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# Study the drying characteristics of apple pomace

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**Abstract**
Apple pomace is a left-over residue after apple juice extraction amounting to about 20-30% of the total processed apple fruits. To utilize this waste, a study of the effect on the different quality attributes of apple pomace powder, prepared by two different dryers viz. tray dryer and hot air oven, was carried. Apple pomace was exposed to three different temperatures (60, 70 & 80 °C) in both dryers. Drying of apple pomace took place in falling rate period. Initial moisture content of the apple pomace was an average of 84.48±1% w.b. Overall drying rate increased with temperature in both dyers.

**Keywords:** Apple pomace, drying, tray dryer, hot air oven & moisture content

## 1. Introduction
Apple (*Malus domestica* Borkh.) is the most favoured fruit of millions of people and is a widely grown fruit in temperate regions of the globe (Kaushal and Joshi 1995, Kaushal *et al.* 2002, Agrahari and Khurdiya 2003) [8-10, 1]. The world production of apple is about 58 million tons from an area of about 5.26 million ha. About 71% of apple is consumed as fresh apple while about 20% is processed into value added products of which 65% are processed into apple juice concentrate (AJC) and the balance quantity into other products which include packed natural ready-to-serve (RTS) apple juice, apple cider, wine and vermouth, apple purees and jams and dried apple products (Downing 1989, Joshi *et al.* 1991, Joshi 1997, Kaushal *et al.* 2002) [5, 7, 6, 9, 10]. Most of the production of the fruit is used for table purpose but apportion is being processed into various products of which apple juice is processed to a greater extent .The world production of apple is about 58 million tons from an area of about 5.26 million/ hectare. Presently, India is the largest producer of apples in the world contributing about one third of total apple production of the world with an annual production of 1.42 million tons from an area of 0.25 million/ hectare. It is the 4$^{th}$ major fruit crop of India (Govt. of India, 2011).

The composition of apple pomace with respect to its fibber content viz sugar, cellulose, hemicelluloses, pectin and roughage appears to have the best proposition for incorporation in the bakery industry for production of high fibre baked foods. The crude fibre content of apple pomace is approximately 14-30% of the dry weights. Apple fibre is higher in TDF (Total Dietary Fibres) than wheat and oat bran. It has good water holding capacity and act as humectants in certain food products. Apple fibre has been incorporated into cookies, granola bars and muffins to produce high fibre bakery products. Use of apple pomace has been made through fermentation into several product including citric acid, ethanol, pigment etc.

Bates and Roberts (2001) [3] studied that apple pomace, through traditionally utilized as cattle feed, only a fraction of apple pomace is used due to rapid spoilage of the wet pomace. Drying of the apple pomace seems to be a promising utilization way for animal feed or for further processing such as nutrient recovery. Drying techniques have been used for centuries, undergoing important evolutions. Studies on the drying processes are numerous because it is one of the most common industrial operations and involves high energy consumption, 10-25% of the total energy used in manufacturing processes worldwide (Chen *et al*.1988) [4]. Wang and Thomas (2007) [13] stated that apple pomace needs to be first dried and stored for a period of time; otherwise it is hard to extract the pectin from it. Pomace is therefore usually brought from over a wide area from a number of drying plants. Shahnaz and Parveen (2014) [12], carried the study on analysis of mutton nuggets produced with the addition of apple pomace at the levels of 0% (Control), 5% (Treatment 1), 10% (Treatment 2) and 15% (Treatment 3) were evaluated for emulsion stability, cooking yield, pH, proximate composition, texture analysis

and sensory properties. Apple pomace addition resulted in significantly higher ($p \leq 0.05$) emulsion stability and cooking yield of treatments in comparison to control and pH values were significantly higher ($p \leq 0.05$) for the control as compared to treatments.

**Materials and methods**

The main objective of this experiment is to study the drying characteristics of apple pomace. The experiments were carried out in the Food Processing Laboratory of the department of agricultural engineering and food technology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut-250110, (U.P.) India

**Raw Material:** Mature apple fruits, were obtained from the local market, Modipuram, Meerut during the months of January to March, 2016. The mature fruits are collected when they were fully grown and firm.

**Sample Preparation:** Samples were prepared as given in following flow chart.

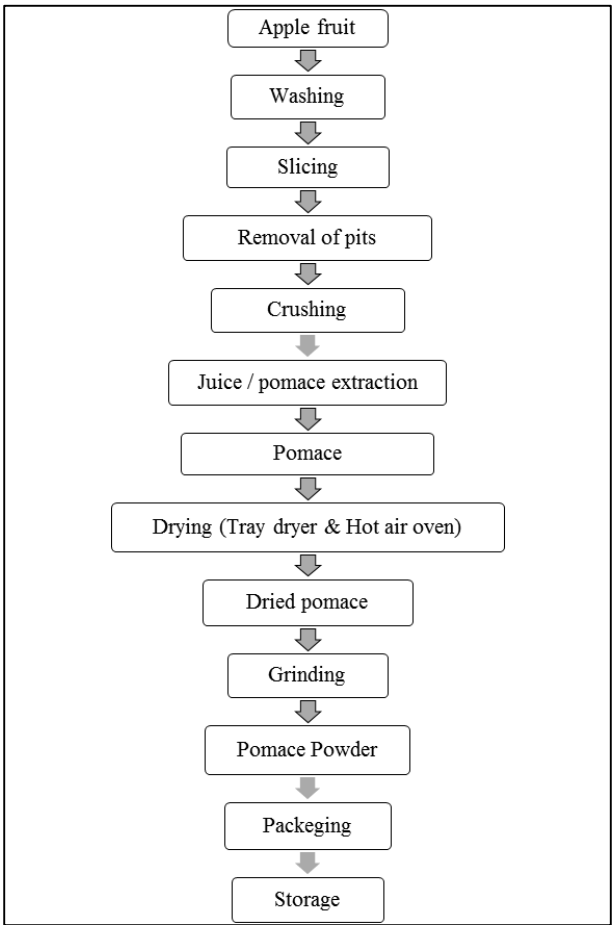


**Fig:** flow chart of apple pomace drying and powder preparation.

**Drying methods:** The pomace samples were dried using tray dryer and hot air oven at three different temperatures, viz. (60, 70, 80 $^0$C).

**Cabinet tray dryer**

A Cabinet type mechanical tray dryer (Industrial Dryer, M/s Navyug Udhyog Pvt. Ltd Ambala) was used to conduct drying experiment. The heating air circulated inside the cabinet with the help of circulating fan. The thermostatic controller (50-250 ℃) is attached with the heating unit to control the desired temperature for the drying experiment.

**Hot air oven drying**

The pomace samples were kept on hot air oven at 60, 70, 80±5 °C till no further weight loss occurred. Hot air oven (Instron, IN-301 Model) used is a double walled chamber of size 78×27×116 (in centimeter). Outer chamber is made of stainless steel. Hot air ovens are electrical devices used in sterilization. The oven uses dry heat to sterilize articles. Generally, they can be operated from 50 to 300 ℃ (122 to 572 °F).

**Drying characteristics analysis**

**Moisture content:** Moisture content and total solids will be determined by method of AOAC (1990**)** [2]. The moisture content (% w.b.) of sample was calculated by using following equation:

$$\text{M C\% (w.b.)} = \frac{(\text{initial weight} - \text{final weight})}{\text{initial weight}} \times 100$$

**Dehydration ratio:** Drying ratio was calculated by taking the ratio of weight of samples loaded for drying in order and that the dried samples immediately after drying.

$$D_r = \frac{W1}{W2}$$

Where,
Dr=Drying ratio
W1=Initial weight of sample before drying (g)
W2= final weight of dried product (g)

**Average drying rate**

The average drying rates at different times were computed using following relationship suggested by Mishra (1991) [11].

$$\left(\frac{dM}{dt}\right)_{avg} = \frac{M_t - M_{t+\Delta t}}{\Delta t}$$

Where,

$\left(\frac{dM}{dt}\right)_{avg}$ = average drying rate, % d.b. /min

t = time at any instant, min

t+ Δt = time after an interval of Δt, min

**Result and Discussion**

Results of apple pomace drying with tray dryer and hot air oven at three different temperatures, are presented in following heads. Samples were dried untill they stop loosing moisture. Moisture content (wb%), dehydration ratio and average drying rate was measured. Dehydration ratio is an important factor, which shown bulk reduced in weight of the sample.

**Drying Characteristics in tray drying:** Apple pomace dried using tray dryer at tree different temperature viz. 60, 70 & 80 $^o$C.

Moisture content (wb%) ranges from 84.48 to 11.34 at 60 $^o$C. Dehydration ratio and average drying rate were ranged from 5.71 to 1.00 and 2.66 to 0.01 respectively (Table 1). At 70 $^o$C, moisture content (wb%) ranges from 84.48 to 6.91. Dehydration ratio and average drying rate were ranged from 6.00 to 1.00 and 2.71 to 0.01 respectively (Table 2). Moisture content (wb%) ranges from 84.48 to 1.75 at 80 $^o$C. Dehydration ratio and average drying rate were ranged from 6.33 to 1.00 and 2.81 to 0.01 respectively (Table 3).

**Drying Characteristics hot air oven drying:** Apple pomace dried using hot air oven dryer at tree different temperature viz. 60, 70 & 80 ºC.

At 60 ºC moisture content (wb%) ranges from 84.48 to 16.03. Dehydration ratio and average drying rate were ranged from 5.41 to 1.00 and 0.97 to 0.04 respectively (Table 4). Moisture content (wb%) ranges from 84.49 to 11.65 at 70 ºC. Dehydration ratio and average drying rate were ranged from 5.69 to 1.00 and 1.07 to 0.03 respectively (Table 5). At 80 ºC, moisture content (wb%) ranges from 84.49 to 6.65. Dehydration ratio and average drying rate were ranged from 5.69to 0.95 and 1.17 to 0.04 respectively (Table 6).

**Table 1:** Drying charecteristics of apple pomace in tray dryer at 60 ºC.

| Time (Min.) | 0 | 60 | 120 | 180 | 240 | 300 | 360 | 420 | 480 | 540 | 600 | 660 | 720 | 780 | 840 | 900 | 960 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample(gm) | 400.00 | 300.83 | 241.11 | 182.78 | 138.94 | 113.55 | 99.94 | 91.77 | 84.77 | 80.51 | 77.28 | 75.05 | 73.44 | 72.38 | 71.75 | 70.88 | 70.00 |
| MC (wb%) | 84.48 | 79.37 | 74.26 | 66.05 | 55.33 | 45.35 | 37.90 | 32.38 | 26.79 | 22.91 | 19.69 | 17.31 | 15.49 | 14.26 | 13.51 | 12.44 | 11.34 |
| Dehy. ratio | 5.71 | 4.30 | 3.44 | 2.61 | 1.98 | 1.62 | 1.43 | 1.31 | 1.21 | 1.15 | 1.10 | 1.07 | 1.05 | 1.03 | 1.03 | 1.01 | 1.00 |
| Avg. D. rate | 0.00 | 2.66 | 1.00 | 0.97 | 0.73 | 0.42 | 0.23 | 0.14 | 0.12 | 0.07 | 0.05 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 |

**Table 2:** Drying charecteristics of apple pomace in tray dryer at 70 ºC.

| Time (Min.) | 0 | 60 | 120 | 180 | 240 | 300 | 360 | 420 | 480 | 540 | 600 | 660 | 720 | 780 | 840 | 900 | 960 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample(gm) | 400.00 | 299.17 | 237.11 | 179.78 | 134.94 | 110.05 | 95.94 | 88.44 | 81.11 | 76.17 | 73.28 | 71.05 | 70.11 | 69.05 | 68.42 | 67.55 | 66.67 |
| MC (wb%) | 84.48 | 79.26 | 73.83 | 65.48 | 54.01 | 43.61 | 35.32 | 29.83 | 23.49 | 18.52 | 15.31 | 12.66 | 11.48 | 10.13 | 9.30 | 8.13 | 6.91 |
| Dehy. ratio | 6.00 | 4.49 | 3.56 | 2.70 | 2.02 | 1.65 | 1.44 | 1.33 | 1.22 | 1.14 | 1.10 | 1.07 | 1.05 | 1.04 | 1.03 | 1.01 | 1.00 |
| Avg. D. rate | 0.00 | 2.71 | 1.03 | 0.96 | 0.75 | 0.41 | 0.24 | 0.13 | 0.12 | 0.08 | 0.05 | 0.04 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |

**Table 3:** Drying charecteristics of apple pomace in tray dryer at 80 ºC.

| Time (Min.) | 0 | 60 | 120 | 180 | 240 | 300 | 360 | 420 | 480 | 540 | 600 | 660 | 720 | 780 | 840 | 900 | 960 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample(gm) | 400 | 295.51 | 232.45 | 176.12 | 131.28 | 105.72 | 92.28 | 84.78 | 77.31 | 72.51 | 69.68 | 67.39 | 66.45 | 65.39 | 64.26 | 63.89 | 63.17 |
| MC (wb%) | 84.49 | 79.00 | 73.30 | 64.76 | 52.73 | 41.30 | 32.75 | 26.80 | 19.72 | 14.41 | 10.93 | 7.92 | 6.60 | 5.10 | 3.42 | 2.86 | 1.75 |
| Dehy. ratio | 6.33 | 4.68 | 3.68 | 2.79 | 2.08 | 1.67 | 1.46 | 1.34 | 1.22 | 1.15 | 1.10 | 1.07 | 1.05 | 1.04 | 1.02 | 1.01 | 1.00 |
| Avg. D. rate | 0.00 | 2.81 | 1.05 | 0.94 | 0.75 | 0.43 | 0.22 | 0.13 | 0.12 | 0.08 | 0.05 | 0.04 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 |

**Table 4:** Drying charecteristics of apple pomace in hot air oven dryer at 60 ºC.

| Time (Min.) | 0 | 60 | 120 | 180 | 240 | 300 | 360 | 420 | 480 | 540 | 600 | 660 | 720 | 780 | 840 | 900 | 960 | 1020 | 1080 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample(gm) | 400.00 | 363.85 | 329.24 | 295.38 | 265.74 | 234.88 | 206.08 | 179.71 | 161.40 | 146.03 | 130.30 | 116.13 | 101.80 | 92.35 | 83.74 | 79.41 | 77.13 | 75.47 | 73.90 |
| MC (wb%) | 84.48 | 82.94 | 81.15 | 78.99 | 76.65 | 73.58 | 69.89 | 65.47 | 61.55 | 57.50 | 52.37 | 46.56 | 39.04 | 32.80 | 25.89 | 21.85 | 19.53 | 17.77 | 16.03 |
| Dehy. ratio | 5.41 | 4.92 | 4.46 | 4.00 | 3.60 | 3.18 | 2.79 | 2.43 | 2.18 | 1.98 | 1.76 | 1.57 | 1.38 | 1.25 | 1.13 | 1.07 | 1.04 | 1.02 | 1.00 |
| Avg. D. rate | 0.00 | 0.97 | 0.93 | 0.91 | 0.80 | 0.83 | 0.77 | 0.71 | 0.49 | 0.41 | 0.42 | 0.38 | 0.38 | 0.25 | 0.23 | 0.12 | 0.06 | 0.04 | 0.04 |

**Table 5:** Drying charecteristics of apple pomace in hot air oven dryer at 70 ºC.

| Time (Min.) | 0 | 60 | 120 | 180 | 240 | 300 | 360 | 420 | 480 | 540 | 600 | 660 | 720 | 780 | 840 | 900 | 960 | 1020 | 1080 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample(gm) | 400.00 | 360.19 | 325.74 | 292.38 | 261.08 | 231.38 | 202.08 | 176.38 | 157.74 | 141.69 | 126.30 | 112.13 | 98.47 | 89.02 | 80.41 | 76.08 | 73.80 | 71.47 | 70.24 |
| MC (wb%) | 84.49 | 82.77 | 80.95 | 78.77 | 76.23 | 73.18 | 69.29 | 64.82 | 60.66 | 56.20 | 50.86 | 44.66 | 36.97 | 30.29 | 22.82 | 18.43 | 15.90 | 13.16 | 11.65 |
| Dehy. ratio | 5.69 | 5.13 | 4.64 | 4.16 | 3.72 | 3.29 | 2.88 | 2.51 | 2.25 | 2.02 | 1.80 | 1.60 | 1.40 | 1.27 | 1.14 | 1.08 | 1.05 | 1.02 | 1.00 |
| Avg. D. rate | 0.00 | 1.07 | 0.93 | 0.90 | 0.84 | 0.80 | 0.79 | 0.69 | 0.50 | 0.43 | 0.41 | 0.38 | 0.37 | 0.25 | 0.23 | 0.12 | 0.06 | 0.06 | 0.03 |

**Table 6:** Drying charecteristics of apple pomace in hot air oven dryer at 80 ºC.

| Time (Min.) | 0 | 60 | 120 | 180 | 240 | 300 | 360 | 420 | 480 | 540 | 600 | 660 | 720 | 780 | 840 | 900 | 960 | 1020 | 1080 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample(gm)** | 400 | 356.53 | 321.08 | 288.72 | 257.08 | 227.05 | 198.42 | 172.72 | 153.94 | 138.03 | 122.70 | 108.47 | 94.81 | 85.36 | 76.25 | 72.42 | 70.30 | 67.81 | 66.48 |
| **MC (wb%)** | 84.49 | 82.59 | 80.67 | 78.51 | 75.86 | 72.67 | 68.72 | 64.07 | 59.69 | 55.04 | 49.42 | 42.79 | 34.54 | 27.30 | 18.61 | 14.30 | 11.72 | 8.48 | 6.65 |
| **Dehy. ratio** | 5.69 | 5.08 | 4.57 | 4.11 | 3.66 | 3.23 | 2.82 | 2.46 | 2.19 | 1.97 | 1.75 | 1.54 | 1.35 | 1.22 | 1.09 | 1.03 | 1.00 | 0.97 | 0.95 |
| **Avg. D. rate** | 0.00 | 1.17 | 0.95 | 0.87 | 0.85 | 0.81 | 0.77 | 0.69 | 0.50 | 0.43 | 0.41 | 0.38 | 0.37 | 0.25 | 0.24 | 0.10 | 0.06 | 0.07 | 0.04 |

Where: MC (wb%) = Moisture content (wet basis), Dehy. Ratio = Dehydration ratio, Avg. D. rate = Average drying rate.

## Conclusion

From the present study it was found that it took 960 minuts in tray dryer and 1080 minuts in hot air oven to dry the apple pomace completely, which means that more moisture transfer took place in the case of tray drying than hot air oven drying. The moisture loss and the drying time relation were non-linear and initially higher moisture loss was observed due to release of free moisture as compared to the later part of drying.

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