



Design, construction and testing of a hot water food dryer

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Abstract

The study includes design, fabrication and testing to hot water food dryer. The drying theory depends upon hot water as source of energy for drying the product. Potatoes product was selected to test the dryer performance. The drying was done under constant condition of 63°C temperature , 13%relative humidity and 1.5 (m/s) air speed. Three different drying methods were used based on the location of fan which was used inside the drying chamber (top, bottom or both).The dried products were subjected to moisture content test .Also organoleptic properties evaluation was done for color, taste, flavor and general appearance. The results indicated that, bottom fan drying method scored lower percentage 3.25% moisture content followed by both fans 3.49%. The organoleptic evaluation indicated that, the dryer gave the prefer results with both fans 1.29, 2.18, 2.53 and 2.24 for color, taste, flavor, and general appearance respectively.

Keywords: drying, hot water, potatoes, moisture content, organoleptic properties.

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Introduction

Dehydration is the oldest method of food preservation practiced by man..The main reason for drying a food is to extend its shelf life beyond that of the fresh material without the need for refrigerated transport and storage. This goal is achieved by reducing the available moisture, or water activity to a level which inhibits the growth and development of spoilage and pathogenic microorganisms, reducing the activity of enzymes and the rate at which undesirable chemical changes occur (Brennan, 2006).

Potatoes are the fourth most important vegetable for human nutrition in the world and approximately 12% are dehydrated

products. This product is semi-perishable in nature because it contains about 80% water. Therefore, post-production management is as important as production management(Aghbashlo, et al ,2009).Leeratanarak et al., (2006) reported that, many works have been performed to study hot air drying of potato pieces of various shapes.Generally, it is found that hot air drying causes much quality degradation (in terms of nutritional values, color, shrinkage and other organoleptic properties). Puttongsiri, et al., (2012) studied the effect of drying temperature and drying time onmoisture content and physical properties of instant mashed potato. Instant mashed

potato was prepared by drying at 60, 70 and 80 °C and drying times of 5, 6.5 and 8 hr. After that, moisture content, water absorption, water solubility index and rehydration ratio of the dried product were determined. It was found that drying time and drying temperature at the studied condition did not affect water absorption and water solubility of the final product. However, increase drying temperature and drying time resulted in instant mashed potato with decrease moisture content and rehydration ratio. Instant mashed potato had moisture content of 4.5 to 8.5% (db) depend on the drying conditions. Loeseck, (2012) stated that, both tunnel dryer and conveyor dryer are used with a dry bulb temperature of 160 °F. Dehydrated is finished in bin dryer to final moisture content of 7% and the drying time in the tunnel is about 3 hours and from 3-4 hours in the bins. He also mentioned that an average yield could be obtained of about 16% based on the weight of the fresh tuber. The effects of drying conditions on shrinkage of potato slices were studied by Yadollahinia and Jahangiri (2009). A thin-layer dryer with machine vision system and image processing software was used. Potato slices were dried at temperatures of 60, 70, 80 °C and air velocities of 0.5 and 1.0 m/s. Changes in area, perimeter, major and minor diameters, diameters parallel and perpendicular to airflow, roundness and elongation of the slices were measured continuously during drying. Shrinkage showed almost linear relation with moisture content. It was found that airflow direction had significant effect on shrinkage of parallel and perpendicular diameters in 60 and 70 °C and no significant effect at 80 °C. Drying took place entirely in the falling rate period. Air velocity had no significant effect on drying time and shrinkage in the range tested. Slices dried in 80 °C showed more circularity than slices dried in 60 and 70 °C. Puttongsiri, et al., (2012) found that, potatoes

dried at 60, 70 and 80°C and drying time of 5 hr had moisture contents of 8.5, 6.5 and 5.2% respectively. Khraisheh, et al., (2004) studied the quality and structural changes (in terms of vitamin C destruction, shrinkage and rehydration) of potato during microwave and convective drying. They reported that air drying led to higher vitamin C destruction than in the case of microwave drying. The rehydration potential of the air-dried sample was also lower than that of microwave-dried sample. Moreover, case hardening of the surface developed in the case of air-dried sample at higher temperatures and thus reduced the degree of shrinkage. Krokida, et al., (2001) investigated the effects of drying methods on the color of dried potatoes and found that the conventional air drying caused extensive browning with a significant drop of the lightness and an increase in the redness and yellowness of dried potato. Krokida et al., (1998), McMinn and Magee, (1996) and Wang and Brennan, (1995) study the effect of hot air drying of potatoes pieces of various shapes. Generally, it is found that hot air drying causes much quality degradation (in terms of nutritional values, color, shrinkage and other organoleptic properties). Hence the objective of this study was the design, construction and testing of a hot water potatoes dryer.

Materials and Methods

Design of water dryer

Refrigerator frame was used as a frame to the designed dryer. It consists of heat exchanger, drying chamber, water tank, hot water circulation pump, trays, fans, water heater, thermostat, inlet and outlet opening and shelves. The general view of the dryer components were shown in Fig (1). The dryer had the dimensions of 56 cm × 46 cm × 158 cm length width and height respectively. The dryer body consist of three layers, the out side layer was made up of high- grade plastic and the inside layer was lined with aluminum sheet while the gap of

about 2.7cm between the two previous layers was filled with insulator material(cork) .

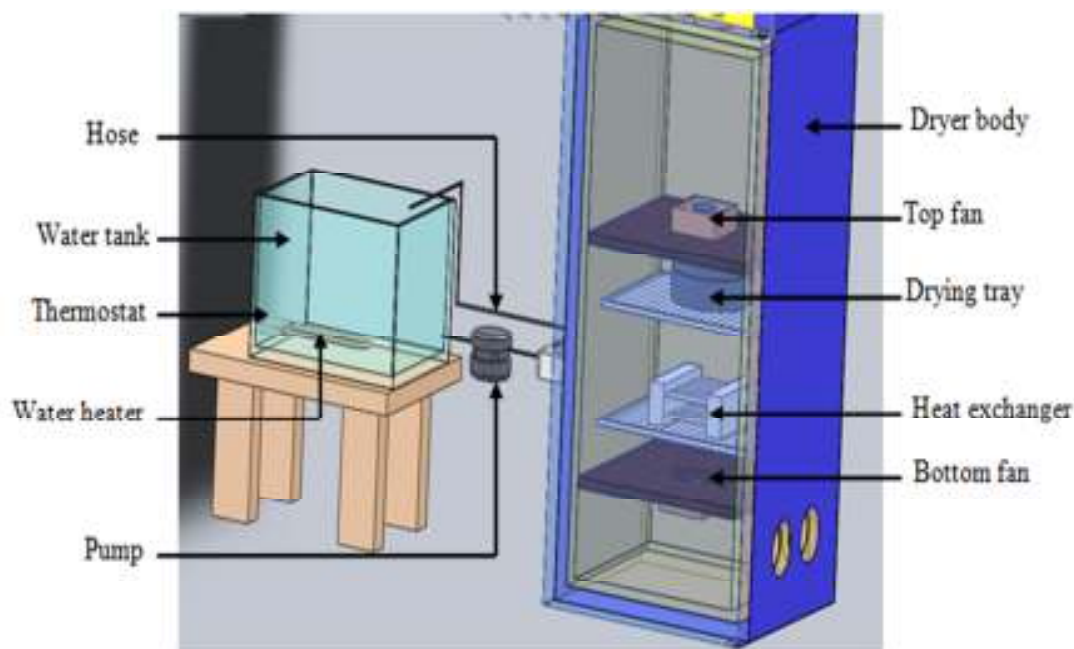


Fig1: General view of the dryer

Operation mechanism

Three different drying methods were used in the drying system based on the location of fan inside the drying chamber, these included :-

- Air suction method (one fan at the top of the drying chamber).
- Air intake method (one fan at the bottom of the drying chamber).
- A combination of suction and intake air methods (using two fans at the same time).

Air suction method with one fan at the top of the drying chamber (Fig 2a):

In this method the fan on the top slot of the drying chamber has been only used to move the air. When air suction occurred , it passes through the water heat exchanger in order to increase air temperature and then continued moving through the product on

the drying tray. The result of that heat exchange occurred and then stream of hot wet air get out of the dryer through the top suction fan of the dryer.

Air intake method with one fan at the bottom of the drying chamber(Fig 2b):

This method bear a resemblance to the air suction method, except that the air flow came through the intake fan , which fixed to the bottom of the drying chamber system. The suction air comes across the heat exchanger and then passes through the raw material in the drying trays.

A combined method using two fans simultaneously(Fig 2c):

This method combined the two methods previously discussed. In these methods the raw materials were subjected to excess rates of air flow that minimizing the drying time of the raw materials.

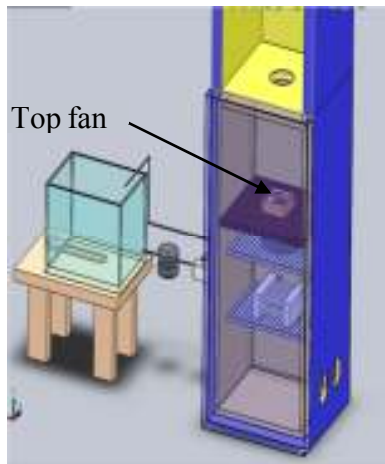


Fig 2a: Shows top fan position

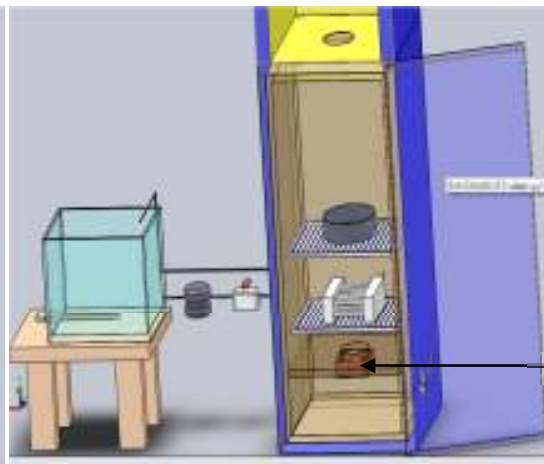


Fig 2b: Shows bottom fan position

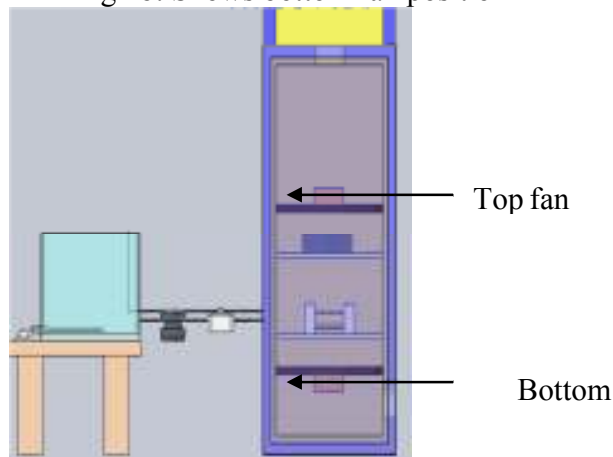


Fig 2c: Shows the position of both fans

Method:

A good quality potatoes were purchased from Giza local market- Egypt (Fig 3) which constituted the sample for the experiment. The pretreatments consist of washing and peeling. The selected amount which peeled were then sliced in a circular shape. Each slice had 50 mm in diameter and 6 mm thickness. The slice making is entrusted to specialized food

slicer. The prepared potatoes slices were placed in a vegetable basket which in turn was placed in a boiling water. The basket was left in the boiling. The blanching time take 5 minutes. The blanched potatoes slices were immediately placed in a cold water and left for 15 minutes. Finally, the slices were spreaded in single layer between paper towels to dry.



Fig 3: Sample of potatoes before treatment

The experiments were conducted under controlled conditions at velocity of 1.5 (m/s) and air temperature of 63°C which corresponded to 13% relative humidity. using thin layers of potato slices. The samples were weighted with sensitive balance. As soon as the samples were placed in the drying chamber the starting time of drying was recorded. For the first hour the weighting process of the samples was carried out every 20 minutes and then every 30 minutes. The weighting period was kept within a period not exceeding 10 seconds. The process was repeated until fixed weight was reached. The samples were placed in desiccator for 10 minutes to cool and then placed and closed in plastic bags.

Determination of potatoes moisture content

Determination of potatoes moisture content is done by weighting the drying tray with slices at successive periods. The original moisture content on wet basis, Mw_o , was determined by the oven drying method at 105°C (AOAC, 1990). The weight loss was calculated in each of these experiments separately and its value correlated with drying air temperature and velocity. The moisture content wet basis of the fresh product was expressed as:

$$Mw_o = \frac{w_o - w_d}{w_o} \times 100$$

Where:

Mw_o moisture content, wet basis of the fresh vegetables.

W_o weight of fresh sample, (kg).

W_d weight of dried sample, (kg).

Organoleptic properties evaluation method

The organoleptic evaluation was carried out according to Sidel and Stane (1976). Twenty trained panelists from the Food Science and Technology Department, College of Agricultural Studies, Sudan University of Science and Technology were asked to evaluate the potatoes dried products. The evaluating parameters were color, taste, flavor, and general appearance using the following Hedonic Scale: 1 = excellent, 2 = v. good, 3 = good, 4 = acceptable and 5 = unacceptable. The data collected from the panelists were subjected to statistical analysis for randomized complete block design.

Results and Discussion

Potato moisture content

The results obtained were exposed in (Fig 4). There were clear differences between different treatments. These differences were confirmed by the statistical analysis at ($p > 0.05$). The bottom fan method gave the lowest moisture content percentage 3.33% followed by two fans method. This result agreed with the finding of Loeseck, (2012)

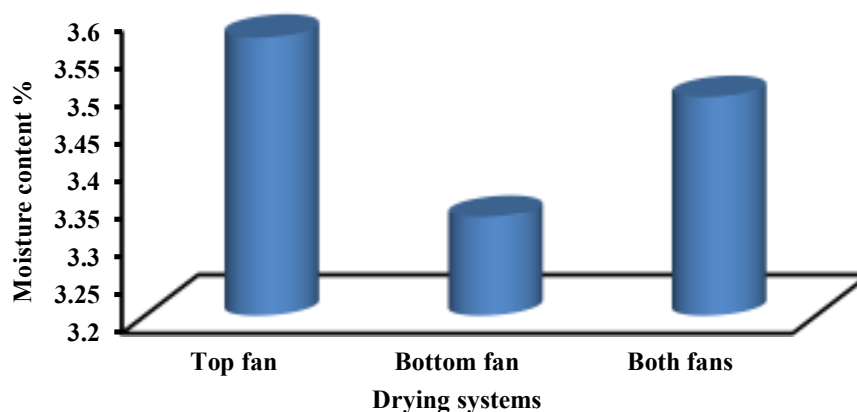


Fig. 4: Moisture content of dried potato

Organoleptic evaluation (color, taste, flavor and general appearance)

Color evaluation

High temperature and long drying times, required to remove water from the sugar containing raw material in convective air drying, may cause serious damage to the flavour, colour, nutrients, reduction in bulk density and rehydration capacity of the

dried product (Tajner-Czopek, et al; 2007). The result of color evaluation of potato dried sample showed significant difference ($p > 0.05$) between the treatments (Fig 5). The lowest value (best result) obtained by hot water system with two fans at the top and bottom 1.29, followed by the same drying system using the top fan 1.47.

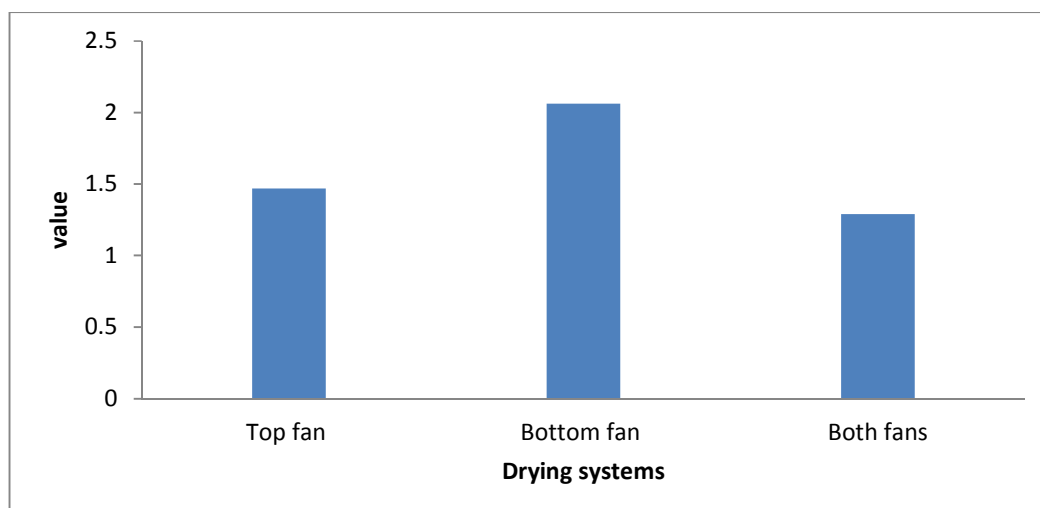


Fig 5: Color evaluation of potatoes

Taste evaluation

Although the results of taste evaluation of potato dried sample (Fig 6) showed no significant differences ($p > 0.05$) between all

treatments, but the hot water system with two fans recorded the lowest value 2.18 , and at the same time it recoded the highest value 2.65with bottom position fan.

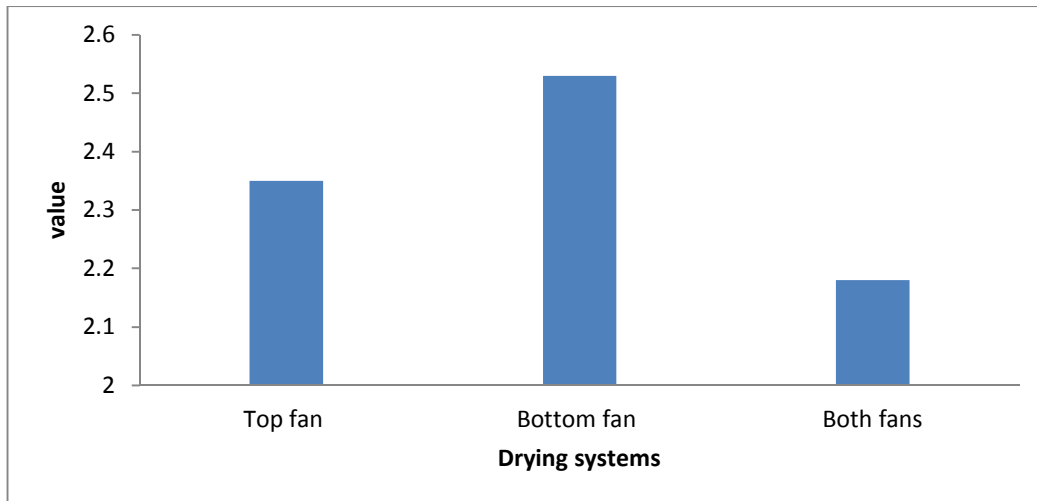


Fig 6: Taste evaluation of potatoes

Flavor evaluation of potatoes

Although the results of flavor evaluation of potatoes dried samples showed no significant differences ($p > 0.05$) among all

treatments, (Fig7) the hot water dryer using top fan and two fans gave the lowest and identical value 2.53.

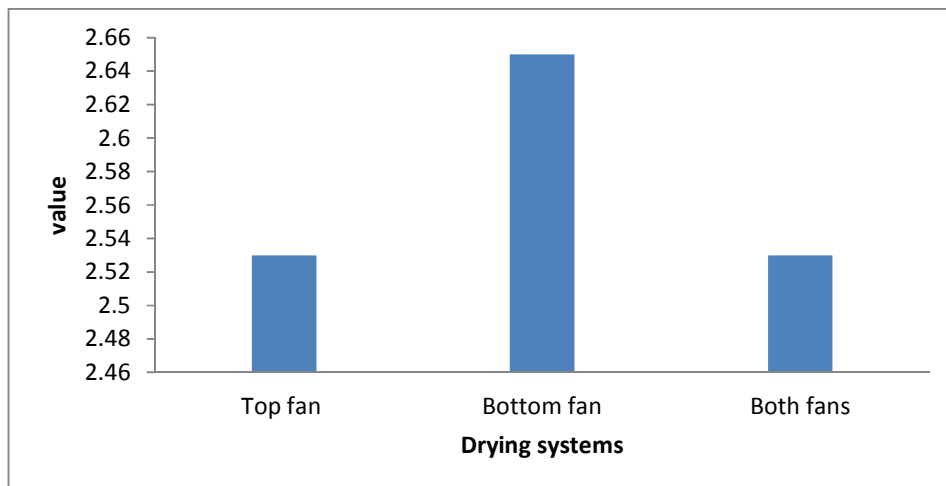


Fig7: Flavor evaluation of potato

General appearance evaluation of potatoes

The results of potatoes general appearance indicated that, there were no significant

differences ($p > 0.05$) among all treatments (Fig 8). The best result was observed with hot water dryer using top and bottom fan 2.24. This may due to used of two fans

which can accelerate the movement of drying air. This result followed by hot

waterdryer using top fan of drying chamber 2.35.

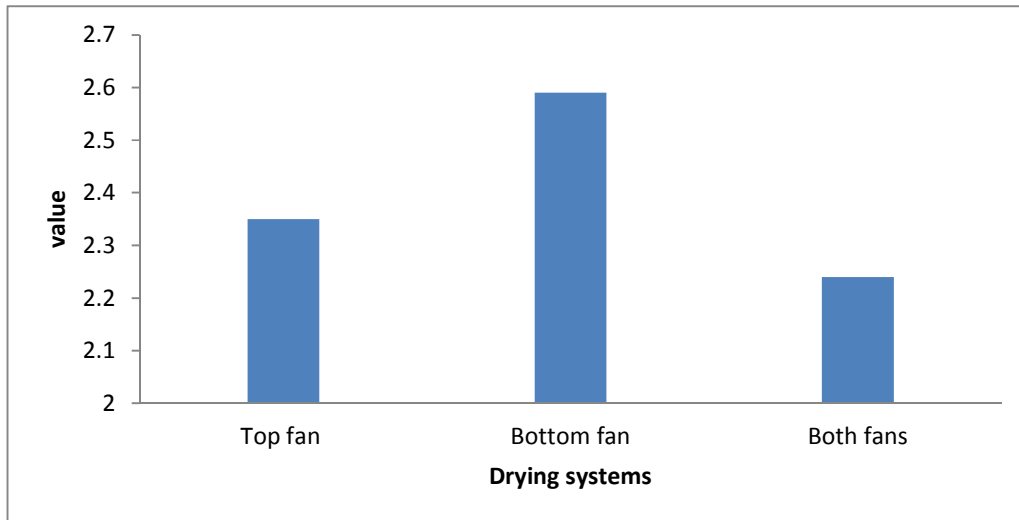


Fig 8: General appearance evaluation of potatoes

The dried potatoes by using different systems showed in Fig 9, 10 and 11



Fig 9: Dried potatoes using top fan

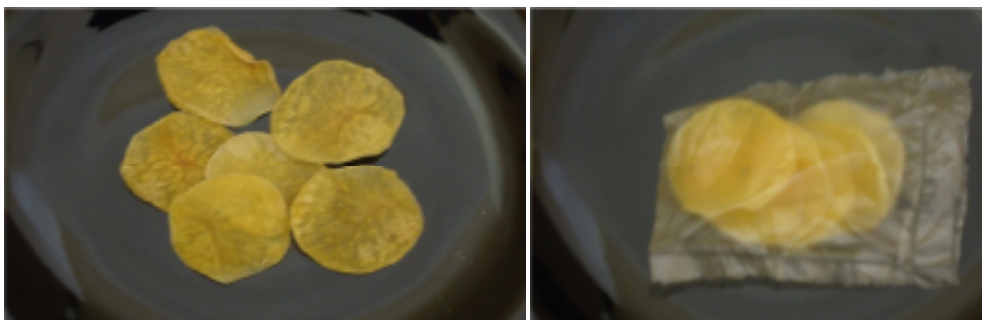


Fig 10: Dried potatoes using bottom fan



Fig 11: Dried potatoes using both fans

Conclusion

Hot water dryer for drying potatoes showed high values when using both fans together through all evaluation parameters.

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تقييم وإختبار أداء مجفف الأغذية يعمل بالماء الساخن

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المستخلص

تحتوى الدراسة على تصميم مجفف مائى . نظرية عمل المجفف تعتمد على استخدام الماء الساخن كمصدر للحرارة لتجفيف المنتج. تم اختيار منتج البطاطس لاختبار اداء المجفف . تم اجراء عملية التجفيف تحت ظروف 63 درجة مئوية مع 13% رطوبة نسبية وسرعة هواء 1.5 متر فى الثانية. تم تطبيق ثلاثة طرق للتجفيف بناء على وضعية المروحة داخل غرفة التجفيف (اعلى، اسفل و الوضعين معا). تم اخضاع المنتج المجفف لاختبار نسبة الرطوبة وايضا الخصائص الحسية تم تقييمها (اللون ، الطعم ، الرائحة و المظهر العام) . اظهرت النتائج ان استخدام المروحة السفلى كطريقة تجفيف اعطت اقل نسبة رطوبة 3.25% تلتها المروحتين معا 3.49% اما بالنسبة لتقييم الخواص الحسية كان الملاحظ من النتائج ان المجفف اعطى نتائج جيدة عند استخدام المروحتين معا و هى 1.29، 2.18، 2.53 و 2.24 للون ، الطعم ، الرائحة و المظهر العام على التوالى.