.85	0.39	0.27	6.89	0.42	0.28	6.79	0.39	0.26
6.10	0.58	0.14	6.13	0.61	0.15	6.15	0.64	0.15	6.14	0.69	0.15	6.19	0.66	0.16	6.21	0.69	0.16	6.15	0.64	0.15

M.C. = Moisture Content; D.R. = Drying Rate ; MR = Moisture Ratio

Table 6: Values of drying rate and moisture ratio at different drying time for different trays at 45 0C drying air temperature and 1.0 m/s air velocity (Treatment T_2)

Sr. No.	Drying Time (IST), h	Tray 1			Tray 2			Tray 3			Tray 4			Tray 5			Tray 6		
		M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR
1	10:00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00
2	11:00	10.60	0.40	0.93	10.53	0.47	0.92	10.51	0.49	0.91	10.47	0.53	0.91	10.46	0.54	0.91	10.41	0.59	0.90
3	12:00	9.89	0.71	0.81	9.87	0.65	0.80	9.81	0.70	0.79	9.80	0.67	0.79	9.72	0.74	0.78	9.66	0.75	0.77
4	13:00	9.17	0.73	0.68	9.00	0.88	0.65	9.01	0.80	0.65	8.95	0.85	0.64	8.91	0.81	0.63	8.81	0.85	0.62
5	14:00	7.96	1.20	0.47	7.94	1.05	0.46	7.93	1.08	0.46	7.87	1.08	0.45	7.82	1.09	0.44	7.78	1.03	0.44
6	15:00	7.38	0.59	0.36	7.29	0.65	0.35	7.24	0.68	0.34	7.18	0.69	0.33	7.11	0.71	0.32	7.04	0.74	0.31
7	16:00	6.79	0.59	0.26	6.75	0.54	0.25	6.71	0.53	0.25	6.69	0.49	0.24	6.61	0.50	0.23	6.56	0.48	0.22
8	17:00	6.51	0.28	0.21	6.50	0.25	0.21	6.37	0.34	0.19	6.32	0.37	0.18	6.27	0.35	0.17	6.18	0.39	0.15

Tray 7			Tray 8			Tray 9			Tray 10			Tray 11			Tray 12			Mean		
M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR
11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00	11.00	0.00	1.00
10.43	0.57	0.90	10.45	0.55	0.90	10.48	0.52	0.91	10.54	0.47	0.92	10.57	0.43	0.92	10.59	0.41	0.93	10.50	0.50	0.91
9.65	0.78	0.76	9.75	0.71	0.78	9.79	0.69	0.79	9.83	0.71	0.79	9.91	0.66	0.81	9.97	0.62	0.82	9.80	0.70	0.79
8.87	0.78	0.63	8.95	0.79	0.64	8.99	0.80	0.65	9.03	0.80	0.65	9.09	0.82	0.67	9.23	0.73	0.69	9.00	0.80	0.65
7.80	1.07	0.44	7.89	1.06	0.45	7.95	1.04	0.47	7.97	1.05	0.47	8.01	1.08	0.48	8.06	1.17	0.48	7.92	1.08	0.46
7.06	0.74	0.31	7.11	0.78	0.32	7.19	0.77	0.33	7.21	0.76	0.34	7.31	0.70	0.35	7.38	0.68	0.36	7.21	0.71	0.33
6.62	0.44	0.23	6.70	0.41	0.25	6.76	0.43	0.26	6.80	0.42	0.26	6.84	0.48	0.27	6.90	0.47	0.28	6.73	0.48	0.25
6.20	0.42	0.16	6.22	0.48	0.16	6.28	0.48	0.17	6.33	0.47	0.18	6.50	0.33	0.21	6.56	0.34	0.22	6.35	0.38	0.18

M.C. = Moisture Content; D.R. = Drying Rate ; MR = Moisture Ratio

Table 7: Values of drying rate and moisture ratio at different drying time for different trays at 50 ^{0}C drying air temperature and 0.50 m/s air velocity (Treatment T_3)

Sr. No.	Drying Time (IST), h	Tray 1			Tray 2			Tray 3			Tray 4			Tray 5			Tray 6		
		M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR
1	10:00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00
2	11:00	10.46	0.79	0.91	10.42	0.83	0.90	10.39	0.86	0.89	10.36	0.64	0.89	10.33	0.92	0.88	10.29	0.96	0.88
3	12:00	10.13	0.33	0.85	10.07	0.34	0.84	10.05	0.35	0.83	9.98	0.38	0.82	9.93	0.40	0.81	9.88	0.41	0.80
4	13:00	9.42	0.71	0.72	9.38	0.70	0.72	9.35	0.70	0.71	9.30	0.69	0.70	9.27	0.66	0.70	9.21	0.67	0.69
5	14:00	8.95	0.46	0.64	8.91	0.46	0.63	8.89	0.46	0.63	8.84	0.46	0.62	8.79	0.47	0.61	8.76	0.46	0.61
6	15:00	7.30	1.65	0.35	7.27	1.64	0.35	7.21	1.67	0.34	7.20	1.64	0.33	7.16	1.64	0.33	7.12	1.64	0.32
7	16:00	6.81	0.50	0.26	6.78	0.50	0.26	6.74	0.48	0.25	6.70	0.50	0.25	6.68	0.48	0.24	6.63	0.49	0.23
8	17:00	6.24	0.57	0.16	6.21	0.57	0.16	6.16	0.58	0.15	6.12	0.58	0.14	6.06	0.62	0.13	6.01	0.62	0.12

Tray 7			Tray 8			Tray 9			Tray 10			Tray 11			Tray 12			Mean		
M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR
11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00
10.31	0.94	0.88	10.37	0.88	0.89	10.45	0.80	0.90	10.47	0.78	0.91	10.52	0.73	0.92	10.54	0.71	0.92	10.41	0.84	0.90
9.87	0.44	0.80	9.92	0.45	0.81	9.95	0.50	0.82	9.99	0.48	0.82	10.03	0.49	0.83	10.08	0.46	0.84	9.99	0.55	0.82
9.22	0.65	0.69	9.28	0.64	0.70	9.33	0.61	0.71	9.39	0.61	0.72	9.43	0.60	0.73	9.48	0.60	0.73	9.34	0.65	0.71
8.77	0.46	0.61	8.80	0.47	0.61	8.84	0.49	0.62	8.90	0.49	0.63	8.92	0.51	0.64	8.99	0.49	0.65	8.86	0.80	0.63
7.14	1.63	0.32	7.19	1.62	0.33	7.22	1.62	0.34	7.26	1.63	0.34	7.29	1.63	0.35	7.34	1.65	0.36	7.22	1.64	0.34
6.65	0.49	0.24	6.71	0.48	0.25	6.74	0.49	0.25	6.80	0.47	0.26	6.84	0.46	0.27	6.89	0.45	0.28	6.75	0.60	0.25
6.04	0.61	0.13	6.10	0.61	0.14	6.14	0.60	0.15	6.21	0.59	0.16	6.25	0.59	0.17	6.27	0.63	0.17	6.15	0.48	0.15

M.C. = Moisture Content; D.R. = Drying Rate ; MR = Moisture Ratio

Table 8: Values of drying rate and moisture ratio at different drying time for different trays at 50 ^{0}C drying air temperature and 1.0 m/s air velocity (Treatment T_4)

Sr. No.	Drying Time (IST), h	Tray 1			Tray 2			Tray 3			Tray 4			Tray 5			Tray 6		
		M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR
1	10:00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00
2	11:00	10.37	0.88	0.89	10.35	0.90	0.89	10.30	0.95	0.88	10.26	0.99	0.87	10.25	1.00	0.87	10.20	1.05	0.86
3	12:00	9.63	0.75	0.76	9.61	0.74	0.76	9.57	0.73	0.75	9.54	0.72	0.74	9.51	0.74	0.74	9.47	0.73	0.73
4	13:00	9.90	-0.27	0.81	8.96	0.65	0.64	8.91	0.66	0.63	8.89	0.66	0.63	8.84	0.67	0.62	8.80	0.67	0.61
5	14:00	8.16	1.74	0.50	8.12	0.84	0.50	8.09	0.83	0.49	8.03	0.86	0.48	7.97	0.87	0.47	7.94	0.86	0.46
6	15:00	7.20	0.97	0.33	7.15	0.98	0.32	7.13	0.96	0.32	7.09	0.94	0.31	7.05	0.92	0.31	7.01	0.93	0.30
7	16:00	6.41	0.78	0.20	6.40	0.75	0.19	6.37	0.76	0.19	6.35	0.74	0.18	6.33	0.72	0.18	6.30	0.72	0.17
8	17:00	6.07	0.35	0.13	6.03	0.37	0.13	5.99	0.38	0.12	5.94	0.41	0.11	5.92	0.41	0.11	5.90	0.40	0.11

Tray 7			Tray 8			Tray 9			Tray 10			Tray 11			Tray 12			Mean		
M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR	M.C. % (wb)	D.R. (%/h)	MR
11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00	11.25	0.00	1.00
10.22	1.03	0.86	10.26	0.99	0.87	10.29	0.96	0.88	10.31	0.94	0.88	10.36	0.89	0.89	10.39	0.86	0.89	10.30	0.95	0.88
9.49	0.73	0.73	9.53	0.73	0.74	9.56	0.73	0.75	9.61	0.70	0.76	9.63	0.73	0.76	9.65	0.74	0.76	9.57	0.73	0.75
8.82	0.67	0.62	8.77	0.76	0.61	8.91	0.66	0.63	8.94	0.67	0.64	8.97	0.66	0.64	9.02	0.64	0.65	8.98	0.80	0.65
7.96	0.86	0.47	8.01	0.76	0.48	8.07	0.84	0.49	8.12	0.83	0.49	8.15	0.82	0.50	8.18	0.84	0.51	8.07	0.91	0.49
6.98	0.98	0.30	7.02	0.99	0.30	7.07	1.00	0.31	7.09	1.03	0.31	7.13	1.03	0.32	7.18	1.01	0.33	7.09	0.98	0.31
6.35	0.64	0.18	6.39	0.64	0.19	6.42	0.65	0.20	6.46	0.63	0.20	6.50	0.62	0.21	6.54	0.63	0.22	6.40	0.69	0.19
5.91	0.44	0.11	5.95	0.44	0.11	5.98	0.45	0.12	6.02	0.44	0.13	6.05	0.46	0.13	6.09	0.45	0.14	5.99	0.41	0.12

M.C. = Moisture Content; D.R. = Drying Rate ; MR = Moisture Ratio

Table 9: Mean values of biochemical parameters of groundnut kernels dried solar dryer

Sr. No.	Moisture Content (%(w.b.))	Protein Content (%)	Carbohydrate Content (%)	Fat/Oil Content(%)
1	6.88	23.77	22.36	46.04
2	6.55	24.27	21.68	45.23
3	6.87	23.59	22.68	46.64
4	6.28	23.88	22.63	44.82
5	6.95	23.23	21.89	45.79
Mean	**6.71**	**23.75**	**22.25**	**45.70**
SD	**0.11**	**0.38**	**0.45**	**0.71**

Table 10: Mean values of biochemical parameters of groundnut kernels dried by sun drying

Sr. No.	Moisture Content (%(w.b.))	Protein Content (%)	Carbohydrate Content (%)	Fat/Oil Content(%)
1	8.54	22.58	20.79	41.90
2	8.85	23.06	20.16	41.16
3	7.50	22.41	21.09	42.44
4	7.30	22.69	21.05	40.79
5	8.10	22.07	20.36	41.67
Mean	**8.06**	**22.56**	**20.69**	**41.59**
SD	**0.59**	**0.32**	**0.37**	**0.58**

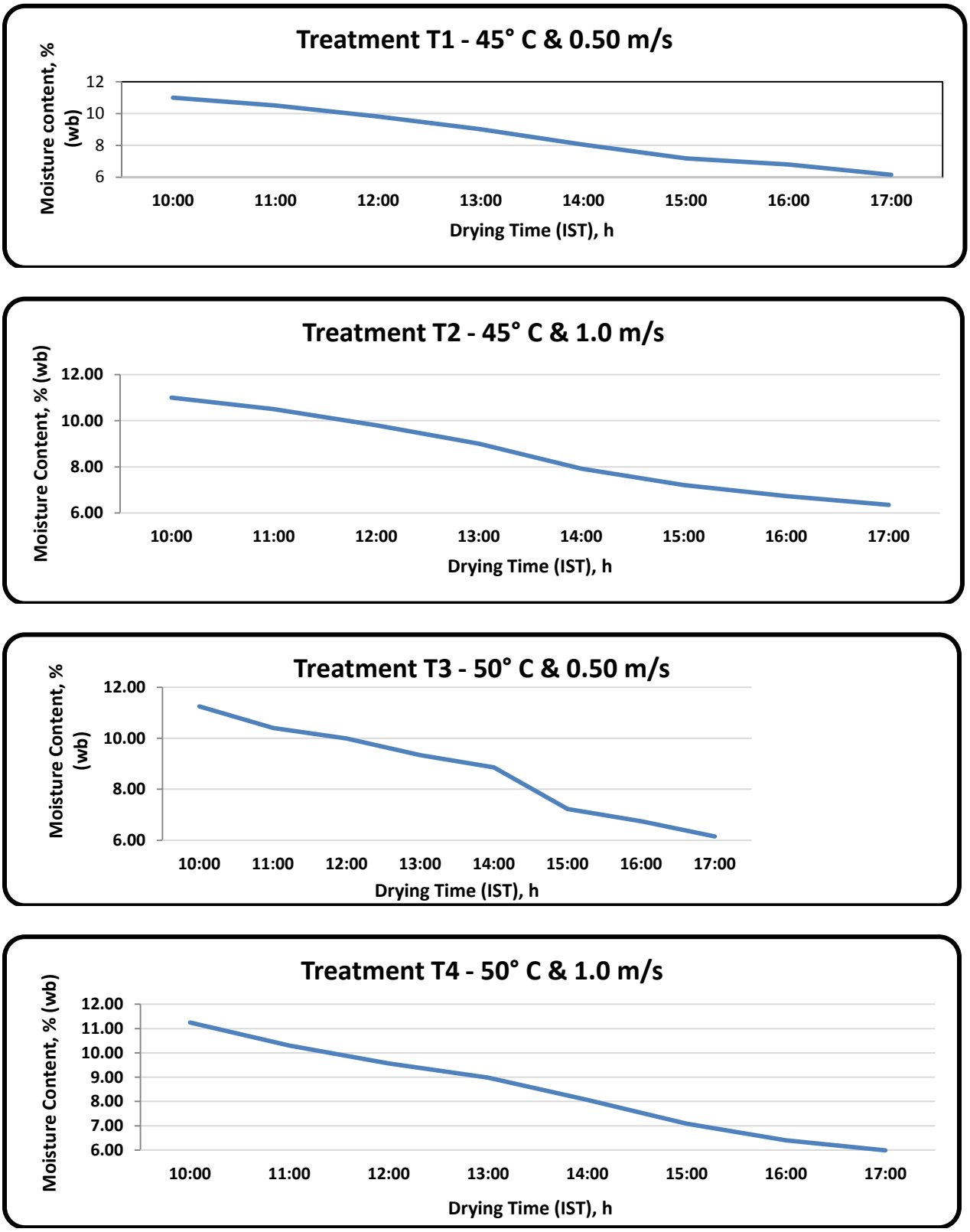

Figure 1: Relationship between drying time and moisture content for different treatments

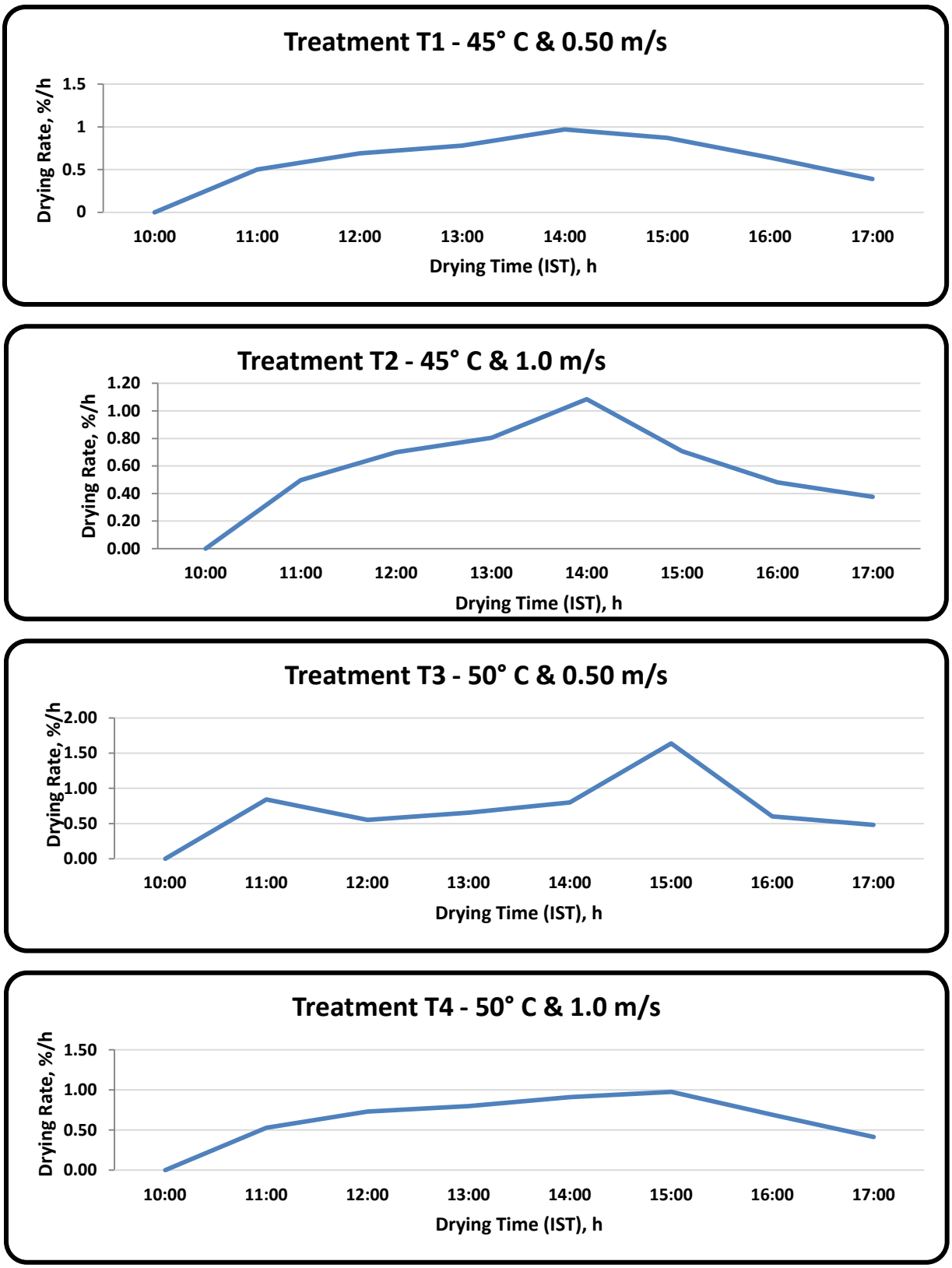

Figure 2: Relationship between drying time and drying rate for different treatments

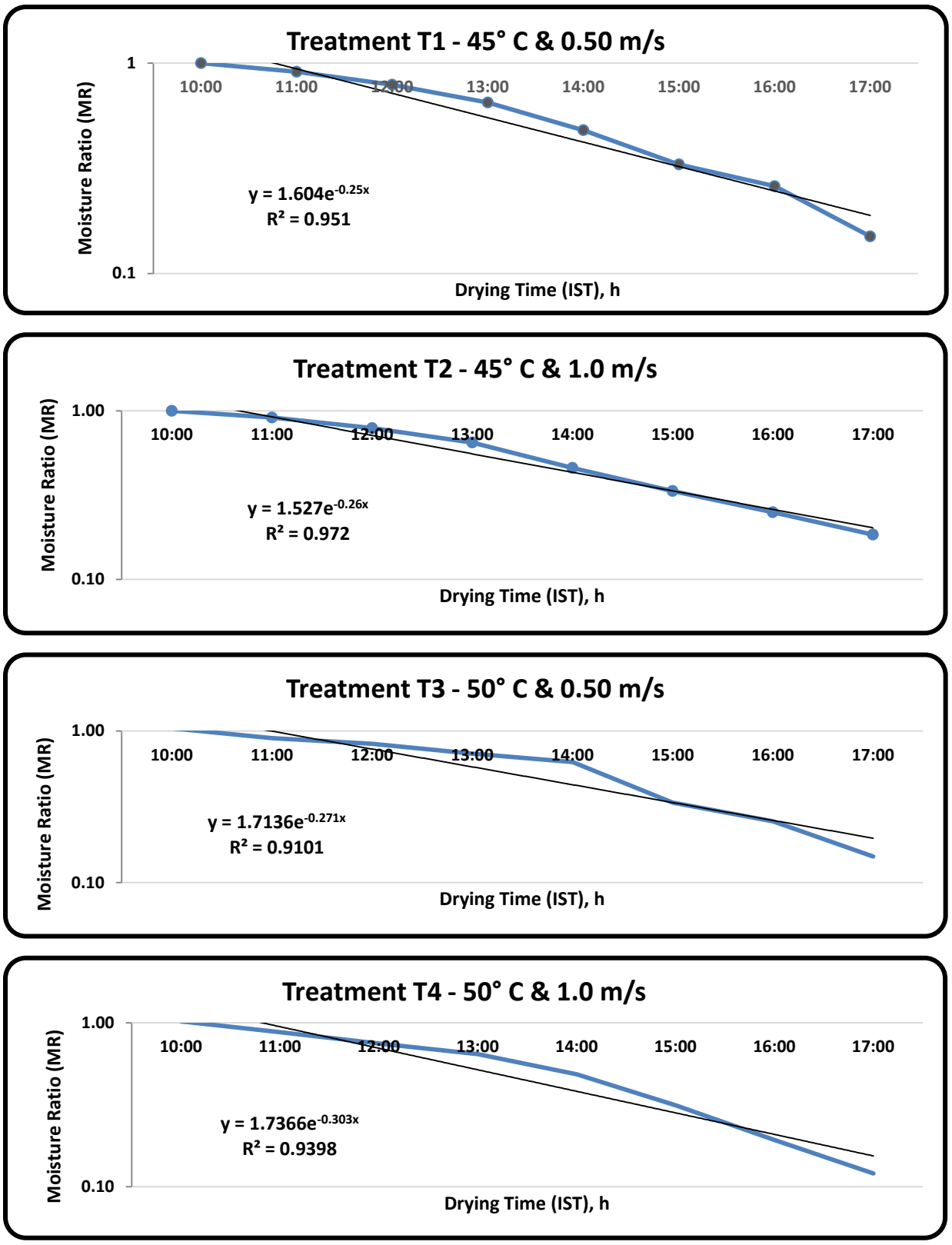

Figure 3: Relationship between drying time and moisture ratio for different treatments

Plate 1: Groundnut pods (GG 20)

Plate 2: Biochemical analysis of groundnut pods (GG 20)

Plate 3: Drying of groundnut pods using solar dryer

[MS received : March 18, 2018] ***[MS accepted : March 24, 2018]***