Jewel Journal of Scientific Research (JJSR) 7(1): 141–149, 2022
©Federal University of Kashere-Nigeria (Print ISSN: 2384 – 6267, Online ISSN 2756-651X)
jjsr.fukashere.edu.ng

Post-Harvest Physiology of Tomato (*Solanum lycopersicum* L. Mill) under different Drying Environments and Methods

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Abstract
Post-harvest losses of tomato (*Solanum lycopersicum* L. Mill) are enormous making output not commensurable with cost of production talk less of profit. Post-harvest management that will reduce lost and make the product available during off-season becomes pertinent. Thus, this research was conducted at the Teaching and Research Farm, Department of Agronomy, Federal University of Kashere, Gombe State, Nigeria (Latitude 95^0 45" 50.34" N and Longitude 11^0 00" 24.43"), to study the post-harvest physiology of tomato under different drying environments and methods. Solar drier was constructed using blocks, cement, iron bars, wire mesh, black paint and polythene sheets for Experiment 1. A tarpaulin was obtained for sun drying in farmer's way in an open environment as Experiment 2. Tomato was obtained from the market to form the treatments of the two experiments as follows: sliced and dried inside the solar drier, unsliced and dried inside the solar drier, sliced and dried on tarpaulin outside the solar drier and unsliced and dried on tarpaulin outside the solar-dried. The parameters assessed for the two experiments were weight loss (g), days to final drying, percentages physical appearance, fungal load, total dry matter, crude protein, oil content, crude fibre, ash and nitrogen-free extract. Data generated were subjected to analysis of variance and means were separated using least significant differences at 5 %. The two experiments were compared using bar charts. Results revealed that sliced tomato inside the solar drier, dried within few days (5 days) with good physical appearance, low fungal load and other contaminants. Thus, solar drier environment and sliced tomato method should be adopted to curb post-harvest wastage and make tomato available during off-season.

Keywords: Solar drier, Tarpaulin, Tomato, sliced, unsliced

Received: 20th Mar, 2022 *Accepted:* 21st April, 2022 *Published Online:* 5th June, 2022

Introduction

Tomato (*Solanum lycopersicum* L. Mill) is the most important vegetable crop in Nigeria and indeed the rest of the world. Global tomato production is estimated at 162 million tonnes with Nigeria being the second producer in Africa producing about 1.6 million tons (FAOSTAT, 2014). Tomato is considered for its rich source of vitamins and minerals with various culinary uses either in its fresh form, as salad or as puree in stew and soups (Arah *et al*., 2015). Tomato production is also a source of income to farm-farming families and marketers.

Despite the importance of fruit vegetables such as tomato and pepper as a source of vitamins, minerals (Arah *et al*., 2015), and a source of income; inadequate postharvest handling, lack of appropriate processing technology and storage facilities, poor infrastructure as well as poor marketing systems (Buyukbay *et al*., 2011) accounts for its great losses (Kereth *et al*., 2013). Due to poor storage conditions by using local storage facilities such as sacks, baskets, etc. the resistance of vegetables to diseases usually declines, leading to infection by pathogens causing a post-harvest yield loss between 40-60% more than that from the improved storage facilities of 20-25% (Awan *et al.,* 2012). For farmers to make appreciable income and curb the anomalies highlighted; preservation in an affordable way and make it available year-round at appreciable prices becomes paramount. Thus, the objectives of this study to develop solar tent drier to tomato farmers using low external input and sustainable agriculture and to determine the differences between the solar drier and the traditional methods of drying.

Materials and Methods

Two experiments were carried out at the Teaching and Research Farm, Department of Agronomy, Federal University of Kashere, Gombe State, Nigeria (Latitude 95^0 45” 50.34” N and Longitude 11^0 00” 24.43”) to study the Postharvest Physiology of Tomato (*Solanum lycopersicum* L. Mill) under different drying environments and methods. Solar drier was constructed using; blocks, cement, iron bars, wire mesh, black paint and polythene sheets as one of the drying environments (Experiment 1). A tarpaulin was obtained as another drying environment (sun drying as practice by local farmers), Experiment 2. A local tomato variety ROMA VF fruits were obtained from Kashere market for the experiments. The treatments are sliced and dried in the solar drier, unsliced and dried in the solar drier, sliced and dried on tarpaulin outside the solar drier and unsliced and dried on tarpaulin outside the solar drier (Plates 1 & 2). The treatments were arranged in a Randomized Complete Block Design. Data were collected on rate of drying at two days intervals, number of days to fully dried fruits, physical appearance (measured using a scale of 1 - 9 where 1 – 3 is not appreciable, 4 – 6 is moderately appreciable and 7 – 9 is appreciable), total fungal load (yeast/mould) and other contaminants. A sample of the tomatoes after drying was taken to laboratory for proximate analysis to determine total dry matter, crude protein, oil content, crude fibre, ash and nitrogen free extract using standard procedure AOAC (1990). Data generated was analyzed using analysis of variance (ANOVA) using SAS (SAS, v8, 2000) and treatment means were compared using the least significant difference (LSD) at 5% level of probability. Furthermore, the two experiments were compared using bar charts.

Plate 1: Outside (left) and inside (right) view of locally constructed Tomato Solar drier

Plate 2: Dried tomato inside solar drier (left) and dried tomato on tarpaulin outside solar drier (right)

Results and Discussion

The effect of drying environment and methods on weight loss (g day^{-1}) of tomato (*Solanum lycppersicum* L. Mill) is presented in Table 1. There was a highly significant difference ($P < 0.01$) among the treatment means due to drying environments and methods. Sliced tomatoes lost weight significantly faster than the un - sliced with lower mean weight value throughout the sampling periods. Furthermore, when the drying environments were compared weight lost in both the sliced and un – sliced was faster inside the solar drier (Figure 1). The faster weight lost on the sliced tomato may be due to the increase in the surface area due to cutting. Similarly, weight lost in the solar drier may be due to increase in temperature (Figure 2), black surface is known to absorb solar radiation, and the flow of the solar drier was painted black. In the other hand slow loss of moisture on the tarpaulin may be due high moisture level of the environment during the period of the experiment. The result of this study agreed with the report of Idah *et al*. (2010) that temperature and slicing of tomato promotes rapid drying.

Table 1: Effect of drying environment and method on weight loss (g day^{-1}) of tomato (*Solanum lycopersicum* L. Mill)

	Day 1		Day 3		Day 5		Day 7	
Treatment	**S/drier**	**Tarpaulin**	**S/drier**	**Tarpaulin**	**S/drier**	**Tarpaulin**	**S/drier**	**Tarpaulin**
Sliced	220.60	290.00	149.68	171.75	111.00	145.28	86.62	137.05
Un-sliced	299.38	313.33	255.72	284.35	200.73	211.90	146.55	184.61
LSD	60.650	14.556	37.056	53.528	11.074	6.512	38.194	30.366
S/level	**	**	**	**	**	**	**	**

S/drier = solar drier S/level = signifant level ** = highly signicant ($P < 0.01$)

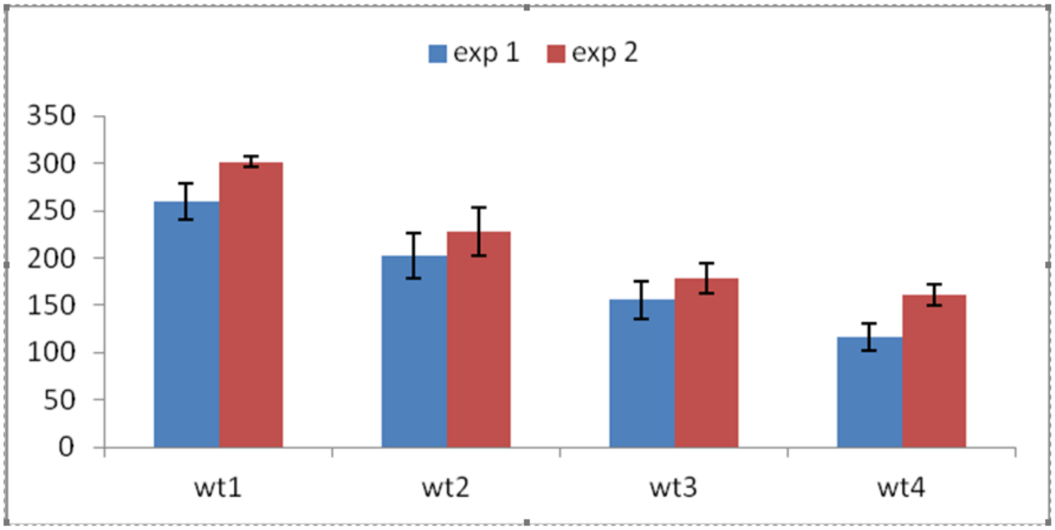

Figure 1: Comparative rate of weight (g) loss of tomato (*Solanum lycopersicum* L. Mill) in the drying environments. Wt = week, exp 1 = solar drier, exp 2 =tarpaulin. Error bars represent standard error (n = 3)

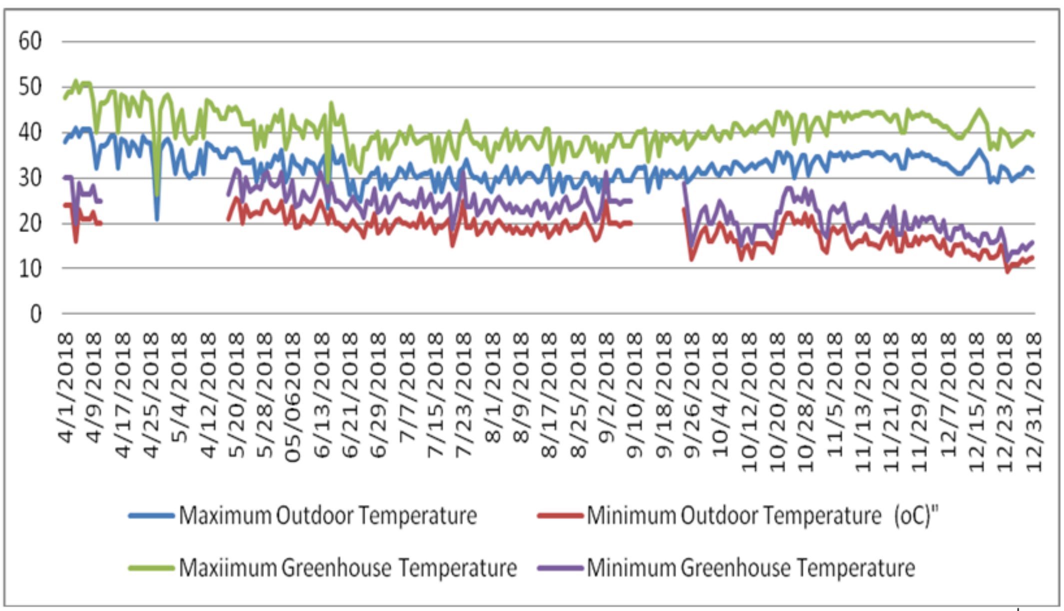

Figure 2: Minimum and maximum temperatures (^{0}C) of the drying environments of Tomato (*Solanum lycopersicum* L. Mill)

The effect of drying environment and methods on number of days to final drying of tomato (*Solanum lycopersicum* L. Mill) is presented in Table 2. There was a highly significant difference ($P < 0.01$) among the treatment means due to drying environment and method. The un-sliced tomato significantly gave a higher mean value on number of days to final drying over the sliced in the drying environments. Similarly, when the two drying environments (Figure 3) were compared both the sliced and un – sliced tomatoes took fewer days to dry in the solar drier than that dried on tarpaulin. This may be connected with the heat generated in the solar drier. Also in Table 2 the physical appearance for the two drying environments and methods was significant in the solar drier with sliced tomato looking more appreciable at day 5 and 7 after drying. No significant effect of drying methods on physical appearance in the two drying environments and method at day 3 and all days on the tarpaulin. When the two drying environments were compared (Figure 3), tomato dried in the solar drier was more appealing. This result may be due to control environment found in the solar drier, no foreign body will contaminate the tomatoes.

Table 2: Effect of drying environment and method on number days to final drying and physical appearance of tomato (*Solanum lycopersicum* L. Mill)

	Days to final drying		Physical appearance rating					
			Day 3		Day 5		Day 7	
Treatment	S/drier	Tarp	S/drier	Tarp	S/drier	Tarp	S/ drier	Tarp
Sliced	5.33	8.67	8.00	6.00	7.00	5.33	6.00	4.60
Un-sliced	7.33	11.67	8.33	2.33	6.00	2.33	5.00	3.00
LSD	1.235	2.484	1.440	3.795	0.305	4.234	0.345	2.868
S/level	**	**	ns	ns	*	ns	*	ns

S/drier = solar drier, S/level = signifant level ** = highly signicant ($P < 0.01$), * =signifant ($P \leq 0.05$), ns = not significant ($P > 0.05$), Tarp = tarpaulin

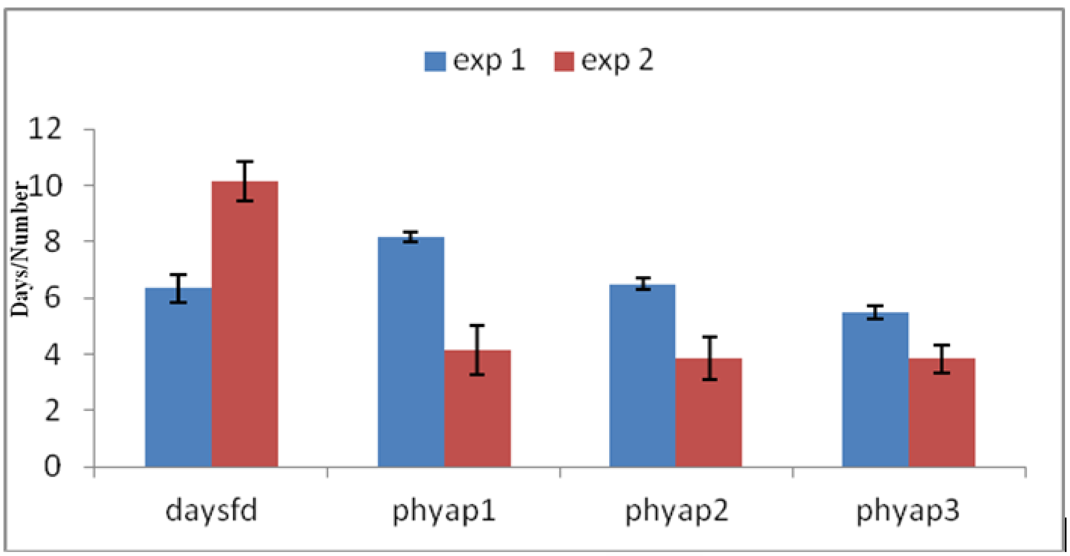

Figure 3: number of days to final drying (daysfd) and physical appearance (phyap) of Tomato (*Solanum lycopersicum* L. Mill) in the drying environments. exp 1 = solar drier exp 2 = tarpaulin. Error bars represent standard error (n = 3)

Table 3 shows the effect of drying environment and methods on fungal load ($cfug^{-1}$) and other contaminants in tomato (*Solanum lycppersicum* L. Mill). There was no significant difference ($P > 0.05$) among the treatment means due to drying methods. But when the growing environments (Figure 4) were compared tomato dried on the tarpaulin had higher contaminants. The highest colony forming on tomato outside the solar drier may be due to poor handling and exposure to free environment. According to Khadka *et al*. (2017) some microorganisms are present as natural microflora in tomato which can be more active under natural environment. Khadka *et al*. (2017) further reported that fungi are among the microbes that affect shelf life of tomato which made it unsafe for human consumption at highest level.

Table 3: Effect of drying environment and method on fungal load (cfug^{-1}) and other contaminants in tomato (*Solanum lycopersicum* L. Mill)

Treatment	Solar drier	Tarpaulin	Solar drier	Tarpaulin
Sliced	3333	30000	3333	30000
Un-sliced	16667	43333	2000	43333
LSD	14342	37946	37946	37946
Significance level	Ns	ns	ns	ns

ns = not significant (P > 0.05)

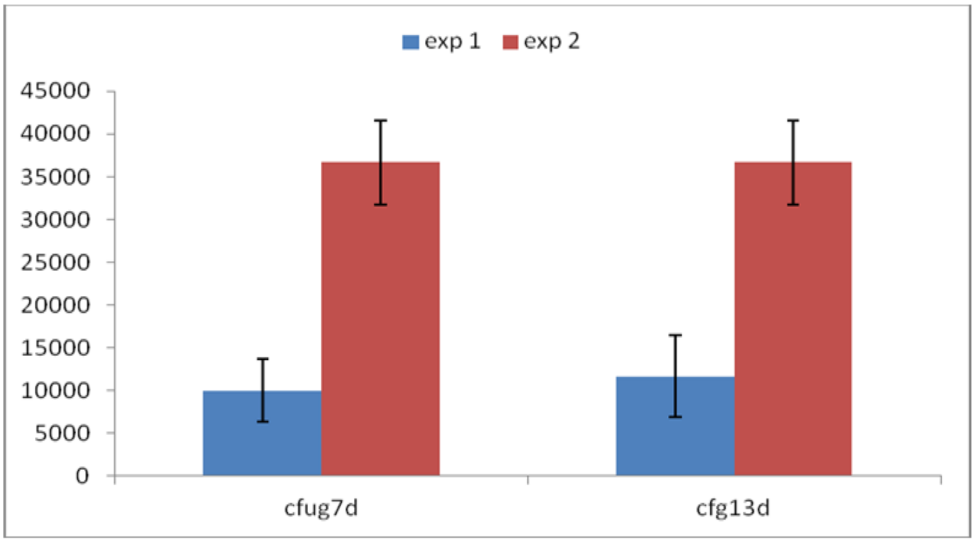

Figure 4: Comparative fungal load (cfug^{-1}) and other contaminants in tomato (*Solanum lycopersicum* L. Mill) after drying in the drying environments. exp 1 = solar drier exp 2 = tarpaulin. Error bars represent standard error (n = 3)

Table 4 shows the effect of drying environment and methods on percentage dry matter, crude protein and oil content of tomato (*Solanum lycppersicum* L. Mill). There was no significant difference (P > 0.05) among the treatment means on the parameters measured. Even when the environments (Figure 5, 6 & 7) were compared no significant differences was observed.

Table 4: Effect of drying environment and method on Dry matter, Crude protein and Oil content of tomato (*Solanum lycopersicum* L. Mill)

	Dry matter (%)		Crude protein (%)		Oil content (%)	
Treatment	**S/drier**	**Tarp**	**S/ drier**	**Tarp**	**S/ drier**	**Trap**
Sliced	85.56	85.42	5.49	5.14	0.97	0.91
Un-sliced	86.35	84.44	4.76	5.11	0.87	1.01
LSD	3.115	2.466	1.311	0.291	0.545	0.259
Significance level	Ns	ns	ns	Ns	ns	Ns

ns = not significant (P > 0.05). S/drier = solar drier, Tarp = tarpaulin

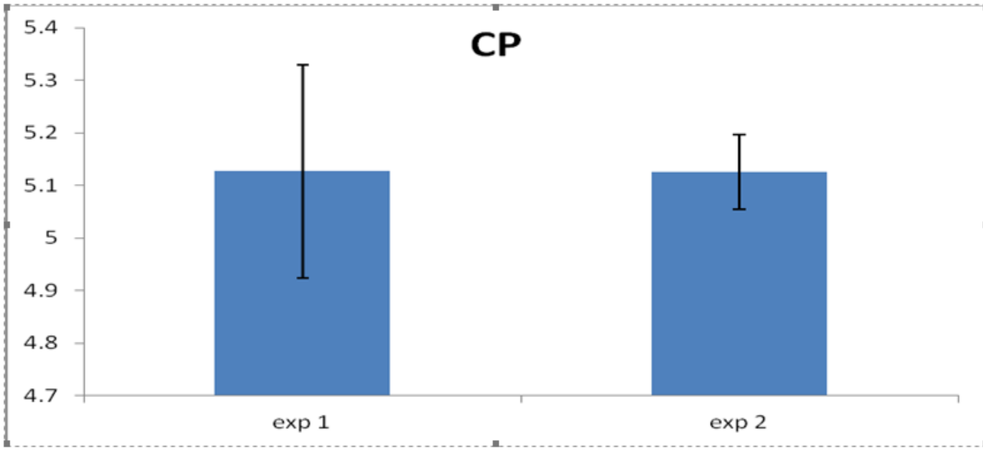

Figure 5: Comperative percentage of crude protein (CP) after drying of tomato (*Solanum lycopersicum* L. Mill) in the drying environments. exp 1 = solar drier exp 2 = tarpaulin. Error bars represent standard error (n = 3)

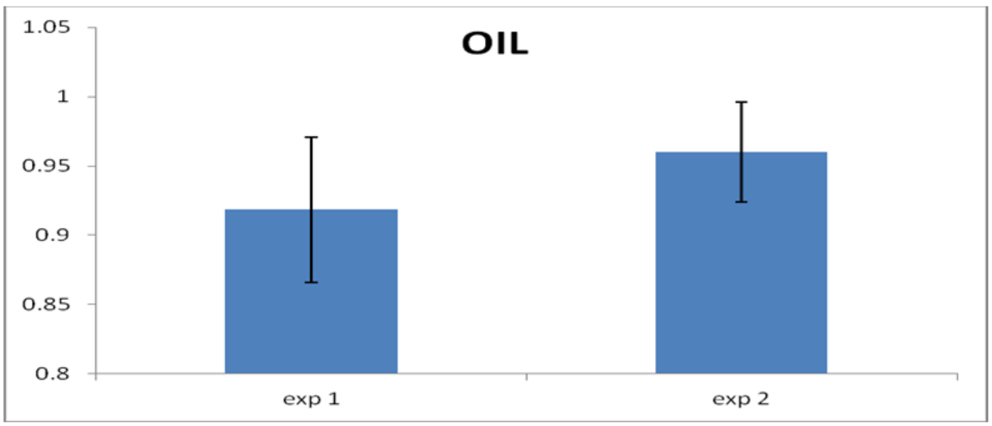

Figure 6: Comperative percentage oil after drying of tomato (*Solanum lycopersicum* L. Mill) in the drying mediums. exp 1 = solar drier exp 2 = tarpaulin. Error bars represent standard error (n = 3)

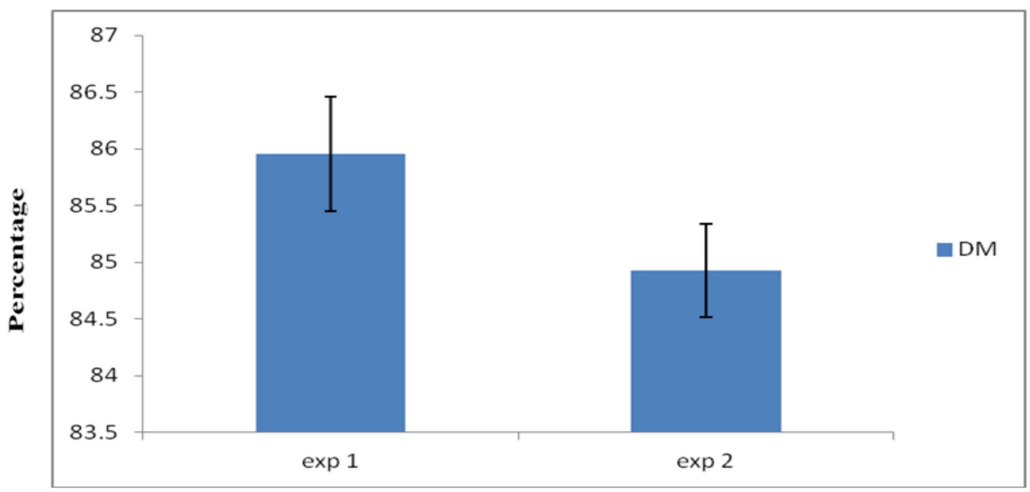

Figure 7: Percentage dry matter (DM) after drying of tomato (*Solanum lycopersicum* L. Mill) in the drying mediums. exp 1 = solar drier, exp 2 = tarpaulin. Error bars represent standard error (n = 3)

Table 5 shows the effect of drying environment and methods on percentage crude fibre, Ash and nitrogen free extract of tomato (*Solanum lycppersicum* L. Mill). There were no significant differences (P > 0.05) among the treatment means due to drying methods on the parameters. Similarly, drying environment (Figure 8) had no significant differences. This observation disagrees with Babalola *et al.* (2010), who had earlier reported that in developing countries, storage, packaging, transport and handling techniques are practically non-existent for perishable crops, this allows for considerable losses of produce.

Table 5: Effect of drying environment and method on crude fibre, Ash and Nitrogen free extract of tomato (*Solanum lycopersicum* L. Mill)

	Crude Fibre (%}		Ash (%)		Nitrogen Free Extract (%)	
Treatment	**Solar drier**	**Tarp**	**Solar drier**	**Tarp**	**Solar drier**	**Trapaulin**
Sliced	13.89	16.40	14.11	17.62	74.19	66.59
Un-sliced	22.91	16.17	19.25	17.85	52.22	59.87
LSD	28.516	7.791	16.425	14.022	18.555	31.628
Significance level	Ns	ns	Ns	ns	Ns	Ns

ns = not significant (P > 0.05), Tarp = tarpaulin

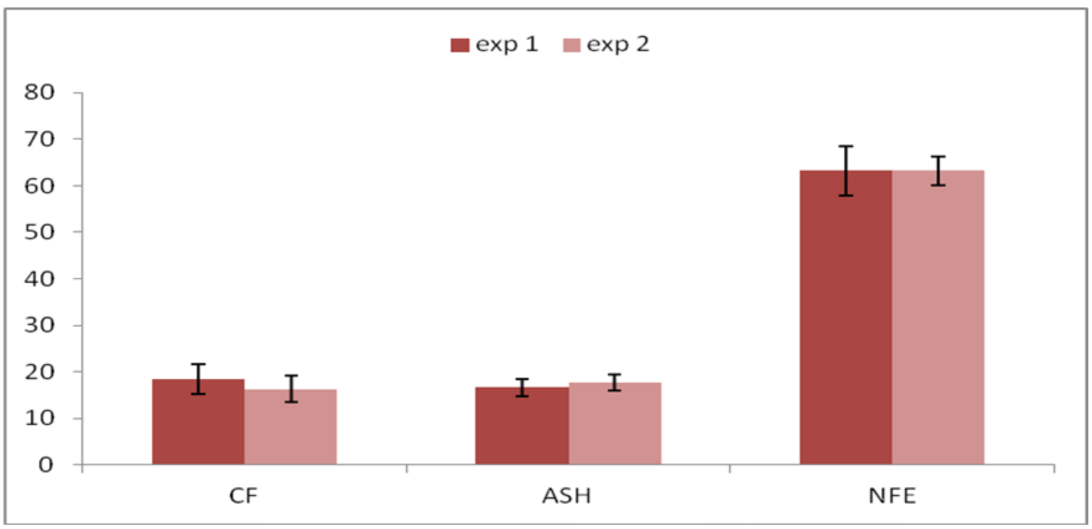

Figure 8: Comparative percentage of crude fibre (CF), ash and nitrogen free extract (NFE) after drying of tomato (*Solanum lycopersicum* L. Mill) in the drying environments. exp 1 = solar drier exp 2 = tarpaulin. Error bars represent standard error (n = 3)

Conclusion

Drying environment and method have a significant influence on tomato drying, appearance and contaminations. Thus, tomato can be best dried in a solar drier, sliced or unsliced, but the sliced tomato is the best. It dries faster within five days with less handling, good physical appearance and low fungal load and other contaminants. Thus, should be adopted to curb wastage and make it available during offseason.

Acknowledgement

The Research team wishes to thank the Federal University of Kashere (FUK) and the Tertiary Education Trust Fund (TETFUND) for sponsoring the research through the Institutional Based Research (IBR).

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