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RESEARCH ARTICLE

VALUE ADDITION OF GRAPES USING HOT AIR DRYERS

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ABSTRACT

This study includes to study the effect of air temperature on raisins and to study the economic analysis of proposed methodology and compare the output with conventional techniques. It can be seen from the results that both the hot air dryers e.g. solar and electric dryer produce raisins in a much lower time in comparison to the traditional method of raisin dryer. Solar dryer takes 96 hours to produce raisin while electric dryer takes 15 hours for raisin production. This time frame for raisin production is much lower than that of 336 hours or 2 weeks, an average time for raisin production using traditional sun drying method. Raisin produced using traditional methods are associated with many of health issues. Generally, raisins produced using the traditional method has a risk of being rotten. Rainwater may reach the grapes that are placed for being dry in traditional method. Such raisin has a light color as its color is washed away. Customers find such raisins less attractive. Moisture content of raisins is an important parameter to evaluate the quality of raisin. Moisture content present in the market available raisin that is produced using traditional method is 25.30 %.

KEYWORDS

Raisins, conventional, production, traditional, Moisture

1. INTRODUCTION

Drying is an important tool for handling, transportation, and storage of agricultural products. Fundamental principle behind drying procedure is to reduce the moisture content. Earliest method used for drying the grapes involve laying the grapes in sunlight on the rooftop, mat, or drying floors. Such methods have several disadvantages e.g. dust contamination, dirt, insects, or adverse climactic affects. Sun Belt regions takes the total amount of annual global radiation on a horizontal surface that may reach in over 2,200 kWh/m^2 (Ghazanfari et al., 2003). Pakistan is a region with a high potential of horizontal solar radiation. Therefore, Pakistan has a huge potential of solar equipment to be developed. Country can move from use of nonrenewable energies to renewable and cost-effective energy which is ecofriendly as well (Arinze et al., 1996). Löf has pointed out that sunlight is one of the main sources for the processing of foods (Löf, 1962). Research was conducted to use solar energy for the drying of grapes into raisins.

Grapes were exposed to solar heat it was found that the internal temperature was higher than the surrounding temperature and it was 4 to 8 °C higher than the surrounding temperature. When grapes were kept in shady area the temperature of grapes was less than the surrounding. During the shaded midday time, as well as after sunset, the sun energy taken by the vegetables, fruits and other food used these energies for dehydration. In this process the drying time was generally high. This usually takes from 14 to 21 days depending on the atmospheric conditions. Due to mass decreasing and poor grades of raisins was formed due to weather conditions such as dust. pests and insect attack, the above approach was found to be unsatisfactory. Furthermore, direct exposure to solar radiation leads to unnecessary changes in color.

Uncontrolled conditions can also lead to microbial attacks which spoil the large number of grapes and the raisins which was in process. So, the processing of grapes into raisins through dryers was useful and profitable technique but high installation cost and maintenance cost is high. Due to all these factors, small farmer would not adopt this invention. But if improvement were made that small amount of energy used and more food is dried than this technique is more useful and small farmers easily adopt this technique. A group researchers conducted a study that the raisins were dry using only a single method 2450 MHz duct applicator (Tulasidas et al., 1995). Many qualities, such as shade, harm, dark, solidified glucose, softness, and semi- uniformity, assessed the durability of the grapes. Dry micro grapes were lighter in color and therefore preferable to hot air-dried tests. Specific energy consumption of selected MW drying technique is shown in table 1.

Table 1: Specific Energy Consumption of Selected Mw Drying Treatments Which Yielded Good Quality Raisins

Treatment No	Air velocity (m/s)	MW power (w/g)	Air temp (°C)	Specific energy consumption (MJ/kg H_2O)
15	2	0.5	50	21.86
14	2	0.5	40	24.31
17	2	1	30	12.77
1	1	0.5	30	10.74
21	2	1	30	9.51
16	2	0.5	60	19.08
2	1	1	40	8.25
18	2	1	40	13.26

This table shows that treatment no 2 consumes the least specific energy for drying the product while maximum specific energy consumption is shown for treatment no 14. Total world production of raisin is shown in figure 1. It is clear from the figure that till 2012. Europe was leading grape production worldwide. Although the trend was more in favor of Asian countries to lead grape production as shown in figure 2 Trend from 2000 – 2012 shows that Europe share in grape production is decreased from 62.5 % to 39 % from 2000 to 2012 while in this period grape production

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increased from 19.4 to 31.2 percent in Asian countries. This trend shows the potential of Asian countries to produce grapes.

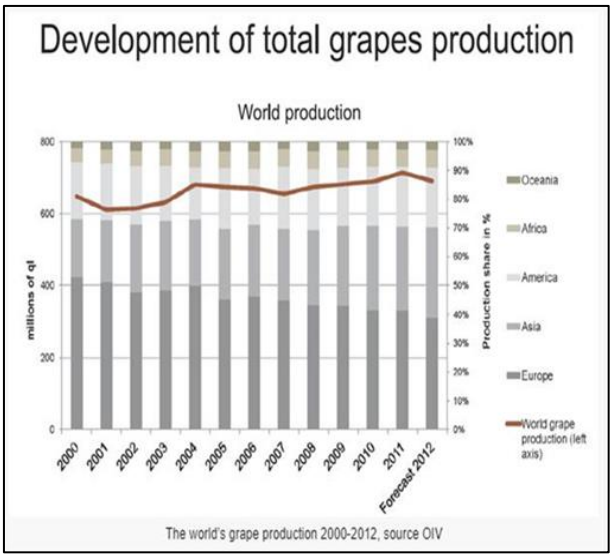

Figure 1: Grape's production in the world

The above methods are not good enough as it includes mass losses and low-quality raisins production. Quality of raisin is low because of the exposure to duct, insects, and rain. Further direct exposure to sunlight causes an unwanted color change. Moreover, uncontrolled conditions are more likely to result in microbial attacks which may spoil the whole stock in process. These drawbacks attract the farmer to go for mechanical methods for grapes drying that is rapid and is carried out in controlled conditions, but a huge number of small farmers cannot afford this because of massive initial investment and an additional running cost. Energy cost involved in such mechanical methods was higher even before the energy crisis of Pakistan. Thus, increasing rate of fuel consumption in agriculture has made researchers to think of some methods that save energy by intensifying the drying process, improving design etc., but also by means of some renewable energy.

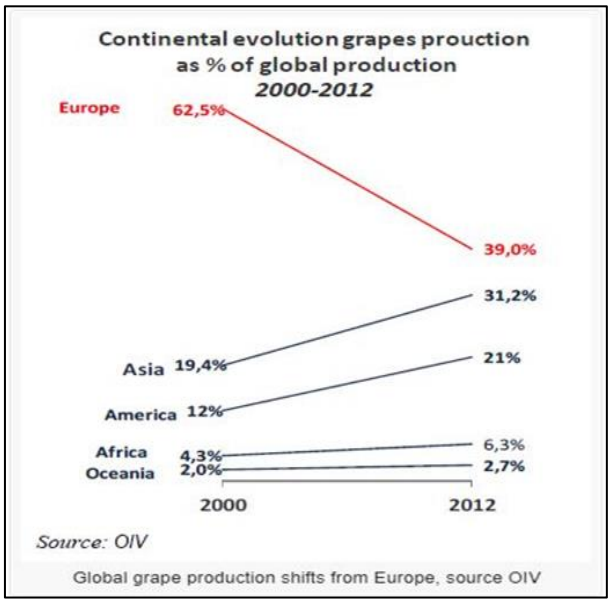

Figure 2: Evolution of grapes production from 2000 – 2012

Low temperatures are desired for quality dehydration, which can be easily obtained from indirect solar or waste heat sources (Yoo et al., 2017). Fruit preservation by drying technique is traditional and methods used for this purpose varies greatly depending upon the geography and locality of area. Grapes are among the palatable and profitable fruit. Drying of grapes to get raisin has widely been used since centuries. Conventional methods used for this purpose include drying using sunlight, shade drying and even mechanical drying techniques. All these traditional techniques for raisins production have disadvantage of being time taking, cumbersome and unhygienic. Moreover, such techniques utilize great energy thus being costly way of raisins production. This research work involves hot air dryers used for such purposes. Solar and electric dryers are introduced for raisins production. Research has focused on energy and cost efficiency of such drying techniques. Research will also cover quality assessment of raisins produced. This research is based on the problems for both small- and large-scale farmers who are looking for one of these techniques, according to their requirement and needs that can help to improve their quantity along with their quality of their product in future. The objectives of this study include:

1. To study the effect of air temperature on raisins.
2. To study the economic analysis of proposed methodology and compare the output with conventional techniques.

2. Material and Methods

The experimental setup was so designed to achieve the stated objectives; to study the efficiency of solar and electric dryers for raisins production, to study the effect of air temperature on raisins, to study the quality of raisins produced using such hot air dryers on small and large scale, to study the economic analysis of proposed methodology and compare the output with conventional techniques. This research work is carried out with an aim of determining the efficiency of electric and solar air dryer used for raisins production. Research is carried out by collecting the grapes available in market. These grapes are washed and dried. The weighted amount of these air-dried grapes is then placed in solar and electric dryers for a specified period. Raisins produced using both these techniques is evaluated by comparing it with the raisins produced using traditional methods. Criteria that are set to evaluate raisins includes color, quality, moisture content and health aspects. Grapes were obtained from the market for its future use of raisins production. Grapes that are obtained from the market are first washed using water and then they are made air dried prior to their placement in solar or electric dryer. Grapes in solar tunnel dryer is shown in figure 3.

Figure 3: Grapes in solar tunnel dryer

2.1 Study area

The research was carried out at engineering workshop, University of Agriculture Faisalabad. In engineering workshop there are two dryers which are used for this research as shown in figure 4. In these dryers' grapes are processed into raisins. Different varieties of solar dryers have been designed, developed, and tested in the varying areas of the tropics and subtropics. Dryers are of two basic classification i.e. natural convection solar dryers and forced convection solar dryers (Bala and Janjai, 2012). Fundamental principle behind natural convection solar dryers involves, the airflow is established by buoyancy induced airflow while in forced convection solar dryers the airflow is provided by using a fan either operated by electricity/solar module or fossil fuel (Visavale, 2012).

Figure 4: Satellite view of study area

Two of the available hot air dryers were used for raisins production. Main objective of the research work is to evaluate the efficiency of both these technique in comparison to already existing standard and traditional direct sun drying technique. Fundamental principles and major parts of these equipment is described in the coming line. Solar tunnel dryers were designed as a portable method that can be used for drying many of the agriculture products. Agriculture University has developed such solar air dryer portable tunnel that can be used at any desired location for drying purpose. Fundamental principle behind solar air tunnel available in the university along with schematic diagram is presented in the coming lines.

2.2 Design Parameters

Angle of the collector is very important in term of efficiently drying of agriculture products. (Deceased and Beckman, 2013). The angle of the collector is selected according to the latitude. The angle is selected in such a way that it is applicable in both season summer and winter. Solar dryer size was selected in such a way that it easily moves to the exact location and easily handle when the dryer is in operation. The dryer height is selected in such a way that easily loaded and unloaded of agriculture products are done. The major purpose of flat plate collector to pre heat the air and dried agriculture products at optimum temperature without any damage. The collector most desirable region is 40.0 to 45.0 percent to get more energy from solar radiation. Collector size was chosen so that heated air enters the drying chamber easily and drying the agriculture products in an effective way. The collector is placed before the drying chamber so the hot air enters without any interruption (Adsten et al., 2002). Insulator chamber was fastening with the help of silicon to ensure airtight chamber. The optimal air speed is 1 ms^{-1}. DC fans are installed in solar dryer. To ensure maximum speed of fans these fans are operated with solar panel. These fans throw high stream of air into the drying section. The air speed rate depends upon the intensity of sunlight. When the intensity of sunlight is weak or strong than the fans works according to sunlight intensity (Munir et al., 2013). Dryer location is very important for effective drying of products. So, the dryer angle is placed in such a way that it absorbs more sunlight from collector and easy flow of air circulation was obtained without any interruption.

2.3 Solar Drying of Various Agriculture Products

For the quantitative procedure within solar dryer, two criteria were chosen, based on which all testing approach and computation are made. Liquid bulb and inlet temperature were recorded during drying of the product. Every experiment run begins by calculating the product's moisture levels for 24 hours, e.g. grapes by oven drying method at a temperature of 105 °C.

2.4 Electric Dryer Construction

Electric dryers were also used for raisins production. Electric dryers used in this research work is electrically powered cross flow tray dryer using micro hydro which can produce high quality raisins. This is highly used technology across the developed world to get high quality dried crops. This project does have the objectives of increasing the quality production of raisins in Pakistan that can increase the social standard of the low-income farmers. This method of raisin production is associated with low initial cost; therefore, it can be a game changer for the farmers of Pakistan. Electric dryer used for the research work is shown in figure 5. These electric dryers are available in the laboratory of agriculture university Faisalabad.

Figure 5: Electric dryer used in the research

2.5 Electric Dryer Schematic

Drying is the procedure of removing moisture from the food product. Removed moisture is absorbed into the surrounding air. Effective drying involves the air that is hot, dry, and moving. These factors are chained with each other, and it is important that each factor is considered well:

- Air must be dry, so it can absorb the moisture from the fruits and vegetables
- Heating the air around the product makes it to dry more quickly
- If the air is not moving across the food, it cannot get rid of the water vapor that it has collected. Fan or air blower is needed to keep the air circulating

When hot air meets the food, it makes the food dry and move away. New hot air comes in contact and absorb more water and goes away. This process continues till the food is free from all the entrapped moisture. Schematic diagram of hot electric dryer is shown in figure 6

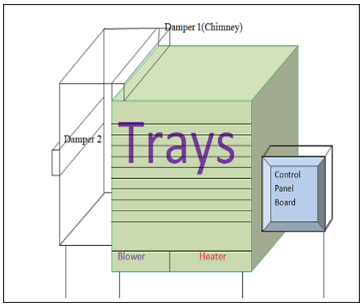

Figure 6: Schematic diagram of Electric dryer used for raisin production

3. Results and Discussion

Raisins produces using both the techniques are evaluated based on various criteria. Quality of raisins produced by these methods is evaluated based on their color, moisture content and health aspects of the raisins. Time required for raisins production per batch is also a fundamental criterion for evaluating the methods.

3.1 Effect of Drying Temperature on Raisins Production

Main objective of doing this research work is to evaluate these methods keeping quality of raisin, a top priority. Literature has suggested that drying grapes in open sun at various temperature greatly affect the quality of raisin produced. Table 2 shows the color combinations of various raisin produced at different temperatures. Raisin color varies from pale yellow to dark brown under increasing temperature range.

Table 2: Comparison of color of raisin dried at various temperature

Drying temperature (°C)	Drying time (h)	Color of raisin
50-55	36-48	Pale yellow
55-60	24-26	Yellowish Brown
60-65	18-24	Light Brown
65-70	16-18	Brown
70-75	12-16	Dark Brown
65-70 & 50-55	22-24	Greenish Yellow

3.2 Moisture Content of Raisins

This research work is primarily concerned with moisture content (M.C) present in the grapes when it is dried using the drying tool. Moisture content present in the raisin produced using the solar and electric dryer is compared with the moisture present in the market available raisin. Time taken by the solar and electric dryers is calculated. This time is much lower than the time grapes takes to become raisin under traditional direct sun drying. Average time taken by solar tunnel dryer is 96 hours while electric dryer takes 15 hours for raisins production. Figure 7 shows the raisin placed in the oven. After drying the grapes in electric and solar tunnel dryer, we checked that how much moisture content present in our raisins and the moisture content present in market available raisins.

Figure 7: Moisture content determination of the raisin

3.3 Criteria for Evaluating the Dryers

Raisins produced using solar and electric dryers are evaluated based on various criteria of evaluation. These criteria may include moisture content present in the raisins after drying using both these techniques. Moisture content present in the raisins is calculated for both the dryers and this moisture is compared to the moisture present in the raisins available from market. Results have sown that moisture content is more for solar tunnel dried raisins in comparison to that of electrically dried raisins shown in figure 8. Moreover, raisins obtained from both these techniques carry less moisture than that of raisins available in market.

However, the values of moisture content in raisins produced using dryers is comparable to that of available in market. Raisin produced using both the dryers is produced in a very short time in comparison to that of market available raisin that is produced using conventional direct sun drying method. Health aspect of the raisin produced is obviously another important tool to evaluate the quality of the raisin. These methods are free from dirt and other environmental impurities. Raisins produced using such techniques is also less likely to be associated with raisins loss as in case of conventional direct sun drying techniques.

3.3.1 Comparison of Fresh and Dry Weight of Grapes in Electric and Solar Tunnel Dryer

Fresh and dry weight of grapes both in electric and solar tunnel dryer is shown in table 3 & 4 and their graphical representation is shown in figure 9.

Table 3: Comparison of fresh and dry weight of grapes in electric and solar tunnel dryer

Electric Dryer		Solar Tunnel Dryer	
Before Drying (kg)	After Drying (kg)	Before Drying (kg)	After Drying (kg)
2	0.485	5.6	1.501

Figure 8: Electric dried raisins

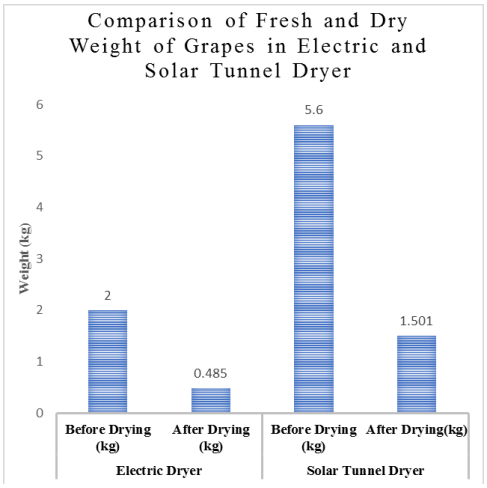

Figure 9: Comparison of fresh and dry weight of grapes in electric and solar tunnel dryer

3.3.2 Comparison of Moisture Content of Electric, Solar Tunnel Dryer and Market Available Raisins

Table 4: Comparison of moisture content of electric, solar tunnel dryer and market available raisins

Raisins	Moisture Content (%)
Electric Dryer	23.37
Solar Tunnel Dryer	24.10
Market Available	25.30

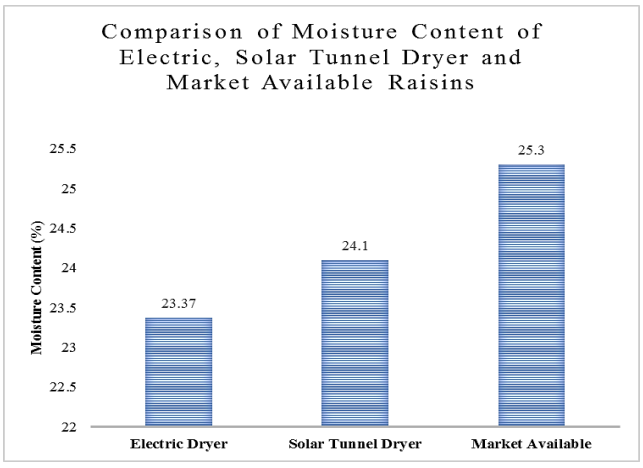

Figure 10: Comparison of moisture content of electric, solar tunnel dryer and market available raisins

Figure 10 shows the bar chart representing the values of percentage moisture content in raisins produced using various techniques. Bar chart shows that highest moisture content is present in the market available raisins. Raisin production by electric dryer carries the least of moisture content. However, both the newly adopted techniques e.g. solar and electric dryers produce reasonable results. Therefore, these results are valid and obviously such techniques must be adopted for raisin production as it has many other advantages. Other factors that are considered while evaluating the efficiency of the solar and electric dryers are explained in the coming lines.

3.3.3 Time for Raisins Production

Time consumed for the raisins production counts very much as it is very much important for farmer to produce raisin in the shortest possible time. Average time taken by traditional method of raisin production is 2 weeks that makes 14 days or 336 hours. Experiments done for raisins production using solar and electric dryers have revealed that both these techniques take much lesser time in comparison to that of traditional method. A bar chart shown in figure 11 explains the time taken in hours for raisin production.

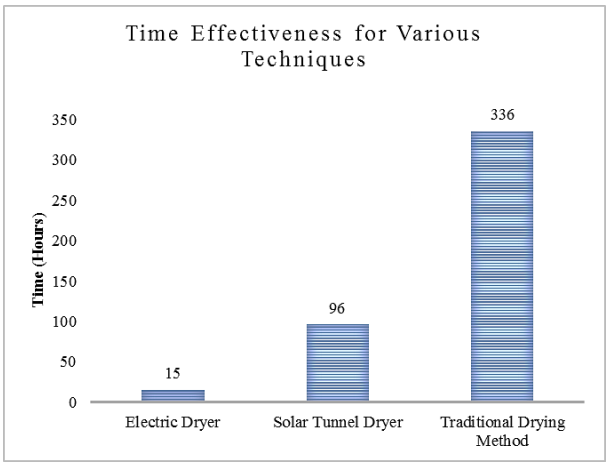

Figure 11: Time effectiveness for various techniques

Bar chart clearly shows that electric method for raisins production is most time effective. Electric method produces raisins in just 15 hours. Solar tunnel drying produce raisins in 96 hours. It is obvious that solar tunnel dryer takes more time rather than time taken by electric dryer. Traditional direct sun drying method takes 336 hours or 2 weeks' time for raisins production. Thus, time effectiveness of both these methods have been proved from the experimental setup.

3.4 Comparison of electric and solar tunnel dryer

The comparison of solar and electric tunnel dryer is shown in following table 5 & 6:

Table 5: Comparison of electric and solar tunnel dryer

	Electric Dryer	Solar Tunnel Dryer
Construction Cost	250,000	130,000
Running Cost	4 amp	0
Maintenance Cost	Required	Not Required
Working Capacity	24 hours	Only on Sunlight
Drying Time	Take less time	Take more time
Operational Cost	More	Less

3.5 Comparison of modern techniques (electric, STD) as compared to conventional techniques

Table 6: Comparison of modern and conventional technique

Modern Techniques	Conventional Techniques
The food processed in this technique are hygiene	The food processed in this technique are not hygiene
There is no wastage of final product	There is wastage of final product
The product manufactured is in good quality.	The product manufactured is not in good quality.

4. Conclusions

This research work was carried out aiming to check the time efficacy of both solar and electric dryers. It can be seen from the results that both the hot air dryers e.g. solar and electric dryer produce raisins in a much lower time in comparison to the traditional method of raisin dryer. Solar dryer takes 96 hours to produce raisin while electric dryer takes 15 hours for raisin production. This time frame for raisin production is much lower than that of 336 hours or 2 weeks, an average time for raisin production using traditional sun drying method. Therefore, time efficiency of the hot air dryers has been proven. Raisin produced using traditional methods are associated with many of health issues. Open sun dryer techniques for raisin production is vulnerable to insects, pest and other impurity addition to raisin produced. Raisin produced using traditional techniques is associated with a massive loss. Generally, raisins produced using the traditional method has a risk of being rotten.

Rainwater may reach the grapes that are placed for being dry in traditional method. Such raisin has a light color as its color is washed away. Customers find such raisins less attractive. Moisture content of raisins is an important parameter to evaluate the quality of raisin. Moisture content present in the market available raisin that is produced using traditional method is 25.30 %. Both the hot air dryers carry less moisture content in comparison to the raisin produced using traditional techniques. Results have shown that moisture content present in solar and electric dryers is 24.1 and 23.37 % respectively. This sows that raisin produced using solar and electric dryer carry moisture content that is near to the moisture content present in raisin that is market available. Raisin production is a profitable business. Traditional method used for this purpose are associated with huge losses along with being unhygienic and time costly. Therefore, raisin production needs to be upgraded. Moreover, this industry needs to be upgraded on modern ways by incorporation of modern technology.

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