

CASE STUDY:

Dried Fruit Processing Using SENTINEL Technology

Drying is one of the oldest preservation methods for fruits and vegetables. The removal of moisture in grapes is a process to retard microbial growth and inactivate enzymes. The result is a shelf stable product high in natural energy, essential minerals, and flavor.

Drying technology has come a long way from spreading grapes in the sun (solar drying) or using a kitchen oven or fireplace, to highly sophisticated industrial dryers using either convection heat, vacuum drying, electromagnetic energy (SENTINEL Technology) or some combination.

In order to retain quality attributes and vitamins such as β -carotene and B-vitamins, it is essential to keep the processing times short. SENTINEL Technology takes advantage of electromagnetic volumetric heating. Heat is generated directly within the product, water is actively driven out to reduce the moisture. SENTINEL Technology does not rely on vaporization and conduction heating, which are slow processes. In addition to higher quality – higher drying rates

translate into shorter processing times, increased production volume and lower cost. Hence, using SENTINEL Technology for drying is more economical and environmentally friendlier than conventional drying methods.

Raisins

Raisins are the most common dried berry fruit in the United States. They are rich in fiber, potassium and many health-promoting phytonutrients and antioxidants (see Table 1 and Table 2). The U.S. consumption of raisins accounts for approximately two-thirds of total dried fruit consumption (*Boriss et al, 2013*). Quality and nutritional attributes of dried raisins include its vitamins and minerals, and organoleptic characteristics such as color, texture,

and taste. All of these attributes are affected by processing temperature and time. Color is the main characteristic that dried fruits such as raisins are judged by (Simal et al, 1996). Therefore, undesirable browning reactions (enzymatic and non-enzymatic) need to be minimized during processing and storage.

The rate of browning reactions depend on multiple factors such as: drying time and temperature, pH, sugar-, and moisture content. Brown pigments and bitter aromatics are formed when heating a reducing sugar, such as glucose or fructose, along with amino acids (proteins). Another heat induced reaction is the caramelization of sugars that contributes to the darkening of dried raisins. To minimize these reactions, process temperatures need to be carefully controlled and kept below 100°C.

Component	Content [%]
Water	15.43
Protein	3.07
Lipid	0.46
Total Carbohydrates	79.18
Sugars	59.19
Dietary Fiber	3.70
Minerals and Vitamins	1.90

Table 1. Composition of dried raisins (USDA)

Vitamins/minerals	Content [mg/100g]
Vitamin C	2.30
Thiamin	0.106
Riboflavin	0.125
Vitamin B6	0.174
Vitamin E	0.120
Niacin	0.766
Calcium	50.00
Iron	1.88
Potassium	749.00
Magnesium	32.00
Sodium	11.00

Table 2. Vitamins and minerals in dried raisins (USDA)

Drying

In dehydration processes, the two mechanisms of water removal are (Kessler, 2002):

- Evaporation – the product is heated to evaporate the free water.
- Vaporization – warm air is moved across the product, cools down and takes up water vapor.

Conventional hot air-drying is the most common method for dehydration of raisins. The underlying mechanism (vaporization) of this process is an inherent disadvantage. Warm air is agitated over the surface of the raisins and vaporizes the water from the surface to reduce the moisture. Therefore the surface is dried-out and hardens, and further moisture reduction relies on slow conduction heating and passive diffusion of water towards the surface.

On the other hand, the SENTINEL dryers use electromagnetic energy to heat free water in raisins from within, actively evaporate water faster, more efficiently and economically. SENTINEL systems take advantage of the water within the food itself. Water and ions are heated within the applied electromagnetic field and the movement (rotation and relaxation) converts the absorbed electromagnetic energy into thermal energy. This is called volumetric heating and is the fastest way to actively drive moisture out of a product. Studies show that the drying times on a percent moisture removal basis of the SENTINEL drying system are down to less than half the drying times of a conventional dryer (see Figure 1).

These studies are grouped by glycerol (a sugar alcohol) content. It is a food additive that dried raisins are infused with to enhance softness and prevent sticking and moisture migration when raisins are mixed with drier products. In addition to the higher drying rates, these results also suggest that when using SENTINEL technology, a common glycerol level of 22% can be reduced while maintaining moisture and glycerol specifications in the end-product. The organoleptic quality of SENTINEL dried raisins was evaluated by a sensory panel and was not found to be affected.

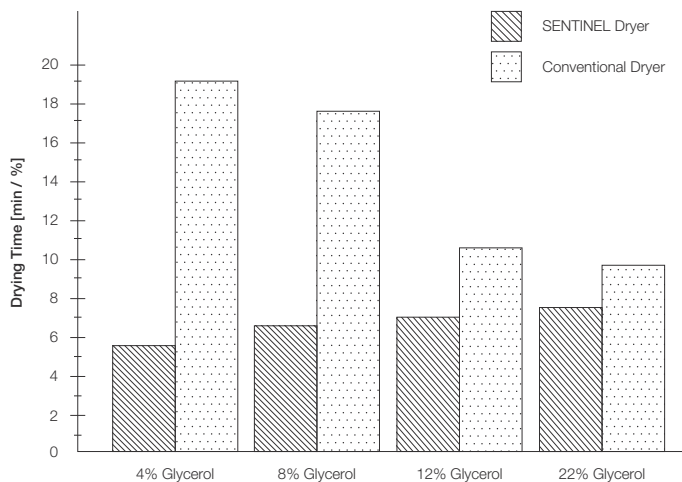


Figure 1. Drying time comparison (minutes per percent moisture reduction) between a SENTINEL dryer and a conventional dryer. Final product temperatures of 92.3°C and 93.3°C respectively were achieved.

Shelf life

In general, the shelf-life of a food product is determined by:

- Number of microorganisms (bacteria, yeast, molds) and pests present;
- Change of defined quality attributes over the course of its shelf-life.

A concern for the raisin industry is the potential risk of cross-contamination of the grapes and/or the raisins with microorganisms throughout harvest, processing, packaging and storage. However, high sugar content and low water activity of raisins ($aw=0.45$ to 0.55) inhibits the growth of microorganisms, and kills most of them.

Still, yeasts and molds tend to survive and a change in storage conditions might lead to their growth. To eliminate this risk, the SENTINEL drying technology reduces mold population in raisins by 1 to 2 logs (90 to 99%), depending on the drying temperatures

(64°C to 87°C). Data on prunes show a 3 to 4 log reduction of yeast (99.9 to 99.99%) at temperatures above 83°C for the SENTINEL dryers.

Accelerated shelf life studies monitoring quality parameters such as moisture content, water activity, sugar content and color of SENTINEL treated raisins showed no change in quality compared to untreated (control) product.

Conclusions

1. SENTINEL drying technology allows for **shorter drying times**. Shorter drying times result in:
 - Shorter processing time
 - higher throughput
 - lower cost
2. SENTINEL drying technology delivers a **kill-step** for yeasts and molds.
 - Increased food safety
 - Longer shelf life
3. SENTINEL dried raisins **maintain their quality** as well as untreated raisins.
4. For SENTINEL dried raisins a **lower amount of glycerol** can be used.
 - Less additives
 - Lower cost

References

- Boriss, H, et al. Raisin-profile: Fruits: Commodities products: Agricultural marketing resource center. Vers. Updated February 2013. 1 September 2006. 15 January 2014.
- Kessler, H G. Food and Bio Process Engineering - Dairy Technology. Munich: A. Kessler Publishing House, 2002.
- Simal, S, et al. "Quality of raisins treated and stored under different conditions." Journal of Agricultural Food Chemistry 44 (1996): 3297-3302.
- USDA. Basic Report: 09298, Raisins, seedless. n.d.