American Journal of Open Research, 2(6), June, 2023, 226-234
E-ISSN: 2834-7668

OPSearch
American Journal of Open Research

COMPARATIVE STUDY BETWEEN OPEN-DIRECT SUN AND SOLAR DRYING OF ONION SLICES (ALLIUM CEPA L.)

Abdel Moneim O. A. Babiker[1], Um Elhassan H.M. Khiar[2], Mortada H.A. Elhesain[3], SH. E. Idriss[4], Sulieman O, A. Figeada[5], Mohammed Abdalla[6]*

[1,2,3,4,5,6]*University of El Imam El Mahdi, Kosti, Sudan*
*e-mail: mohamed25ft@yahoo.com**

*Corresponding Author

Abstract: *Thin layer drying of onion slices (Allium et al.) was experimentally investigated using a free convective solar dryer and open-direct sun. The objective of this study is to compare the two methods of drying onions. The data of sample weight for open-direct sun and solar drying experiments were hourly recorded, drying rate (g water/100 g DM) and moisture contents (%) in dry basis (d,b) and wet basis (w,b) were calculated. Quality analysis for protein, fats, fiber, ash, and carbohydrates contents was also analyzed and evaluated. According to the results, direct open sun drying of onion slices took (19 hours) with a final moisture content of 16% and 13.5% dry basis and wet basis, respectively. At the same time, solar drying took (32 hours) with a final moisture content of 10% and 9.08% dry basis and wet basis, respectively. Solar drying showed a high drying rate as compared with direct sun drying. However, the two drying methods have a high drying rate at noon. The drying experiments showed no constant rate period but a falling rate period. For quality assessments or evaluation of onion slices, onion dried with the direct open sun was very dirty and contaminated with some foreign materials and microorganisms, while onion dried with solar showed no contamination. For quality evaluation analysis of protein, ash, fat, fiber, and carbohydrates contents, these constituents showed an increase for boss solar and direct open sun drying of onion. This is because drying reduces the moisture content of the product significantly; therefore, the dry matter was increased as a percentage.*

Keywords: *Open-direct sun, solar drying, onion slices, drying rate, and moisture content*.

INTRODUCTION

The Onion (Allium et al.) is one of the main crops under the Allium family, cultivated mainly in tropical countries for a long time (Sivamma et al., 2021). Except for the southern part, nearly every region of Sudan produces onions (Abdelaziz, 2008). In Sudan, onion is one of the essential vegetables cultivated in about 33% of the total cultivated area with vegetables (Dawelbeit et al., 2010). Including onions in all diets, particularly those of Sudanese people, makes them a significant component of human nutrition. Due to its detoxifying qualities, the pungent odor may protect you from disease and make you glow as fast-acting are certain prescription medications as an onion. Cure for allergies, the common cold, cough, and sore throat. These issues are quickly resolved by combining honey and onion juice (DeSisto et al., 2014).

The estimated percentage of losses in developing countries when stored fresh onion is very high, up to about 16-35% (Albuquerque, 2010). In Sudan, this Figure reaches 60% in storage for up to five months (Musa et al., 1973). One of the earliest ways of food preservation is drying, which is a challenging food processing operation due to unfavorable changes in the quality of the dried product. Drying is also one of the most popular processes to increase food stability (An et al., 2021). Drying is one of the standard methods to reduce water content in food. By reducing water, the concentration of the component contained in onion will increase. At the same time, drying can reduce storage space and shipping costs. Besides, drying to less than 10% water content can also inhibit microbial growth, causing shelf life extension (Djaeni & Perdanianti, 2019). Drying is a phenomenon of liquid removal by evaporation from a solid (Visavale, 2012). The main aim of drying products is to allow more extended storage periods, minimize packaging requirements and reduce shipping weight (Ismail & Ibn Idriss, 2013). Dehydration is described as removing all moisture from a product until completely dry. This is the equilibrium limit (complete drying) (Babiker et al., 2014). Direct sun energy was used to dry and preserve food a long time ago. However, direct sun drying caused contamination of the products by exposure to dust and dirt, and some insects and pests affected the quality of the product. Solar drying using dryers helps protect the product from contamination increases the air's temperature, and reduces relative humidity. As a result, the drying rate will increase. Therefore, this study's main objective is to compare the open-direct sun and solar drying of thin-layer onion slices.

MATERIALS AND METHODS

A. Materials

Onion (Allium ceapa L.) type was bought from Kosti local market, White Nile State, Sudan was used as testing materials for the experiment.

B. Equipment

1. Solar dryer: A previously constructed natural convective solar dryer was used for carrying out the drying trials of onion slices.
2. Sensitive balance: A digital sensitive balance of model Yass-620 with a capacity of 620 g and an accuracy of ±0.01 g. The scale of Yamato make, made in Japan, was used for moisture content determination of onion,
3. Oven: An oven of Electro Helios make was used for onion moisture content determination, and it had a temperature range of 0-300ºC.
4. Crucibles: were used for holding the samples in the oven for drying and moisture content determination.
5. Stopwatch: was used to record the time.

The methods adopted for carrying out the experiments were as follows:

1. Drying trails for thin-layer onion slices

Drying experiments were carried out using the natural, free convective solar dryer. The solar drying experiments were carried out during April and May. The justification for selecting these months is that these months are almost the hottest ones of the year (Hassan, M. A, 1996). Onion (Allium ceapa L.) was used as testing material for the experiment.

2. The preparation of onion for drying

The head (end of leaves), tail (stem and roots), and outer leaves of the onion were cut and removed using stainless steel knife. Then the onion was cut into thin layer slices). (3mm to 4mm). Two represented samples of (9.9 grams each) for each method (open-direct sun and solar drying) were taken and wrapped with aluminum foil for initial moisture content determination. The drying process was done as follows: The starting time was recorded using a stopwatch. Initially, the weight of the represented onion samples was recorded at zero time. The measurement mentioned above was recorded at intervals of one hour throughout the experimental period, which took three days (32 h), interrupted by two overnights for the solar drying test, and two days (19 h), interrupted by one overnight for open-direct sun drying. The two represented samples (solar and direct-open sun) were taken and wrapped with aluminum foil for final moisture content determination using the oven method.

3. Moisture content determination

Initial and final moisture content was determined according to the method described by (Chemists & (US), 1925). The moisture content of the samples was calculated using the following equations:

(i) $MC(w.b.) = \frac{W_w}{W_w + W_d} \times 100$ ....(1)

(ii) $MC(d.b.) = \frac{W_w}{W_d} \times 100$ ....(2)

Where: -

MC (w.b.) = onion moisture content on a wet basis, percent

MC (d.b.) = onion moisture content on a dry basis, percent

W_w = mass of water, g

W_d = mass of dry matter, g

4. Drying rate determination

The drying rate was calculated using the following equation (Akpinar et al., 2003). Drying Rate (DR) = ...(3)

Where: -

DR = Drying Rate (g of water/g DM.h)

Mt = Moisture content at time t, dry basis

Mt+dt = Moisture content at time t + dt, dry basis, percent.

5. Quality Analysis of Onion

The quality analysis of solar drying and open-direct sun drying of onion was done by determining the following parameters:

1- Chemical composition of onion

(i) Crude oil determination:

Crude oil (CO) was estimated according to the official method described by (Chemists & (US), 1925). Duplicate samples for solar and sun drying of onion were used, and then an average was taken for each test. The crude oil was calculated as a percentage by the following equation:

$CO\% = \frac{W_2 - W_1}{S} \times 100$ ....(4)

Where: -

W_1 = mass of empty crucible, g

W_2 = mass of crucible + oil, g

S = mass of sample, g

(ii) Nitrogen and crude protein determination:

The nitrogen content for the solar and direct sun drying of onion was determined according to the Kjeldahl method described by (Chemists & (US) 1925). The nitrogen content was multiplied by a factor of 6.25 to obtain the percentage of crude protein by the following equation:

$\text{Crude protein } (\%) = \frac{\text{T} \times \text{N} \times 14.0 \times 6.25 \times 100}{W \times 1000}$ ....(5)

Where: -

T = titration number of HCl

N = normality of HCl (0.02N)

W = mass of sample, g

14 = mass of nitrogen molecular, g

6.25 = protein conversion factor

1000 = number of milligrams in one gram

(iii) Crude fiber determination:-

The crude fiber was calculated using the following equation:

$$CF\% = \frac{W_1 - W_2}{S} \quad \text{.....(6)}$$

Where: -

CF % = crude fiber, percent

W_1 = mass of the sample after drying and before being ignited in a muffle furnace, g

W_2 = mass of the sample after being ignited by a muffle furnace, g

S = mass of the sample, g

(iv) Ash content determination: -

Total ash for solar and open-direct sun drying of onion samples was estimated according to the official method described by (Chemists & (US) 1925). The ash content was calculated using the following formula:

$$\text{Total ash\%} = \frac{W_2}{W_1} \times 100 \quad \text{.....(7)}$$

Where: -

W_1 = original mass of sample, g

W_2 = mass of the sample after igniting,

RESULTS AND DISCUSSION

A. Results of the drying experiments:

Table 1. Hourly recorded sample weight, measured moisture contents (w.b and d.b), and drying rate of onion slices during three days of solar drying experiments.

Drying period		Drying test Weight (g)	Moisture content		Drying rate (g water / 100 g DM.h)
Hours	Time		Wet basis(w.b)	Dry basis(d.b)	
First day					
0	7:30	9.9	90.8	990	110
1	8:30	9.2	89.1	820	110
2	9:30	8.1	87.6	710	110
3	10:30	7.0	85.7	600	100
4	11:30	6.1	83.6	510	90
5	12:30	5.9	81.7	450	60
6	1:30	5.0	80.0	400	50
7	2:30	4.8	79.2	380	40
8	3:30	4.7	78.7	370	35
9	4:30	4.1	75.6	310	30
10	5:30	3.8	73.6	280	30
Second day					
11	7:30	3.8	73.6	280	0
12	8:30	3.7	72.9	250	30
13	9:30	3.6	72.2	230	20
14	10:30	3.5	71.4	220	10

15	11:30	3.1	67.7	210	10
16	12:30	2.9	65.5	190	20
17	1:30	2.6	61.5	160	30
18	2:30	2.4	58.3	140	20
19	3:30	2.3	56.5	130	10
20	4:30	2.2	52.3	120	10
21	5:30	1.9	47.3	90	30
			Third day		
22	7:30	1.9	47.3	90	0
23	8:30	1.7	41.10	70	20
24	9:30	1.6	37.50	60	15
25	10:30	1.5	33.30	50	13
26	11:30	1.4	28.50	40	10
27	12:30	1.3	23.00	30	10
28	1:30	1.2	16.60	20	10
29	2:30	1.1	9.09	10	0
30	3:30	1.0	9.08	10	0
31	4:30	1.0	9.08	10	0
32	5:30	1.0	9.08	10	0

Table 2. hourly recorded sample weight, measured moisture contents (w.b and d.b), and drying rate of onion slices during two days of open-direct sun drying experiments.

First day					
Drying period		Drying test Weight (g)	Moisture content		Drying rate (g water/100 g DM.h)
Hours	Time		Wet basis(w.b)	Dry basis(d.b)	
0	7:30	9.9	89.1	825	100
1	8:30	8.7	87.8	725	67
2	9:30	7.9	86.8	658.3	83
3	10:30	6.9	85.1	575	58
4	11:30	6.1	83.5	508.3	67
5	12:30	4.2	71.4	250	41
6	1:30	3.7	67.5	208.3	48
7	2:30	3.1	61.2	158.3	39
8	3:30	2.6	53.8	116.6	33
9	4:30	2.2	45.4	83.3	20
10	5:30	2.0	40	66.6	30
			Second day		
11	7:30	2	40	66.6	0
12	8:30	1.9	36.8	50.2	16
13	9:30	1.7	29.4	41.6	8.6
14	10:30	1.6	25	33.3	8.3
15	11:30	1.5	20	25	8.3
16	12:30	1.4	14.2	16.6	6.6
17	1:30	1.2	13.5	16.0	2.4
18	2:30	1.2	13.5	16.0	0
19	3:30	1.2	13.5	16.0	0

Table 3. Variation of ambient air temp. (open-direct sun drying) and heated air temp. (solar drier)

Time (hours)	Ambient air temp. (open-direct sun drying	Heated air temp. (solar drier)
0	33	36.4
1	33.5	36.6
2	34.3	36.9
3	34.5	37.1
4	34.6	37.8
5	34.8	37.9
6	36.1	41.3
7	36.3	41.4
8	37.2	39.2
9	35	38.3
10	35.1	38.2
11	34.3	39.8
12	36.1	41.4
13	36.7	42.6
14	36.4	42.4
15	37.4	43.7
16	37.6	44.1
17	37.8	44.5
18	38	45
19	38.1	45.9
20	-	43.2
21	-	40.1
22	-	37.7
23	-	37.8
24	-	36.9
25	-	36.7
26	-	36.6
27	-	36.1
28	-	35.7
29	-	35.5
30	-	35.5
31	-	36.4
32	-	36.4

Table 4. Mean values of chemical composition in grams per 100 grams of fresh, solar, and open-direct sun drying of onion slices

Chemical composition (%)	A fresh sample of onion	Solar drying sample of onion	Open-direct sun-drying sample of onion
Moisture (w.b)	84.3	9.08	13.5
Protein	2.7	17.24	17.19
Ash	3,6	27.67	27.67
Fat	0.93	9.89	9.88
Fiber	4	40.96	28.83
Carbohydrates	4.47	4.24	3.2

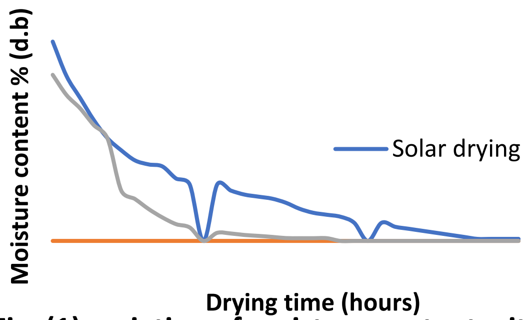

Fig. (1) variation of moisture content with time for solar and direct sun drying

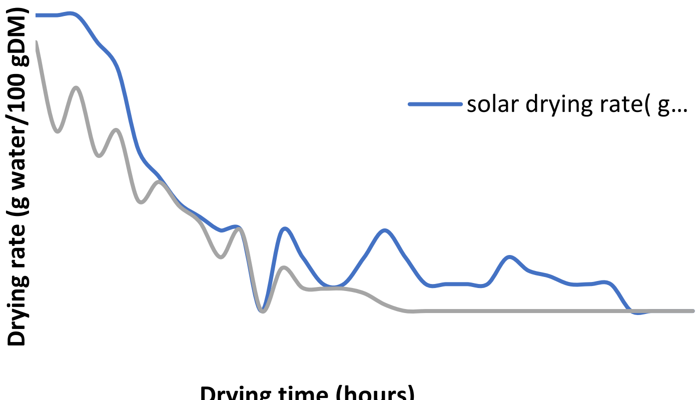

Fig.(2) variation of drying rate with time for solar and direct sun drying of onion slices

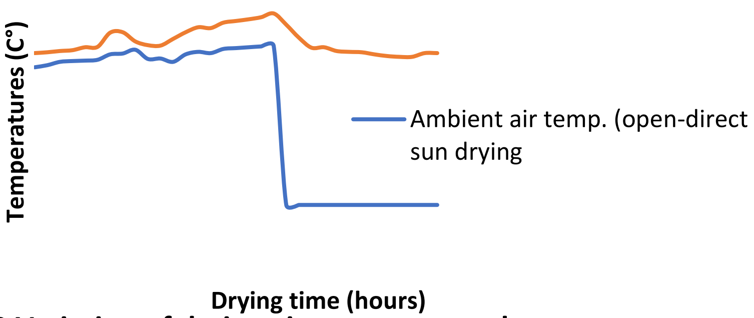

Fig 3 Variation of drying air temperatures between ambient air temp.(open-dircrt sun)and heated air temperature for solar drier

Figure 4. (a) Solar drying slices and (b) Sun drying slices

Table (1 and 2) and Figure. z1, it is clear that the maximum drying speed was performed on the first drying day and reduced in the following days. The drying of onion slices began with an initial weight of 9.9 for each of the two samples (solar and open-direct sun drying). We observed that the dried onion slices through the solar dryer ended with a moisture content of 9.9% on a wet basis and a moisture content of 10% on a dry basis. In comparison, the onion slices dried with open-direct sun started with the same weight and finished with a moisture content of 13.5% on a wet basis and 16% on a dry basis.

Also, from Table 3 and Figure. 3, there was a significant increase in solar drying air temperature compared to ambient air used for the direct-open sun. From these results, although the natural open-direct sun drying dried quickly, the solar dryer with final moisture content was higher than the solar dryer. This may be attributed mainly to the increase of drying air temperature in solar drier, and when it is temperature increased, its efficiency or ability to pull the moisture from the moist products also increases. The high moisture content of onions dried with open-direct sun affects the quality of onions during storage because the storage requires less moisture content. So, drying with a solar dryer is safer for optimum storage of onions and good product quality. These findings agree with (Amjad et al., 2021) in their study design and performance elevation of solar vegetable dryers and (Doymaz 2005) for okra drying.

Table (4) shows the chemical composition of fresh, solar drying, and open-direct sun drying experiments. The onion drying decreased its moisture content through open-direct sun and solar drying. As shown in Table (4), the percentage of dry matter for both sun and solar drying was increased significantly due to the decreasing moisture content for the two methods of drying (solar and open-direct sun drying). Generally, the increase of dry matter for solar is higher than the sun drying because the moisture removed by the solar dryer is higher than that removed by the open-direct sun. This means that drying improves the quality of the products by reducing their moisture content. Figure. (2) The comparison between drying rate (g water/100 DM.h) for solar and direct sun drying of onion slices. From the Figure, it is clear that the drying rate of solar is higher than direct sun. This is because the drying air temperature was increased significantly in solar collectors compared to drying air temperature in direct sun, so the drying rate was higher in solar drying. As shown in Figure. (4) open-sun-drying slices appeared dirty and contaminated with soil particles, other foreign materials, microorganisms, and insects. However, for solar-drying slices, there was no contamination observed (very clean slices). This is because solar driers are closed device systems, so no outer foreign materials or particles can enter. At the same time, for open-direct sun, there is no barrier from contamination, which will considerably affect the quality of sun-dried onion.

CONCLUSION

Solar drying of Onion slices gives a high drying rate with two final moisture content and good quality onion that can be stored for extended periods without considerable deterioration.

REFERENCES

Abdelaziz, H. (2008). Economics of onion production in the Northern part of Omdurman province, Khartoum State. *Albuhuth*, *12*(1), 42–51.

Akpinar, E. K., Bicer, Y., & Yildiz, C. (2003). Thin layer drying of red pepper. *Journal of Food Engineering*, *59*(1), 99–104.

Albuquerque, M. F. de. (2010). *Precipitação nas mesorregiões do estado do Pará: climatologia, variabilidade e tendências nas últimas décadas (1978-2008)*.

Amjad, W., Waseem, M., Munir, A., Ghafoor, A., Asghar, F., & Gilani, G. A. (2021). Solar-assisted dehydrator for decentralized controlled and homogeneous multi-product drying. *Journal of Solar Energy Engineering*, *143*(1).

An, J., Seok, H., & Ha, E.-M. (2021). GABA-producing Lactobacillus plantarum inhibits metastatic properties and induces apoptosis of 5-FU-resistant colorectal cancer cells via GABA B receptor signaling. *Journal of Microbiology*, *59*, 202–216.

Babiker, A. M. O. A., Ismail, I. A., Osman, O. E. M., & Salih, Z. A. (2014). Effect of solar drying using a natural convective solar drier on bacterial load and chemical composition of bayad (Bagrus bayad) fish flakes. *International Journal of Multidisciplinary and Current Research*, *2*, 1100–1104.

Chemists, A. of O. A., & (US), A. of O. A. C. (1925). *Official methods of analysis*.

Dawelbeit, S. E., Salih, F. M., Dahab, O. A., & Ahmed, E. H. (2010). Status of fertilization and crop nutrition in irrigated agriculture in Sudan: Fertilizer use in Sudan —*Research Findings*.

DeSisto, C. L., Kim, S. Y., & Sharma, A. J. (2014). Peer reviewed: Prevalence estimates of gestational diabetes mellitus in the United States, pregnancy risk assessment monitoring system (prams), 2007–2010. *Preventing Chronic Disease*, p. *11*.

Djaeni, M., & Perdanianti, A. M. (2019). The study explores the effect of onion (Allium cepa l.) drying using hot air dehumidified by activated carbon, silica gel, and zeolite. *Journal of Physics: Conference Series*, *1295*(1), 12025.

Doymaz, İ. (2005). Drying characteristics and kinetics of okra. *Journal of Food Engineering*, *69*(3), 275–279.

Ismail, M. A., & Ibn Idriss, E. M. (2013). Mathematical modeling of thin layer solar drying of whole okra (Abelmoschus esculentus (L.) Moench) pods. *International Food Research Journal*, *20*(4).

Musa, S. K., Habish, H. A., Abdalla, A. A., & Adlan, A. B. (1973). Problems of onion storage in Sudan. *Tropical Science*, *15*(4), 319–327.

Sivamma, P., Mounika, E., Carolin Rathina Kumari, K., Senthil Kumaran, G., & Bindu, B. (2021). Drying white onion slices in a modified solar greenhouse dryer using aluminum foil and a black mulch sheet. *Pharma Innovation Journal 2021; 10 (4): 1156-1160 Www. Thepharmajournal. Com*.

Visavale, G. L. (2012). Principles, classification, and selection of solar dryers. *Solar Drying: Fundamentals, Applications and Innovations, Ed. Hii, CL, Ong, SP, Jangam, SV and Mujumdar, AS, Published in Singapore*, 1–50.