

# MODERN FRUIT DRYING TECHNOLOGIES

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## CENTER FOR AGRIBUSINESS AND RURAL DEVELOPMENT

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# The process of food drying

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# Principle of drying

- Drying food products is the oldest way of preserving. The sun was and is still the most important source of heat.
- Bacteriological shelf life of dried products depends on the water activity (relative moisture content). For each product, water activity matches to certain moisture content. It is important to know these specific water activity and moisture content.
- Water activity is written as  $A_w$  and can be between 0,00 and 1,00
- Dried products have low water activity.



# Principle of drying

A general guideline on water activity  $A_w$  is given below.

<u><math>A_w</math></u>	<u>Grow of micro organisms</u>
➤ 0,95	All organism can grow
➤ 0,90	All yeasts, moulds and most bacteria
➤ 0,88	All moulds and some yeasts and bacteria
➤ 0,80	All moulds and only Staphylococci
➤ 0,75	Most moulds
➤ 0,72	Some moulds
< 0,72	No growth of micro organisms

Higher than 0,43 enzymatic and chemical spoilage can appear.  
Oxidation of fats cannot be avoided by drying the product.



# Principle of drying

- Most of dried fruits contain 20-25% of moisture, which is compared to approximately 0.78  $A_w$  (water activity).
- Drying is moving out water from the product. Drying the outside parts of product is very simple and evaporation of water can happen very fast by heating up the air and by moving the air fast.
- More important is to transport the water in the centre of the product to the outside. This can be increased by heating up the product. In practice there is a maximum temperature at which the product can be dried, because too high temperature can damage it (structure, taste and smell).
- During drying also other conditions like contamination of foreign bodies, chemicals, dust and bacteria is important.
- For fast and perfect drying, the circumstances must be optimal and process should be controlled.

***Modern drying systems can do that.***



# Equipment

Dryer types for solid products:

- heating by contact (hot plate)
- heating by convection (batches or continuously)
- heating by infrared (usually combined with convection drying)

Here we will restrict us to heating by convection system.



# Equipment

- Usual air speed for convectional drying in cabinets is 5 – 10 meter per second.
- The speed of drying depends on the temperature. In theory, every additional 10°C of temperature will increase the speed of drying by three times. (e.g. the difference in time between drying at 20°C and 40°C is 9 times).
- However, depending on the product in the initial stages of drying the temperature cannot exceed approx. 70°C (only for about 10% of the drying time) and later on it should be decreased till approx. 50-55°C.

We cannot generalize, and the values are different per each variety of fruit. However, these are the average figures for widely used fruits.



# Equipment

## Sun drying

As we start drying by putting products on shelves and place them under the sun, this is the most simple way of using heated convection air. This is well-known, but not process controlled because it is depending on the actual climate/weather.

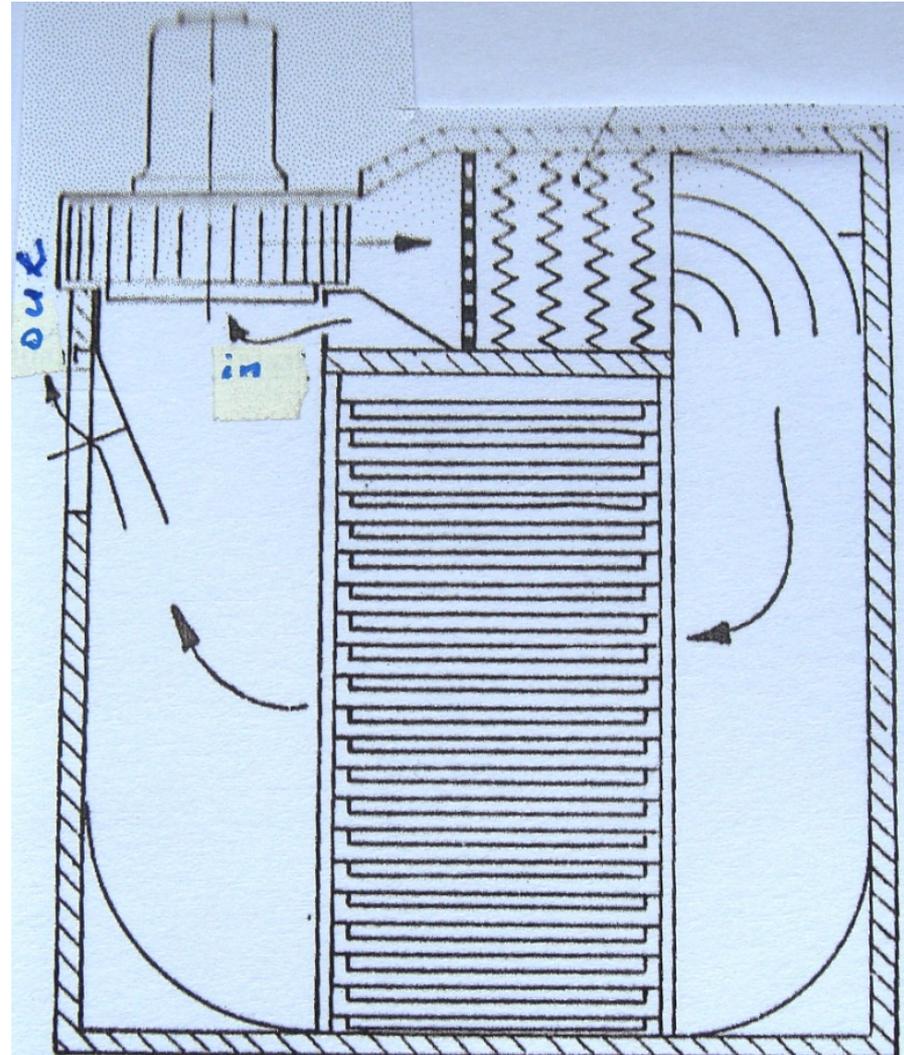




# Equipment

## Cabinet drying:

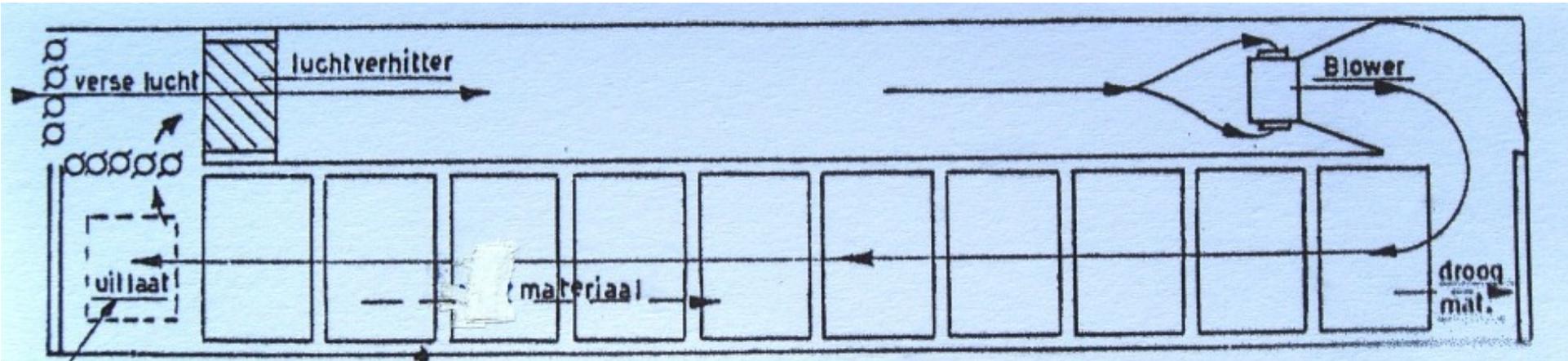
- Product are also on shelves, but in a chamber where temperature, air velocity and moisture controlled.
- A (small) part of the air is refreshed to avoid too high moisture content.
- The most of the air (energy) is reused.





# Equipment Tunnel drying

Instead of one cart with shelves a long chamber or tunnel with many carts can be used. Not only the capacity increase, also the complete processing get more or less continuously by taking out one ready cart and bring in one new cart.



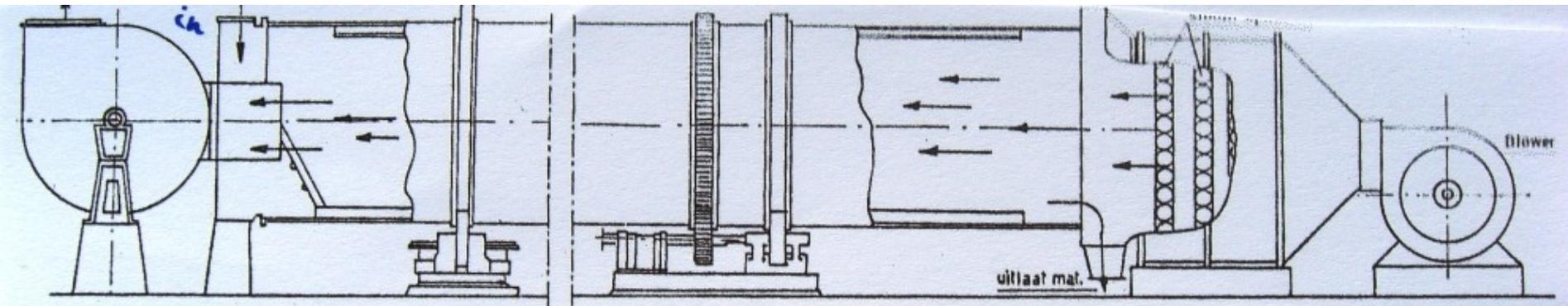
Instead of carts and shelves in a tunnel also a belt can be used. That makes the process really continuously.



# Equipment

## Drum drying

For products that are not sensible for small damages like seeds, sometimes a drum dryer is used. The products tumbling and get transported through the drum by the flow of heated air.





# Energy

- SUN in Armenia is available for free. But regarding the weather, there are no guaranties in time and amount. This is a big disadvantage.
- GAS is a very good source of energy. Burners are well developed and process controlled.
- OIL is a very good source of energy. Also oil burners are perfect. However, burned oil gives more spoilage to the environment.
- ELECTRICITY is a perfect source of energy. When electricity is produced in a sustainable way, there is no spoilage of environment.



# Energy

- SOLAR PANELS are a modern way to produce sustainable electricity. This is also possible “in the middle of nowhere”. As mentioned above in SUN, here we also depend on sunny days.
- The choice for one of these sources depends on the availability and price of the energy. Further, the costs of equipment (especially for SOLAR PANELS) can be important.

For each case it must be found out what will be the best solution.



# Design of dryer

- A modern dryer must be designed in a proper way and cleaning must be possible easily. That means that all material that gets into contact with the product must be food grade, preferable stainless steel.
- Contamination with other materials must be avoided (lubricants, paint, dust, wood, glass or plastic).
- Regarding occupational safety - the equipment should not hurt personnel.



# Calculation of energy demand

To calculate the needed energy, we have to deal with:

1. the amount of products per hour
2. the amount of water we have to evaporate
3. the weight of the equipment that must be heated up till processing temperature
4. losses, interruptions, deviations, process control.  
In general we calculate for this extra 50%



# Quality of raw material

For best final product we need high quality of raw material.

***Be aware that food processing cannot add quality***

In best case losses are only small.



# Losses of peeling, stoning and water evaporation

- Peeling and stoning must be carried out in a proper and hygienic way. Keep in mind that, at this stage, products are very sensible for contamination. The environment, include personnel, must be “food grade”.
- Take care that losses of peeling and stoning are as less as possible. Here, high efficiency of cost of raw materials can be reached.
- Depending on the water content of the raw material and the wished moisture content in the final product, more or less water must be taken out. High water content means more losses of weight and more energy.



# Additives

- To improve drying processes, final products and his shelf life, some additives can be of interest:
  - caustic soda
  - sulfite
  - ascorbic acid
  - citric acid
  - colorings
- The use of additives depends on the desired properties of the final products, legal rules and wishes of the client.
- European law gives maximums for additives. In general: normal use of these additives will not exceed these maximums. For sulfite a maximum of even 2 grams per kg final product is allowed. Sulfuring by smoke will not reach this amount. Nevertheless it is necessary to analyze some samples in a laboratory.



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# Packaging



- For packaging many possibilities are available. Important is to avoid that moisture get back into the product or goes out.
- Cans, jars, plastic and paper are possible depending on wishes of the market.





# Cost price

One of the best ways of cost price calculations is based on Direct Costing. For the producer it is a clear system to know and to control his efficiency.

1. Costs of raw material. This is brut material minus all losses (selection, peeling, stoning, evaporation of water) and plus additives.
2. Costs of all packaging material plus labels and eventually losses.
3. Costs of labor in the factory (not overhead)
4. Costs of energy
5. Costs of the production line (depreciation, interest, maintenance)

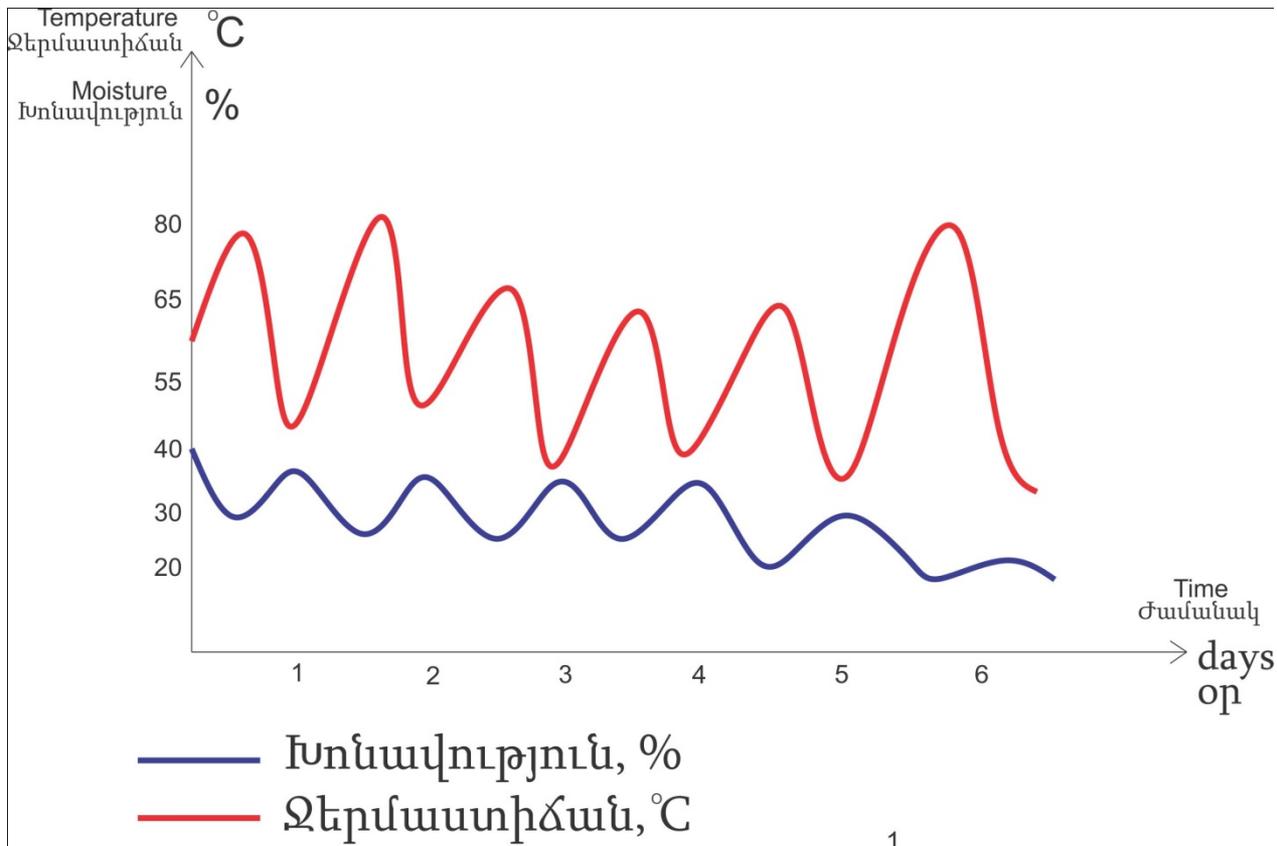


# Modern food drying technology

1. Sun drying
2. Cabinet drying
3. Moisture content
4. Working in line / HACCP
5. Quality



# Sun drying



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Figure 1. Drying curve of sun drying



# Sun drying

## ➤ Traditional way of drying

### ▪ Advantages:

- Low investment
- Sun energy is cheap
- Well know principle

### ▪ Disadvantage:

- Uncontrolled drying process
- No guaranties for final quality
- Takes a long time
- Risks for contaminations (HACCP)
- In case of too less sun, not all crop can be dried, might have product losses (spoilages)



# Cabinet drying

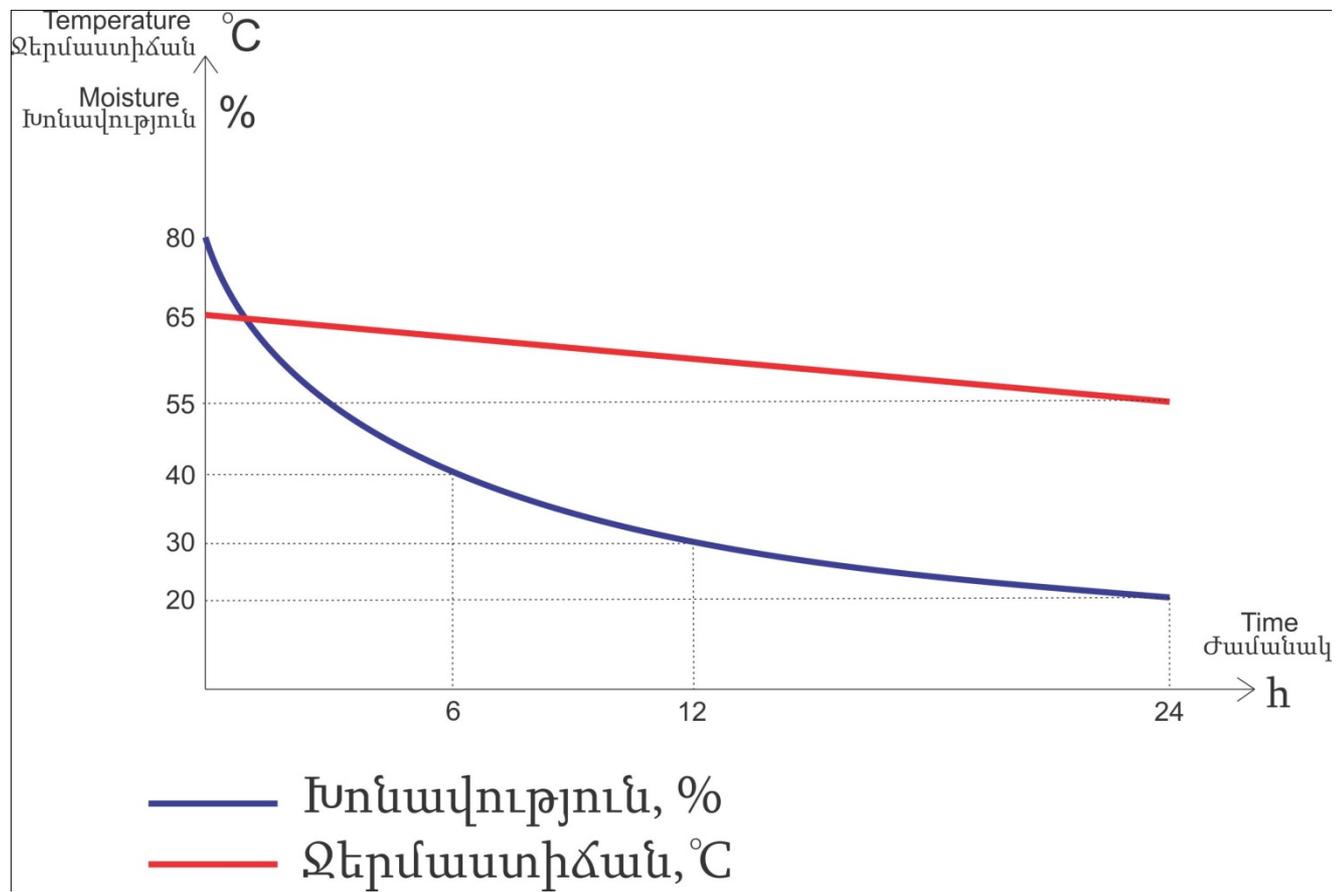


Figure 2. Drying curve of cabinet drying



# Cabinet drying

- With knowledge of modern drying technology we are able to optimize the drying process and are independent of weather conditions.
- Once the process has started it doesn't stop. This is the main reason why the total process time is much shorter. From over one week to one or two days.
- More important is that the moisture content of the drying air also is controlled. In the beginning the moisture content is high. This avoids that the outside (skin) becomes hard. This hardening avoids evaporation of water from the product and the structure of the final product gets lower quality, mainly bad eating properties.

**The hardening prevents evaporation of water from the product and the structure of the final product has lower quality, mainly bad eating properties.**



# Cabinet drying

- The total drying process is running smooth and each batch can be repeated with the same results.
- Caused by the fact that the drying process is not interrupted or disturbed, the quality of the final product shall increase.
- An optimal drying process for apricots, peaches and prunes is a drying temperature starting at maximum 70°C and after one hour going slowly back to 55°C.
- The moisture content is going from 70% to 20% according the example in Figure 2.



# Cabinet drying

- During the drying process the moisture content must be measured regularly. This can be done manually and according to the result, the valve for fresh air must be opened more or less.
- If the moisture measuring is done automatically, the valve can be adjusted mechanically by a serving motor. This is the best way to control the process.



# Cabinet drying

- The drying time depends on many aspects:
  1. type of fruit,
  2. preparation – initial treatment,
  3. size,
  4. quantity
  
- Once the drying time is established, the time can be set as fixed in the program of the dryer.



# Moisture content

- The moisture content of raw material and final product is very important. For raw material it is a sign for ripeness and how many water must be evaporated. For final product it is important for eating properties and shelf life.
- The best way to measuring moisture is using an infra red moisture analyzer.
- Within 10 minutes a samples is analyzed.
- For each final product the optimum moisture content must be described include tolerances.



# Moisture content

- The moisture content should depend on eating properties, shelf life and wishes of the client.
- Typical maximum moisture contents according to the European food law are:

✓	Apricots	25%
✓	Prunes	25%
✓	Apple	20%
✓	Raisins	17%
✓	Figs	24%
✓	Pears	22 %
✓	Bananas	24%



# Working in line / HACCP

Modern processing is not only drying in a cabinet. All steps in the total process must be efficient and process controlled, including hygiene.

- The factory must have a logical route with less transport in between. Keep dirty products separate from clean products.
- Once fruit is cleaned and washed it goes into a hygienic controlled area. Here, product is stoning and put on trays.
- In the same, but preferable a next room, products goes into the dryer.
- After drying, a next hygienic room is necessary for sorting and packaging.
- Final products must be stored in a cool and clean area.



# Working in line / HACCP

- This way of working creates possibilities for cost price reduction regarding labor and losses of raw material.
- HACCP certification can be realized when hygienic, education of personnel and risk management is implemented.
- High quality of final product can be guaranteed.
- Clients with high requirements can realize new turnover.



# Quality

- High quality is the best way for grow and guarantees in the future. Export countries, but also the local market, is asking more and more for higher quality of products.
- In order to comply with this demand it is a **MUST** that processing of dried fruit is done in a modern way.



# Quality

- Be aware that dried product has a lower quality than fresh product. **We cannot add quality.**
- What we add is:
  1. Shelf life
  2. New properties
  3. Possibilities for new products
  4. Transport facilities
  5. Costs
- All these additional properties should satisfy the client, who will be willing to pay a higher price.



**Thank You!**