Drying characteristics of potato slices

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ABSTRACT

Investigations were conducted to study the drying characteristics of potato slices prepared from three varieties of potato viz Kufri Chipsona-2, Kufri Chipsona-1 and Kufri Bahar. Potato slices samples of 500 g each were dried at 50, 60, 70 and 80°C in tray dryer. The initial moisture content of potato slices was determined as 309.83 per cent (Kufri Chipsona-2), 346.42 per cent (Kufri Chipsona-1) and 468.18 per cent (Kufri Bahar) on dry weight basis. The slices took 160 to 350 min drying time depending upon drying temperature, pre-treatments and potato varieties. The samples dried at lower temperature (50°C) took higher drying time to achieve the final moisture content as compared to those dried at higher temperature (80°C) irrespective of potato varieties and pre-treatments. The total drying time required to achieve the final moisture content was dependent upon potato varieties, pre-treatments and the drying temperature. The potato varieties having higher initial moisture content took higher drying time as compared to those with lower initial moisture content. The potato slices having lowest dry matter content exhibited little higher final moisture content at a particular temperature. The final moisture content of hot water-blanched potato slices was found to be little higher as compared to KMS-treated potato slices and control samples at the same drying temperature and drying time irrespective of potato cultivars. Total moisture loss increased with increase in drying temperature. The total moisture loss was highest in case of potato slices of Kufri Bahar, while the lowest in case of Kufri Chipsona-2, irrespective of the drying temperature and pre-treatments. The maximum moisture loss of 99.91 per cent was recorded in case of KMS-treated slices (KufriBahar) dried at 80°C.

Keywords: Potato slices; Kufri Chipsona-2; Kufri Chipsona-1; Kufri Bahar; moisture content

INTRODUCTION

Drying processes play an important role in the preservation of agricultural products. It is a process of moisture removal due to simultaneous heat and mass transfer. The most important reasons for the popularity of dried products are longer shelf life, product diversity as well as substantial volume reduction. Sun drying of crops, grains and other agricultural produce is practiced by human beings since time immemorial. Still, in India, major portion of agricultural produce is dried by this method (Sahay and Singh 2004). Open sun drying is not always suited to large scale production due to the lack of ability to control the drying conditions properly, longer drying time, uncertainty of ambient conditions, large area requirements, insect infestation and contamination with dust. Mechanical drying is nowadays extensively used to remove moisture from the agricultural products. These methods are tray/cabinet drying, tunnel drying, fluidized bed drying, vacuum drying, microwave drying, drum drying, freeze drying etc (Von Loesecke1943, Cruess 1958, Desrosier 1970, van Arsdel et al 1973, Salunkhe et al 1973).

Kapadia et al (2018) subjected potato slices to various pre-drying treatments viz blanching in hot water at 60, 70, 80, 90 and 100°C temperature for 2.0, 3.0, 4.0 and 5.0 min. It was found that 70°C temperature + 2.0 min blanching time was the best among all the treatments with optimum recovery of potato slices' shrinkage percentage, rehydration ratio, reducing sugar, sucrose and total phenol.

Solar drying in a cabinet dryer can be used for most vegetables and fruits (Anon 2020). Solar dehydration is also used in some parts of the country to dry-cooked potato slices. The procedure is similar to the one used for drying raw potato slices, except that potato tubers are cooked in boiling water for about 8 min, before peeling and slicing. Dehydration of such slices takes longer time but they take much less time for cooking during frying than raw slices (Joshi et al 1976). Later, large cabinets with solar concentrator and a home solar dehydrator were also developed by the Central Potato Research Institute, Shimla (Anon 1984b).

Lati et al (2017) investigated the effect of solar drying on the quality of the dried potato slices. The parameters studied included total colour change, reducing sugar and pH. The results of drying tests, using a hybrid solar system led towards the choice of the treatment under controlled air temperature of 50°C with air flow of 1 m/s. At this temperature the measured quality parameters confirmed that the final product could preserve its clear colour, reducing sugar and pH. Thus using solar energy, could offer a practical alternative to the conventional means actually using the cold room techniques.

The Central Food Technological Research Institute, Mysore, Karnataka (Anon 1984a) fabricated a solar tent and trays for dehydrating potatoes in different forms. Potato slices, Sewai, granules and Papads were dried in the solar tent and the dried products after frying in oil were found acceptable. The dried products had a shelf life of 6 months, when packed in low-density polyethylene bags. Drying of potato is mostly carried out by hot air either in thin layer, using cabinet, tunnel or conveyor dryer (van Arsdel et al 1973) or in deep bed dryer (Islam and Flink 1982a). Several researchers have studied the drying characteristics of potato during hot air drying under different drying conditions. Brown and Kilpatrick (1943) studied the effects of loading rate and air velocity on drying of square strips of potato. Ede and Hales (1948) examined the effects of velocity and condition of drying air, size of strips and case hardening on drying rate of potato strips through circulation drying and evolved technique for prediction of drying times and rates. Davidson et al (1959) investigated the effects of scalding on size and shape of potato dice, air flow rate and temperature during shallow and deep bed drying and established their empirical relationships with drying rate. Lescano (1982) studied drying of cooked potatoes using a laboratory cabinet dryer and established that potato varieties with low solid contents provided better quality products than high solid varieties; gelatinization of starch affected the water-sorption isotherms and slowed down the drying rate as compared with uncooked potatoes and the absence of the constant rate period of drying and the presence of more than three falling rate periods of drying for strips and slices.

Jayaraman et al (1982) developed an HTST pneumatic drying technique for production of quick cooking vegetables from starchy vegetables like potato. An optimum temperature of 170°C and drying time of 8 min were recommended for best quality products from fresh potatoes in terms of low bulk density and reconstitution. Highest expansion was achieved with potato. They reported that partial drying before HTST treatment was detrimental for the product quality of quick cooking vegetable. Islam and Flink (1982b) conducted experiments on solar drying and air drying of osmotically-concentrated potato slices. Solar drying proved to have comparable effects on product qualities as with hot air drying. Dehydration of osmotically concentrated product retained better qualities. Mishkin et al (1983) optimized the dehydration process to minimize browning in dehydration of potato.

Diamante and Munro (1991) investigated the effect of dry bulb temperature, relative humidity, and velocity of air and sample thickness on the thin layer air drying of sweet potato slices. The drying rate curves consisted of two approximately linear falling rate periods and contained no constant rate period. Several mathematical models were fitted to the drying rates of sweet potato slices under a range of drying conditions. It was found that the modified Page equation best described the thin layer air drying of sweet potato slices down to a moisture content of 10 per cent dry basis.

Koide et al (1996) conducted drying tests on sweet potato at 40, 50, 60 and 75°C in order to investigate the drying characteristics. In this study, three types of drying periods, the constant rate drying period, the first falling rate drying period and the second falling rate drying period, were found during drying. With regards to this, three drying equations namely modified constant rate drying equation, the first falling rate drying equation and the second falling rate drying equation were applied to the observed drying curves (moisture ratio vs time) for each drying period. These results showed that the calculated values had a good agreement with the data. Furthermore, the results revealed that drying constants in first and second falling rate drying periods had Arrhenius type temperature dependency.

Asgar et al (1998) studied the effect of temperature and drying duration on quality of potato (*Solanum tuberosum* L) chips. First factor was drying temperature that consisted of 40, 50 and 60°C; and second factor was drying duration that consisted of 16, 18 and 20 hours. The results showed that drying temperature at 40°C and 16 hours gave the best quality of potato chips with better consumer preference. Good drying condition with appropriate temperature and time of drying could produce good quality of potato chips.

Ravindra and Chattopadhya (2000) conducted study on drying of potato cubes (10 mm) by osmotic pre-concentration (OPC) followed by fluidized bed drying in order to produce a dried and rapid cooked product. Optimum condition for osmotic pre-concentration was found to be immersion of potato cubes in SO_2 comprising 50 per cent sugar and 10 per cent salt at 47°C for 4 hours. Under these conditions, moisture content was reduced to 60 from 84 per cent with fluidized bed drying at 140°C for minimum solid gain while maintaining acceptable colour in potato cubes.

To investigate mass transfer kinetics, Singh et al (2014) carried out osmosis in binary sugar and salt solution of varying concentrations using a solution to sample ratio of 1:5 at 30°C temperature. The moisture loss from and the solid gain by potato increased non-linearly with duration of osmosis in all solution concentrations and both were higher in the initial period of osmosis than the later period. Further, both moisture loss from and the solid gain by potato dices increased with the increasing salt as well as with the increasing sugar in the osmosis solution.

Zlatkovic and Rajkovic (2005) studied the drying kinetics of potato pieces in laboratory dryer, in order to determine the optimal conditions for their industrial dehydration. It was established that the first quarter of the time of drying, evaporated 28.3 per cent of total evaporation of water and then in order by quarters: 53, 14.1 and 4.6 per cent. The greatest speed of the drying was realized at moisture content of potatoes about 50 per cent.

MATERIAL and METHODS

Experiments were conducted to study the drying characteristics of potato slices of three cultivars viz Kufri Chipsona-2, Kufri Chipsona-1 and Kufri Bahar at 50, 60, 70 and 80°C temperature in a tray drier.

Initial moisture content and dry matter of potatoes

The initial moisture content of different cultivars of potatoes was obtained as 309.83, 346.42 and 468.18 per cent on dry weight basis for Kufri Chipsona-2, Kufri Chipsona-1 and Kufri Bahar respectively. The dry matter content was observed as 24.40 (Kufri Chipsona-2), 22.40 (Kufri Chipsona-1) and 17.60 (Kufri Bahar) per cent. It was, therefore, observed that Kufri Chipsona-2 had highest dry matter content followed by Kufri Chipsona-1 and Kufri Bahar.

Drying characteristics of potato slices

Potato slices of sample size 500 g each were dried at 50, 60, 70 and 80°C in tray dryer. Before drying, samples were prepared and pre-treated. The moisture content of samples during drying was recorded at an interval of 10 min and drying process was continued till the final moisture content (FMC) of samples was achieved.

RESULTS and DISCUSSION

The potato slices took 160 to 350 min drying time depending upon drying temperature, pre-treatments and potato varieties. The samples dried at lower temperature (50°C), took higher drying time in order to achieve the final moisture content as compared to those dried at higher temperature (80°C) irrespective of potato varieties and pre-treatments. The moisture migration from the biological materials depends on difference in the vapour pressure of water present in the sample and the vapour pressure of the water present in the ambient air. An increment in ambient air temperature reduces the vapour pressure of the water present in the air, creating a vapour pressure gradient between the samples and the air.

The results of the study revealed that the drying rate increased with increase in drying air temperature (Figs 1-18). Such increment might be due to the increased heat transfer potential between the air and the product, thus favouring the evaporation of water from the product. The vapour pressure difference between the moisture present in potato slices and the moisture present in the air might be higher at higher as compared to lower drying temperature. This lead to

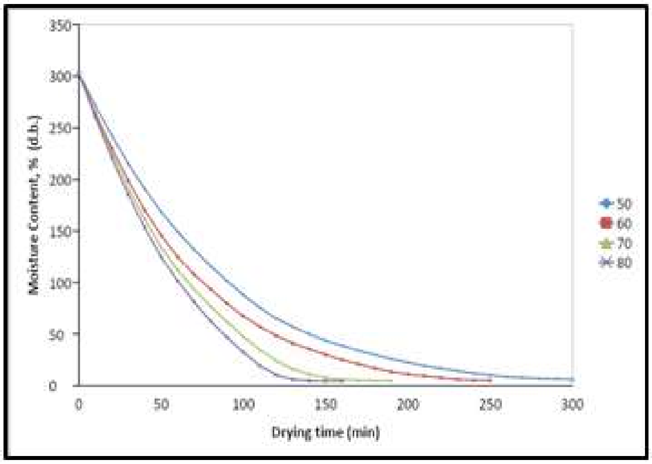

Fig 1. Drying characteristics of hot water-blanched potato slices (Kufri Chipsona-2) under tray drying

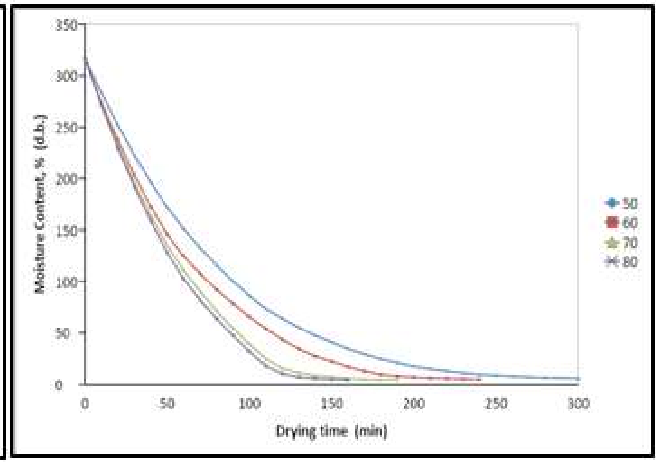

Fig 2. Drying characteristics of KMS-treated potato slices (Kufri Chipsona-2) under tray drying

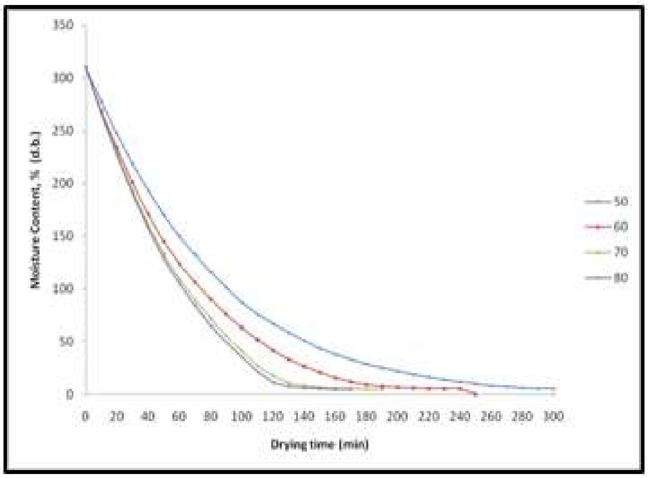

Fig 3. Drying characteristics of untreated potato slices (Kufri Chipsona-2) under tray drying

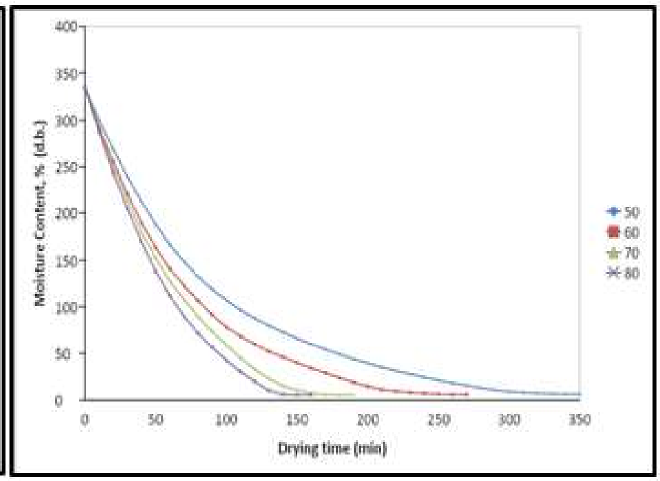

Fig 4. Drying characteristics of hot water-blanched potato slices (Kufri Chipsona-1) under tray drying

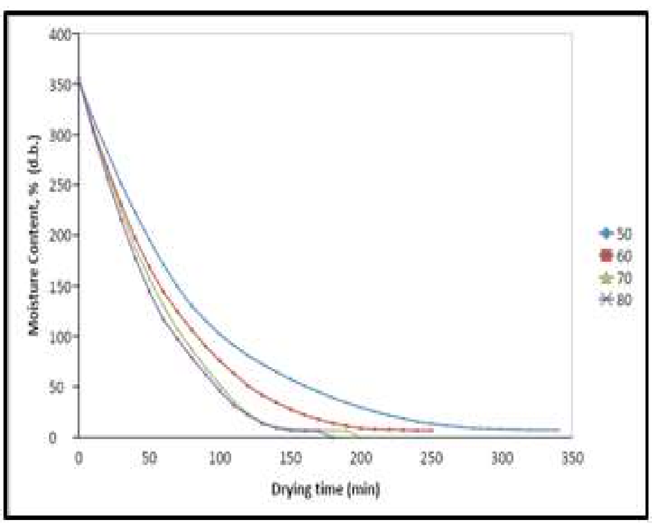

Fig 5. Drying characteristics of KMS-treated potato slices (Kufri Chipsona-1) under tray drying

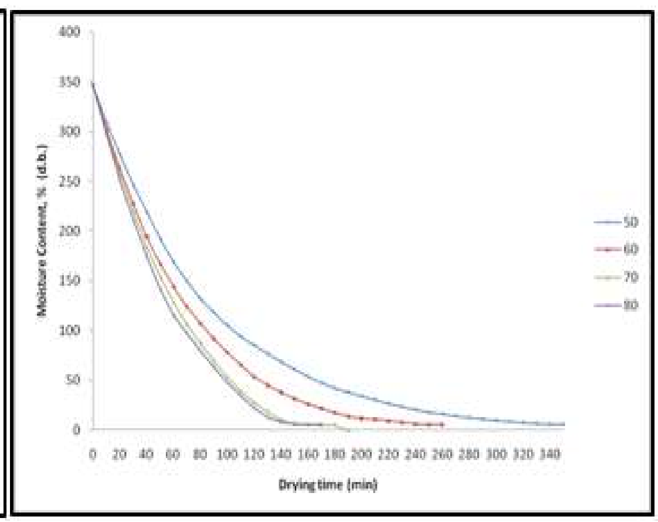

Fig 6. Drying characteristics of untreated potato slices (Kufri Chipsona-1) under tray drying

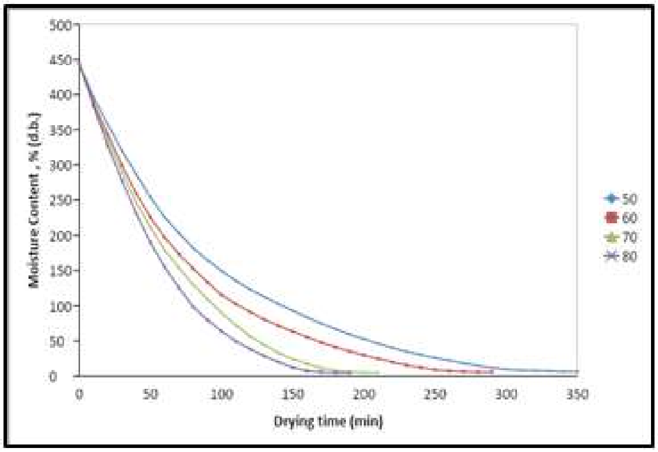

Fig 7. Drying characteristics of hot wate-blanched potato slices (Kufri Bahar) under tary drying

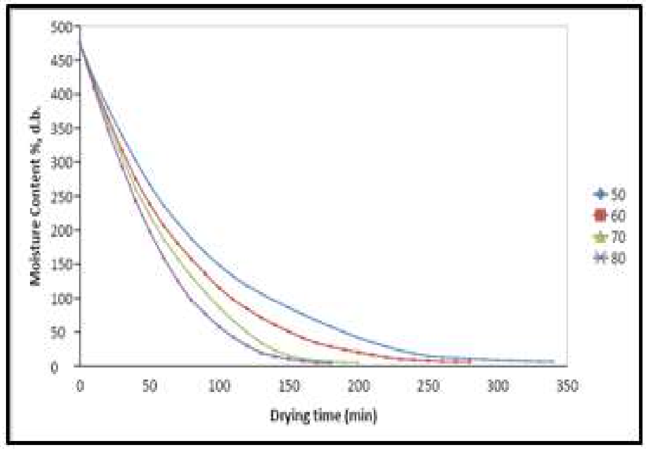

Fig 8. Drying characteristics of KMS-treated potato slices (Kufri Bahar) under tray drying

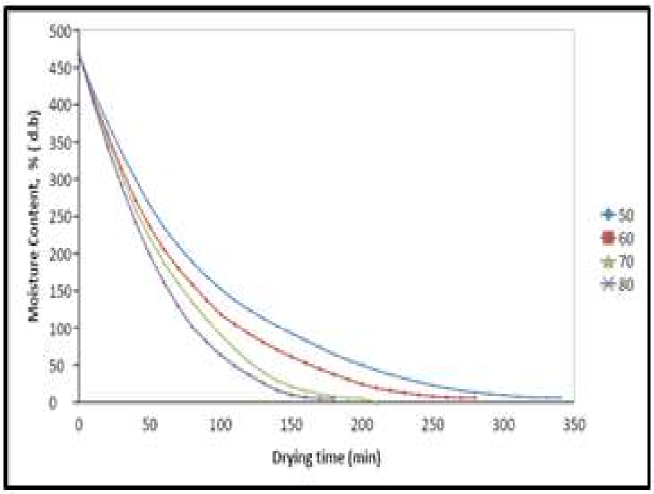

Fig 9. Drying characteristics of untreated potato slices (Kufri Bahar) under tray drying

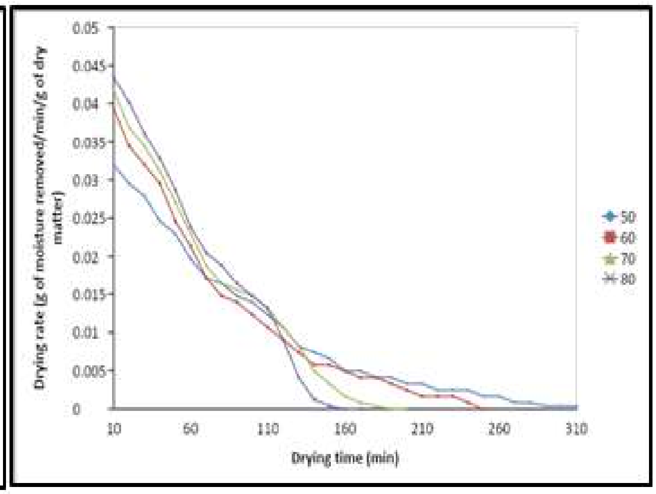

Fig 10. Effect of tray drying temperature on drying rate of hot water-blanched potato slices (Kufri Chipsona-2)

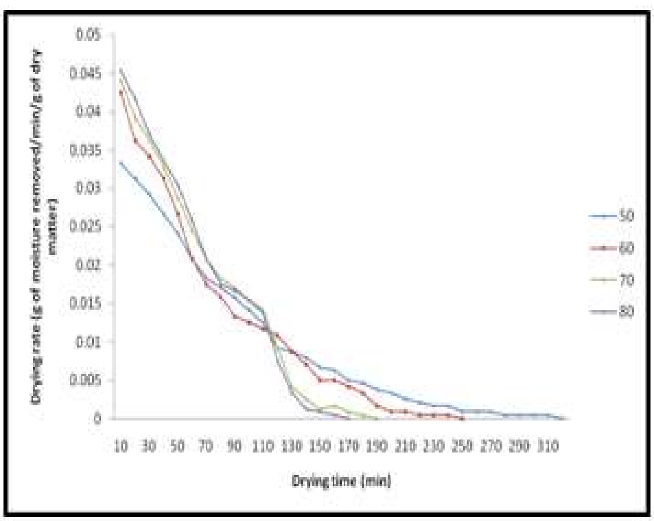

Fig 11. Effect of tray drying temperature on drying rate of KMS-treated potato slices (Kufri Chipsona-2)

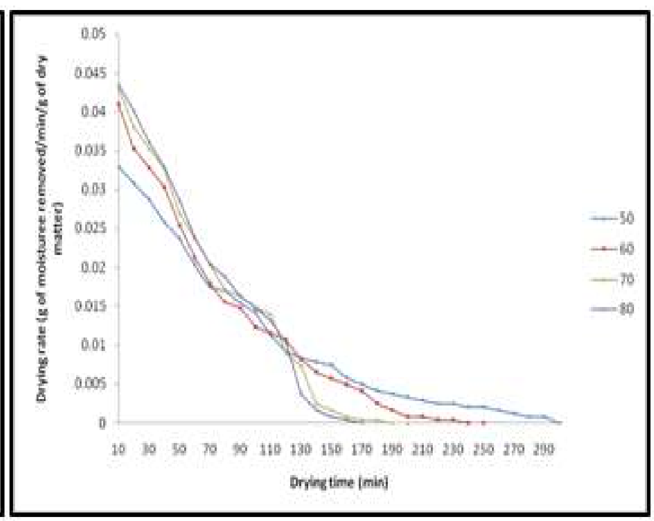

Fig 12. Effect of tray drying temperature on drying rate of untreated potato slices (Kufri Chipsona-2)

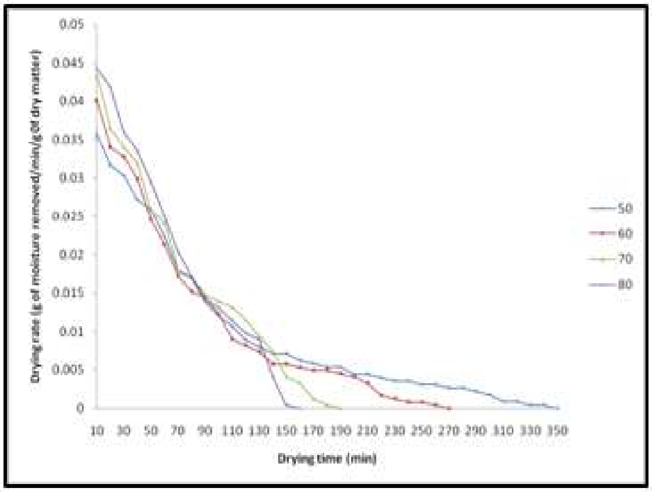

Fig 13. Effect of tray drying temperature on drying rate of hot water-blanched potato slices (Kufri Chipsona-1)

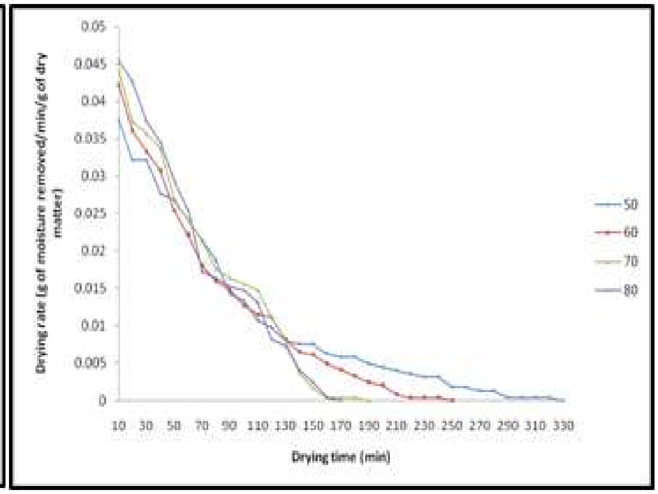

Fig 14. Effect of tray drying temperature on drying rate of KMS-treated potato slices (Kufri Chipsona-1)

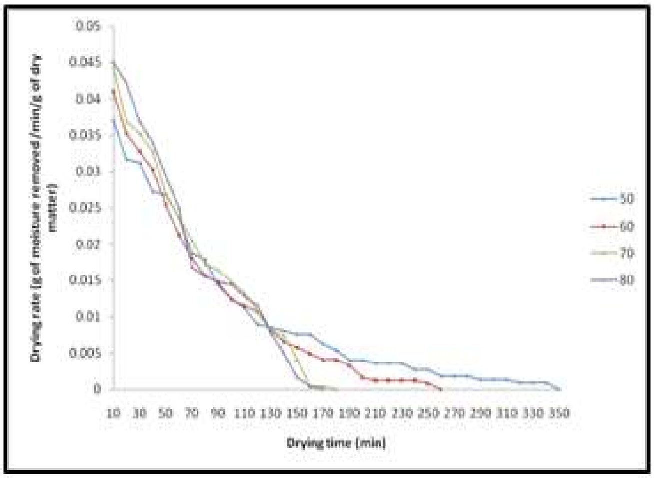

Fig 15. Effect of tray drying temperature on drying rate of untreated potato slices (Kufri Chipsona-1)

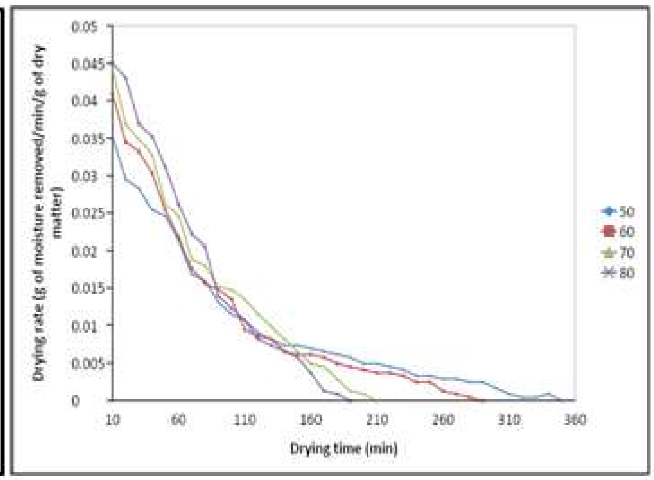

Fig 16. Effect of tray drying temperature on drying rate of hot water-blanched potato slices (Kufri Bahar)

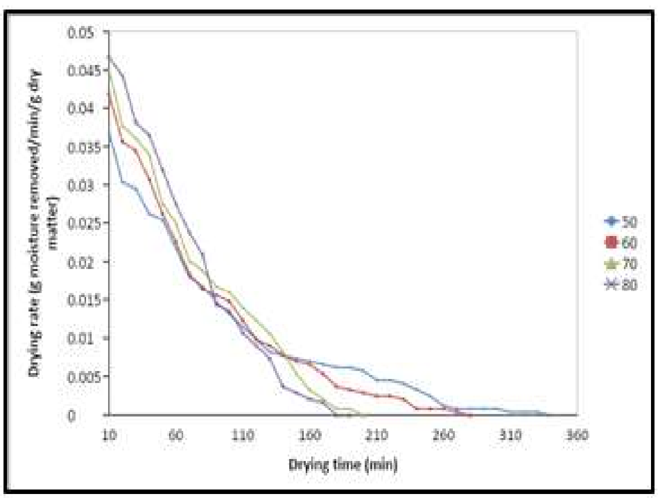

Fig 17. Effect of tray drying temperature on drying rate of KMS-treated potato slices (Kufri Bahar)

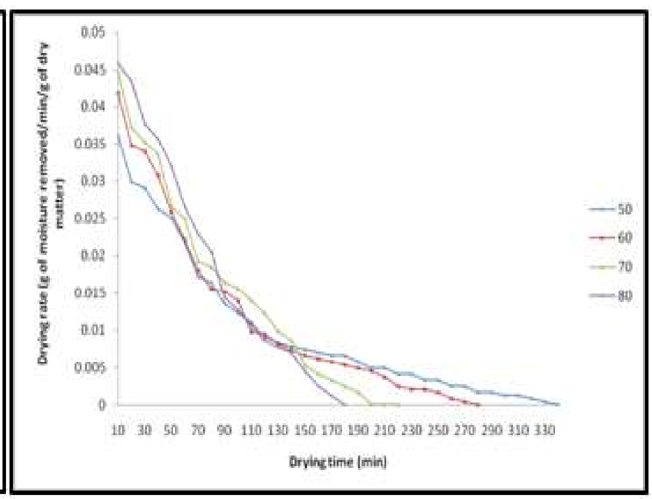

Fig. 18 Effect of tray drying temperature on drying rate of untreated potato slices (Kufri Bahar)

the faster moisture migration from the samples to the ambient air.

The total drying time required to achieve the final moisture content was dependent upon potato varieties, pre-treatments and the drying temperatures. The potato varieties having higher initial moisture content took higher drying time as compared to lower initial moisture content. Results of the study revealed that hot water-blanched slices of Kufri Bahar took 350 min at 50°C, while the slices of Kufri Chipsona-2 took 320 min at the same temperature to reach the final moisture content. In certain cases, hot water-blanched slices took slightly higher drying time as compared to control samples.

Study revealed that the potato slices having lowest dry matter content exhibited little higher final moisture content at particular temperature. The final moisture content for KMS-treated potato slices of Kufri Chipsona-2 at 50, 60, 70 and 80°C was observed as 5.83, 5.41, 5.00, and 5.00 per cent (db) respectively, while final moisture content of KMS-treated potato slices of KufriBaharwas found as 6.89, 6.32, 5.74 and 5.17 per cent (db) respectively. The final moisture content of hot water-blanched potato slices was found to be little higher as compared to KMS-treated potato slices and control samples for the same drying temperature and drying time irrespective of potato cultivars. The probable reasons for such trends could be attributed to gelatinization of starch over surface of the slices during hot water blanching which might have resulted in the reduction of moisture migration from slices to the ambient air.

It was observed that the total moisture loss increased with increase in drying temperature. The total moisture loss for hot water-blanched slices of Kufri Chipsona-2 was 98.00, 98.13, 98.27 and 98.40 per cent at 50, 60, 70 and 80°C temperature respectively, while in case of KMS-treated slices of Kufri Chipsona-2, it was 98.15, 98.28, 98.48 and 98.42 per cent at 50, 60, 70 and 80°C respectively. Total moisture loss was found the highest in case of control samples followed by KMS-treated and the hot water-blanched slices. The moisture loss was highest in case of potato slices of Kufri Bahar, while the lowest in case of Kufri Chipsona-2 slices, irrespective of the drying temperature and pre-treatments. Study also revealed that the maximum moisture loss of 99.91per cent was recorded in KMS-treated slices (Kufri Bahar) dried at 80°C temperature.

The moisture loss during first 2 hours of drying was noted higher for the slices of Kufri Chipsona-2 followed by Kufri Chipsona-1 and Kufri Bahar. It was also noted that moisture loss during first 2 hours of drying in KMS-treated slices was little higher followed by control and hot water-blanched slices. It was 79.73, 86.31, 95.00 and 96.57 per cent at 50, 60, 70 and 80°C drying temperature respectively for KMS-treated slices of Kufri Chipsona-2.

The relationship between moisture content and drying time at various drying temperatures for potato slices of different cultivars are shown in Figs 1 to 9, whereas, plots between drying rate (g of water removed/min/g of dry matter) with respect to drying time are shown in Figs 10 to 18.

The moisture content decreased very rapidly during the initial stage of drying as there was fast removal of moisture from the surface of the product. It could be due to removal of free moisture at the initial stage of drying. Afterwards, bound moisture was removed through diffusion process. It was obsereved that the drying rate at initial stage was very high and subsequently decreased with drying time. The potato slices did not have any constant drying rate period and the entire drying took place in falling rate period, irrespective of drying temperature. The drying rate for samples dried at 80°C was found to be higher than those of other drying temperatures. It is evident from the data that the pre-treatments affected the drying rate irrespective of the dehydration temperature. Study also revealed that KMS-treated slices yielded little higher values of drying rate followed by the untreated slices and the hot water-blanched slices. It could be attributed to water absorption by the slices during the KMS treatment. Amongst all pre-treatments, hot water-blanched slices yielded lowest drying at different temperatures. The reasons for the lower drying rate might be due to water loss which occurred during blanching process and damage of the cell structure due to heating. Similar trends were observed by Ahmed (1997) during tray drying of carrot, radish and turnip slices. Vaishali et al (2020) determined the effect of blanching with pre-treatments viz brine solution, KMS solution and KMS plus blanching on drying characteristics of potato slices (Kufri Chipsona-1, Kufri Jyoti and Kufri Bahar). It was observed that samples pre-treated with brine solution took higher drying time to achieve the final moisture content as compared to other pre-treated samples. The KMS-treated slices achieved higher and brine-treated slices achieved lowest drying rate. Potato slices did not have any constant rate period and the entire drying took place in falling rate period. The drying rate was higher in the initial period of drying and subsequently got reduced with decrease in moisture content.

CONCLUSION

On the basis of the findings of the present investigations, it can be concluded that the initial moisture content of different cultivars of potatoes was 309.83, 346.42 and 468.18 per cent on dry weight basis for Kufri Chipsona-2, Kufri Chipsona-1 and Kufri Bahar respectively. The dry matter content was observed as 24.40 (Kufri Chipsona-2), 22.40 (Kufri Chipsona-1) and 17.60 (Kufri Bahar) per cent. It was found that Kufri Chipsona-2 had highest dry matter content followed by Kufri Chipsona-1 and Kufri Bahar.

The potato slices took 160 to 350 min drying time depending upon drying temperature, pre-treatments and potato cultivars. The samples dried at lower temperature (50°C) took higher drying time to achieve the final moisture content as compared to those dried at higher temperature (80°C), irrespective of potato varieties and pre-treatments. However, the total drying time required to achieve the final moisture content was dependent upon potato varieties, pre-treatments and the drying temperatures. The potato varieties having higher initial moisture content took higher drying time as compared to the lower initial moisture content.The potato slices having lowest dry matter content exhibited little higher final moisture content at particular drying temperature.

The final moisture content of hot water-blanched potato slices was found to be little higher as compared to KMS-treated potato slices and control samples for the same drying temperature and drying time irrespective of potato cultivars. The total moisture loss increased with increase in drying temperature. The values were found to be highest in case of control samples followed by KMS-treated and hot water-blanched slices. The moisture loss during first 2 hours of drying in KMS-treated slices was little higher followed by control and hot water-blanched slices.

The moisture content decreased very rapidly during the initial stage of drying. The drying rate increased initially and then decreased gradually with dehydration time. Potato slices did not have any constant drying rate period and the entire drying took place in falling rate period irrespective of drying temperature.

The KMS-treated slices yielded little higher drying rate followed by untreated slices and the hot water-blanched slices. Amongst all pre-treatments, hot water blanched slices yielded lowest drying rate at different temperatures.

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