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Feasibility of Vegetable Drying Technic by Geothermal Heating at City of Kirsehir

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Abstract

Demand for healthy food products has risen dramatically in recent years in the world. The findings that indicate that some major diseases such as cancer and obesity are triggered by food products which do not satisfy the necessary sanitation conditions have lead the consumers use organic and decontaminated products. Experts indicate that vegetables should be consumed after drying them whether on their natural growing season or out of season. In that case, the demand for dried vegetables would always be high since the drying sector is a preferred field of business and has great contributions to economy. Consumers not only make use of the dried vegetables directly, but also they can benefit from the dried vegetables in instant soup, infant food and additive food flour. The first geothermal fruit and vegetable drying facility has been established at Karakurt town in the city of Kirsehir with the contributions of Kirsehir Municipality and Provincial Administration Corporation. Drying of banana, palm, quince, orange, pineapple, pear, apple kiwi, peach, watermelon and melon is currently practiced in that facility. However, the drying facility in terms of vegetable drying is not currently serving with full productivity. In the city of Kirsehir, 39 different kind of vegetable is grown at 3005,7 ha area. The proper selection of vegetable type according to climate conditions and proper irrigation techniques would yield the city to become more productive in field of vegetable growing. Among countless vegetables; tomato, water melon, melon, pepper, cucumber, eggplant, onion, green beans, white cabbage, lettuce, spinach, garlic, leek and carrot would take the first place to grow. The research that we are presenting would shed light on the sector of vegetable and fruit drying, specifically on vegetable drying. The process of drying that will be used also explained technically step by step.

Keywords: Vegetables, pre-processing, drying, packaging, storage

Introduction

Current active agricultural land in Turkey is about 28.053.500 ha. About 872.000 ha of this agricultural land are used for vegetables production. With about 27.815.682 ton annual vegetable production, Turkey is the fourth largest vegetable grower in the world (TUIK, 2012). Kirsehir has about 454.720 ha of active agricultural land, of which about 3.005,7 ha is used for vegetable production. According to 2011 data, 39 different vegetable types are produced in Kirsehir, with about 49.775 tons of total annual production. The most commonly produces vegetable types in Kirsehir include tomatoes, water melon, melon, onion, pepper, eggplant, green beans, lettuce, garlic, cabbage and zucchini (Madakbas and Feridun, 2013).

Vegetables are one of the important nutrition sources for people. They consist of about 90-95% water, 1-3% nitrogen, less than 1% fat, 3-7% carbohydrate, and 1-2% mineral. Each vegetable type may have slight variations in their percentage make depending on various factors, including region they are produced, regional environmental conditions and soil conditions, soil preparation process, growing methods, cultural practices, product ripeness, transportation and storage techniques (Cemeroglu, 2011).

Turkey is a rare country that has varying climate patterns throughout. As a result, different types of agricultural crop are produced in different regions. Turkey has a high solar potential. Our farmers take advantage of it by using solar energy to dry vegetables. However, vegetable drying process usually takes much longer because certain drying preparation processes are not practiced. At the same time vegetables are subject to dust, rain, dirt, as well as damage and drops from bugs and birds. Accelerating the vegetable drying process by using drying preparation processes will reduce such effect and produce better quality dried vegetables. Additionally, depending on the drying process, dried vegetable weight may reduce to about 1/3rd to 1/10th of original weight. This is another reason why modern and controlled drying methods are required for vegetable drying.

Regardless which processing methods are used, the quality of vegetable production depends on freshness and quality of materials used in production. Vegetables should be harvested when they are ripe before they get too old. This is because the chemical compassion and make of vegetable keeps changing with the harvest and thereafter. Depending on the process, vegetables can lose important nutritional values during preparation, including washing, skin pealing, cutting stages. Additionally, steaming or boiling of vegetables before freezing or canning processes cause significant vitamin C loss. This loss is about 23-55% with steaming process and 39 -81% with boiling process. Similarly, steaming and boiling processes are the cause for significant mineral loss of vegetables. Vitamin C loss and mineral loss from steaming and boiling process can be reduced only when the steaming and boiling processes are done at high temperature and short duration. Regardless how well processed, neither frozen nor canned vegetables can replace taste, nutritional values, or traditional place of dried vegetables on our dinner tables. The most often dried vegetable types observed in drying facilities include water melon, melon, peas, corn, pepper, zucchini, okra, onion and green beans (Anonymous, 2013).

The most effective way to conserve and maintain chemical/microbal integrity of agricultural food produce with high concentration of water is de-watering, or known as drying process. It is possible to preserve and transport delicate agricultural food produce to other regions though drying process (Eroglu and Yildiz, 2011; Ispir, 2006). Therefore, drying vegetables is known as the most inexpensive way of preserving vegetables. Most of the dried produce has certain specialized uses. Among those uses, ready-made soups contain varieties of dried vegetables. (Anonymous, 2007).

Geothermal Energy is the Most Important Energy Source in Vegetable Drying Process

Similar to many other industrial processed, agricultural processes of growing food, transportation, and storage rely on available energy resources. Between 1996-2001, according to TUİK statistics, about 7.5-8.7% of industrial energy is used by agriculture sector in Turkey. Similarly, about 7.7-9.4% of total energy used in Turkey is by agriculture sector in Turkey (Haydaroglu, 2006). Many studies refer to geothermal and solar energy as renewable energy sources that can be used in agricultural produce drying processes. Use of those renewable energy sources will result in great conservation of other non-renewable energy sources (Garg and Kumar, 2001; Fargali et. al., 2008). However, daily and seasonal variability of solar energy caused drying process to take place with intervals. This is the main disadvantage of using solar energy for vegetable drying process. Whereas, geothermal energy shows no daily variation between day and night and between seasons. Geothermal energy is available continuously and it can be used consistently for vegetable drying processes.

Through its geographic location along the Alp-Himalayan belt, Turkey is rated as the seventh most geothermal energy rich country in the world. High temperature rated geothermal energy resources are located in the western parts of Turkey, and medium to low temperature rated geothermal energy resources are located in the central, east and northern parts of Turkey. It is reported that Turkey's geothermal energy capacity is about 31.500 Mega-Watts. Currently about 0.4 % of geothermal energy is used for fruit and vegetable drying processes in Turkey. Many other countries use thermal drying processes for vegetable drying (Helvaci et. al., 2013). Depending on the vegetable types to be dried, required geothermal energy temperatures can vary between 50 ^{o}C and 95 ^{o}C.

The geothermal resources in Turkey have the capacity meet the conditions required for fruit and vegetable drying process. Taze Kuru Gida A.S. in Kizilcahamam region of Ankara uses geothermal resources in vegetable drying process. Similarly, companies and facilities in Karakurt region of Kirsehir and Simav region of Kutahya use geothermal resources in vegetable drying process.

The geothermal energy based vegetable and fruit drying facility in Kirsehir is the most important facility in Turkey. The drying facility is used mostly for drying fruits that not necessarily grown in the Kirsehir region. Whereas, many varieties and sizable quantities of vegetables are grown in Kirsehir which can be dried in the same geothermal drying facility. Drying either the vegetables or the fruits in the same region it was grown provides great economic and dried product quality benefit. The following presents our goal in this study:

Draw to the attention that one of the three geothermal energy based drying facility is located in Kirsehir.

Describe economic benefits and advantages of geothermal energy based vegetable drying methods.

Vegetable drying can also be effectively performed in the Kirsehir facility that dries only fruits currently.

Benefits of vegetable drying in Kirsehir to Kirsehir economics and Turkish economics.

The Purpose of Drying Vegetables and Fresh Vegetables for Drying

Purpose of vegetable drying:

Avoid spoiling of vegetables in storages. Drying process slows down considerably the microbial and other chemical reactions that help to preserve vegetables for longer time.

Reducing water content of vegetables (dehydrating) still maintains taste, fragrance and nutritional values.

Drying process reduce vegetable volume which helps with effective transportation and storage (Anonymous, 2013). Table 1 lists varieties of vegetables that can be dried per months.

Table 1. Varieties of vegetables that can be dried per months.

Months											
January	February	March	April	May	June	July	August	September	October	November	December
cabbage cauliflower mushroom radish zucchini	broccoli cabbage cauliflower mushroom zucchini	artichoke asparagus broccoli lettuce mushroom radish spinach	asparagus cabbage endive radish rhubarb root spinach	asparagus celery tomato cress	melon sweet corn onion cucumber haricot vert peas pepper marrows	cabbage melon sweet corn cucumber dill eggplant haricot vert okra pepper watermelon	tomato beet cabbage carrot sweet corn cucumber dill eggplant melon pepper marrows tomato	broccoli carrot cauliflower sweet corn cucumber dill greens melon okra onion pepper squash tomato	broccoli pepper squash	broccoli cabbage cauliflower eggplant mushroom squash	mushroom

Vegetable varieties listed in Table 1, including squash, okra, sweet corn, pepper, peas, onion, and green beans, are vegetables that can be dried easily (Anonymous, 2007). Other varieties of vegetables that are commonly dried are red pepper, tomatoes, green pepper, broccoli, spinach, kale, leaks, cabbage, and celery. Kirsehir grows all the vegetable varieties listed that are typically dried, except sweet corn, artichoke, rhubarb and asparagus.

Necessary Preparation Procedure of Vegetable Drying

Harvested vegetables need to be moved to processing facilities immediately after harvest and prepared for drying right after. This is because vegetables keep losing from their qualities as time passes after harvest. For example, peas start to lose their sweet taste within several hours of harvest. Pea converts sugar to carbohydrate and produces lactic acid bacteria, which cause degradation of the pea quality. Therefore it is essential that drying facilities be located immediately adjacent to vegetable farms, or if absolutely necessary, the harvested vegetables should be stored in cold storage facilities right after harvest before drying processes to maintain their freshness.

The first process after harvesting vegetables is prewashing. However, vegetables such as carrots, spinach, green beans, and potatoes contain soils that need to be cleaned first. It becomes easier to prewash the vegetables after manually removing soils as much as possible. The prewashing process is not only to remove dust and soil from the vegetables but also to remove any chemical spray residues and other microorganism growth from the vegetable skin. After the prewash the vegetables are placed out on conveyor belt and moved through water spray and washed and rinsed and removed all the residues from prewash cycle. It is important that clean and cold water is used for vegetable washing. Water should contain about 0.5-2 mg/l of active chlorine. This helps to further remove and eliminate microorganisms from vegetables. Tomatoes especially contain eggs of fruit fly situated in the tomato surface cracks. Using about 0.5-1% of NaOH in washing water helps to remove those fruit fly eggs from tomato surfaces. After the washing process, it becomes much easier to see the any bruise, damage, rotten, crack, and other defect on vegetables. After the wash and rinse, all the vegetables with defect are separated from the good and healthy vegetables. Vegetables are sorted by their sizes, ripeness, color and shapes right after removing the defected vegetables. This is the typical process followed for preparation of peas and green beans before drying. It is necessary to remove unused parts from vegetables before drying such as removing end pieces of green beans, or un-shelling peas. This process helps further to remove microorganisms from vegetables before drying. Artichoke, Brussels sprout, asparagus, okra, cucumber, green beans, peas, and carrots require ends be removed before drying. Seeds and end of pepper needs to be removed by hand or machinery before drying (Anonymous, 2014).

Peeling of vegetables and removing parts that are not normally eaten also enhances the appearance of the vegetables. Tomato peel is removed by applying steam first then freezing the skin with chemicals (NaOH), eggplant peel is removed by applying flame over the peel, potato peel is peeled off by mechanically rubbing with grinding tools. Applying NaOH helps to peel off vegetable peel easily. After removing vegetable peel, the next process is cutting and slicing the vegetables into smaller sizes. Drying temperature and duration differs significantly between whole tomato and sliced tomato.

Steaming process sterilizes vegetables after the washing and cutting cycles. This also eliminates unwanted taste and odor, as well as reduces vegetable size and removes unwanted gases from the vegetables. Vegetable enzymes also become ineffective after the steaming process. Darkening of vegetable surfaces and oxidation caused by peroxidase enzyme during the cleaning, peeling and cutting processes are removed with the sterilization process. This steaming process also helps with permeability of vegetable cells and hence accelerates with the drying process. Steaming process also preserves the vitamins and avoids their dissolving during the drying and storing processes. Some vegetables lose their vitamin values when boiled for sterilization. To avoid this, sodium bisulfate ($NaHSO_4$) is added in water before boiling. However, this method cannot be applied to all vegetable varieties. This method should be avoided especially on red onions, leaks and garlic (Anonymous, 2007). Ascorbic acid is used commonly to avoid discoloration of vegetables during drying processes. Large processing facilities are equipped with large scale boiling and steaming processers that use clean water. Smaller processing facilities may place vegetables in perforated dipping containers that will dip in and out of hot water very quickly for sterilization (Cemeroglu 2011).

Vegetable Drying Processes

The preparation processed applied to vegetables before the drying process also include processes that will accelerate removal of water from interior center areas, maintaining taste, color and texture of vegetables, preserving nutritional values, eliminating microbial activities from vegetable surfaces, and maintaining hygiene during and after the drying process. Cutting the vegetables uniformly enhances drying process evenly and effectively (Anonymous 2007). After the boiling and steaming process, vegetables are washed with cold water, placed on trays, and dried with hot air. Water content of vegetables is reduced from 90-95% to 10-20% during the drying process, which enables longer shelf life for the dried vegetables. Vegetable and fruit drying facility in Kirsehir uses geothermal energy to heat potable water which in turn heats air and blows hot air through vegetables placed on trays. The drying room is rectangular in shape and all of its walls are insulated effectively. Vegetable trays are stacked in trailer shelves and drying room door is closed. In this arrangement hot air is blown through the trays uniformly to collected in separate containers. The same dryer system can be suitable for many varieties of fruits and vegetables (Banchero and Badger, 1973; Gungor and Ozbalata, 1997). Stainless steel perforated trays that are coated with teflon are used for dices small size vegetables such as carrots, green beans, onions. The trays are placed on conveyor belts and hot air is applied from both top and bottom of the trays to maintain even drying (Anonymous, 2007).

The required drying temperatures for vegetables usually range from 50-60^oC, and drying duration is usually about 2-18 hours. For some vegetables, drying process takes place in two stages. For example, for carrots, first stage is to dry at 70 ^oC, and second stage is to dry at 65^oC. Total drying duration for carrots is about 14-24 hours. For onions, the first stage drying temperature is 70-88^oC, and second stage drying temperature is 55-60^oC. Total drying duration for onions is about 10-15 hours. Table 2 lists water content of some vegetables before and after drying process and allowed maximum drying temperatures (Gungor, 2013).

Water contents of all vegetables are different at the beginning of drying process. However, after the drying, water contents should be maintained at about 8-10%. After the drying process, spoiled vegetables should be removed from the trays and remaining vegetables are sorted by their sizes. For packaging, polyethylene containers (with inner and outer layers) paper containers, cardboard containers, and tin containers are commonly used.

The most important concerns in storing the dried vegetables and fruits are discoloration and darkening of vegetables as a result of chemical reactions due to high sugar and protein content. To avoid this discoloration and darkening, the storage space should be maintained at low temperatures. If the drying process removed water to the levels listed earlier, microbiologic reaction or rotting of vegetables are not expected (Anonymous, 2007; ISO 2010). The most common vegetable types that are exported most often are tomatoes, sweet corn, leaks, eggplant, garlic, mushrooms, zucchini, onions, okra, potatoes, cabbage, peas, and cauliflower.

Table 2. Water Content of Some Vegetables Before and After Drying Processesand Allowed Maximum Drying Temperatures.

Vegetable name	Drying the moisture level at the start	After drying, the moisture level	Highest allowable drying temperature(˚C)
pea	80	5	65
cauliflower	80	6	65
carrot	70	5	75
green beans	70	5	75
onion	80	4	55
garlic	80	4	55
cabbage	80	4	55
pepper	80	5	65
okra	80	20	65
tomato	96	10	60

Tomatoes alone make about 50% or dried vegetables. Because the dried vegetables maintain nutritional values and they are healthy, they maintain they value in the marketplace (Anonymous, 2011). Vegetables that are dried and packaged with modern techniques can be marketed in every part of our country. After meeting the demand from Turkish market, it is possible to export them to European Union Countries and Middle East countries (Ozler et. al., 2004).

Conclusions

The main goal of drying process is to come up with a high quality dried product that is also economic and uses energy most efficiently. One single drying technique cannot achieve a quality and economic dried product. For some drying processes, use of boiling or steaming preliminary process, dipping in chemical solutions, may increase the quality of the dried product, reduce the drying period and also reduce production costs.

The quality of the vegetables and fruits before drying process and the quality of drying process can increase competition power, survival and longevity of the company that is producing and selling the dried products.When choosing the drying method and associated infrastructure equipment, in addition to upfront cost, it is important to consider also the operational costs.

In addition to drying techniques, drying preparation techniques also have important place in the quality of the dried product. In order to obtain a good quality dried product, energy efficient processes, use good quality raw materials, proper drying techniques, proper preparation processes, market value of the raw material and final dried product, and other variables should be carefully evaluated.

For drying vegetables in the Kirsehir vegetable and fruit drying facility; Introduction of vegetable and fruit drying facility to farmers and growers in the region, In order to secure vegetable and fruit product grown in the region, initiate and develop contracted farming and growing practices, The fresh vegetables to be dried in the facility should have uniform shape and size and purchased from nearby growers when available, The drying facility should integrate additional equipment that will facilitate vegetable drying in addition to the currently ongoing fruit drying processes,Training Kirsehir local workforce to work in the drying facility, providing work to unemployed local Kirsehir youth. In addition to meeting Turkish market demand for dried vegetable and fruits, the facility should target exporting dried vegetables and fruits to other countries.We believe this feasibility study will be valuable in evaluating necessary methods and means for the vegetable and fruit drying facility especially in Kirsehir.

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