

Technology of the walnuts storage and processing

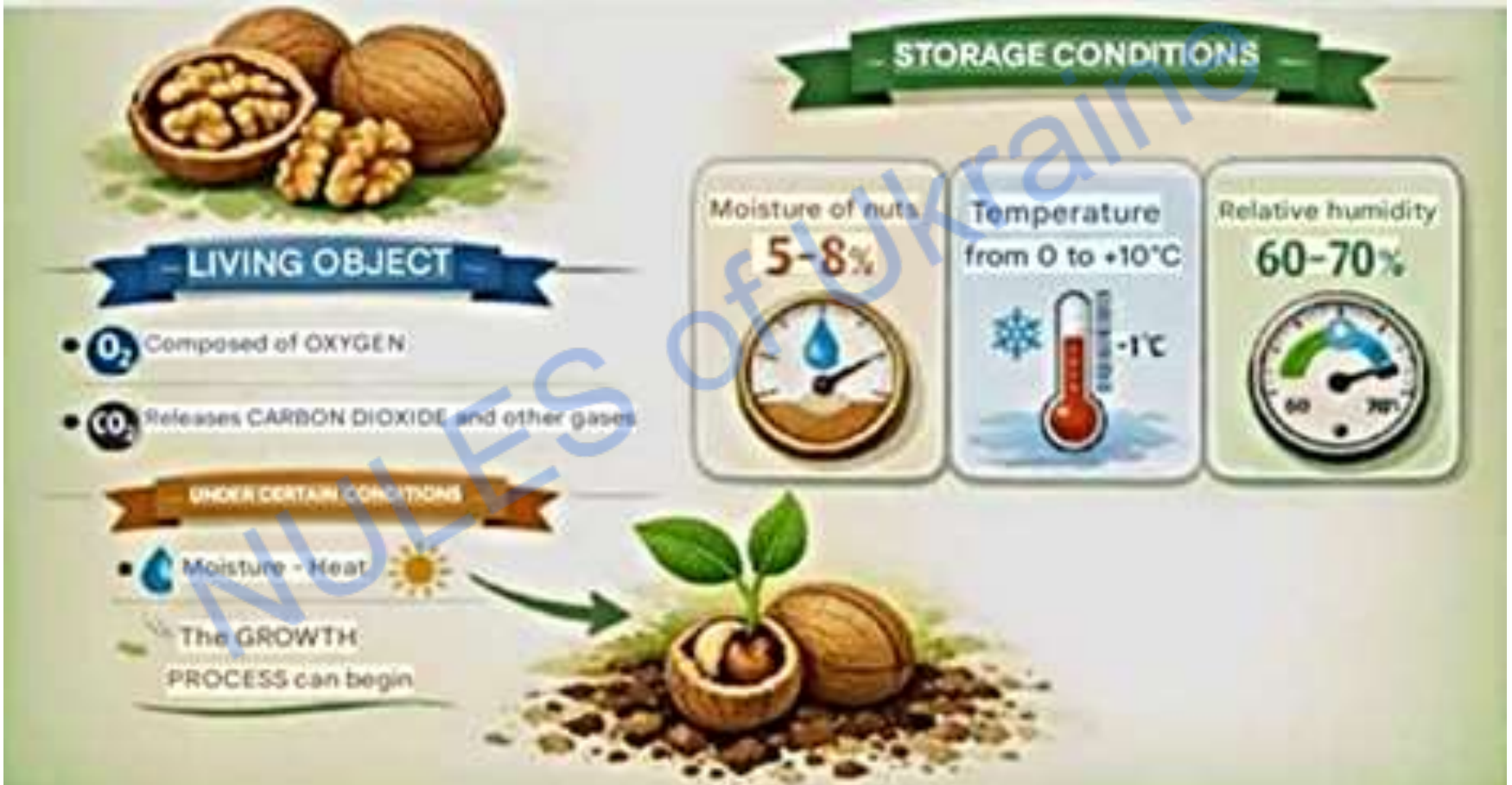


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Walnuts as a storage object



Walnuts as a storage object

Nuts (oil raw materials) have a high tendency to fat oxidation.



It is better to store it in the shell than in the form of a kernel.



Optimal storage conditions: 0...+10 °C and relative humidity 60-70%.



Avoid moisture, light, oxygen and foreign odors.



Violation of storage conditions causes rancidity and loss of quality.



Fat content ranges from 55% to 75%, depending on the variety and growing conditions.

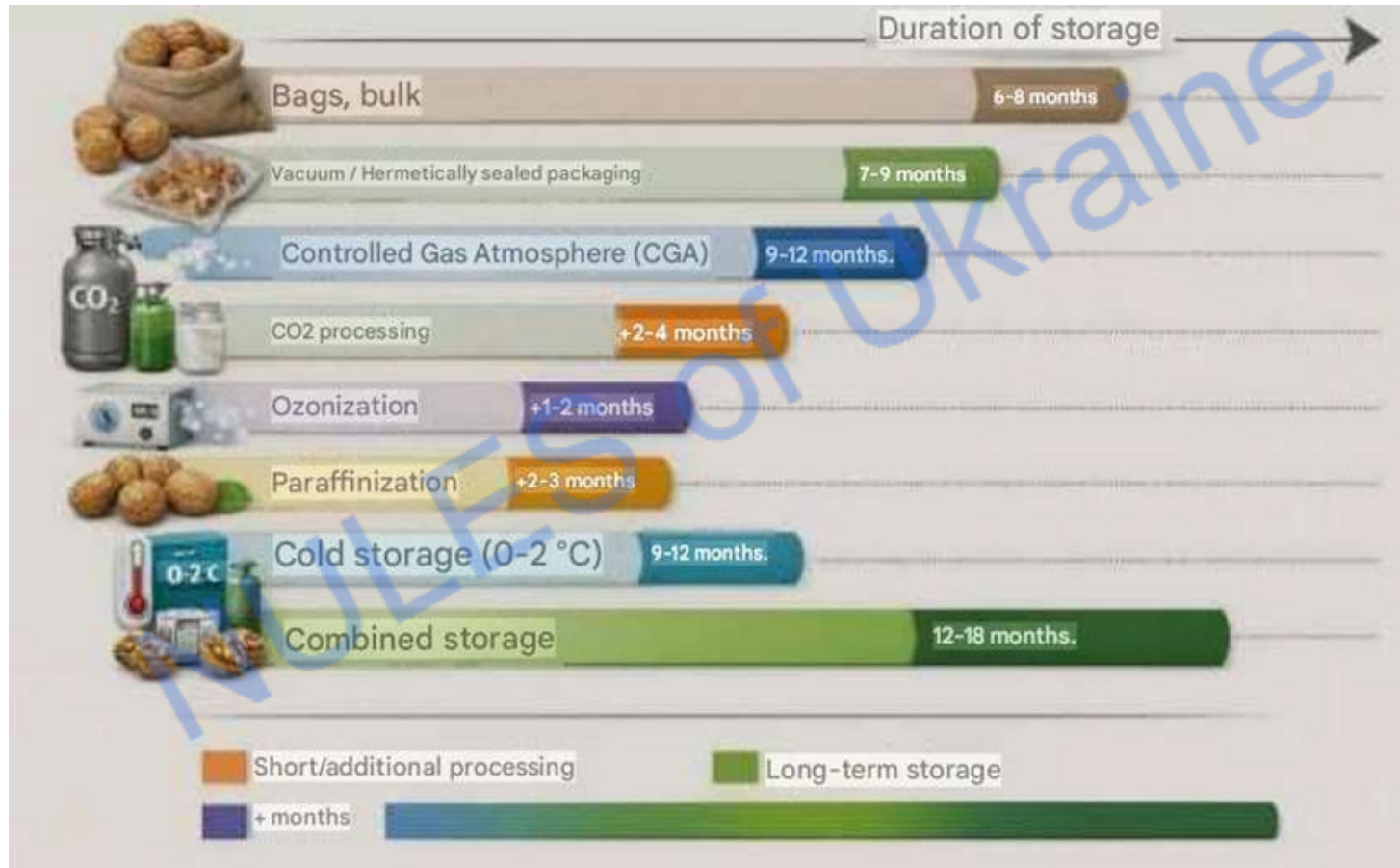
Protects against the harmful effects of UV rays, which promote the oxidation of fats.

Such temperatures slow down oxidation and metabolic processes, while low relative humidity prevents the growth of microorganisms.

Free moisture, light, oxygen or foreign odors may be cause of spoilage.

Failure to follow storage guidelines results in a loss of quality.

Shelf life depending on the way and regime



Microbial growth during walnut storage

When storing walnuts, mold often develops; if temperature and humidity levels are not maintained, this mold can produce dangerous toxins.

The main culprits are *Aspergillus* species, particularly *A. flavus* and *A. parasiticus*. These are the most dangerous because they produce aflatoxins - powerful carcinogens that damage the liver. Some species can produce patulin and other mycotoxins.

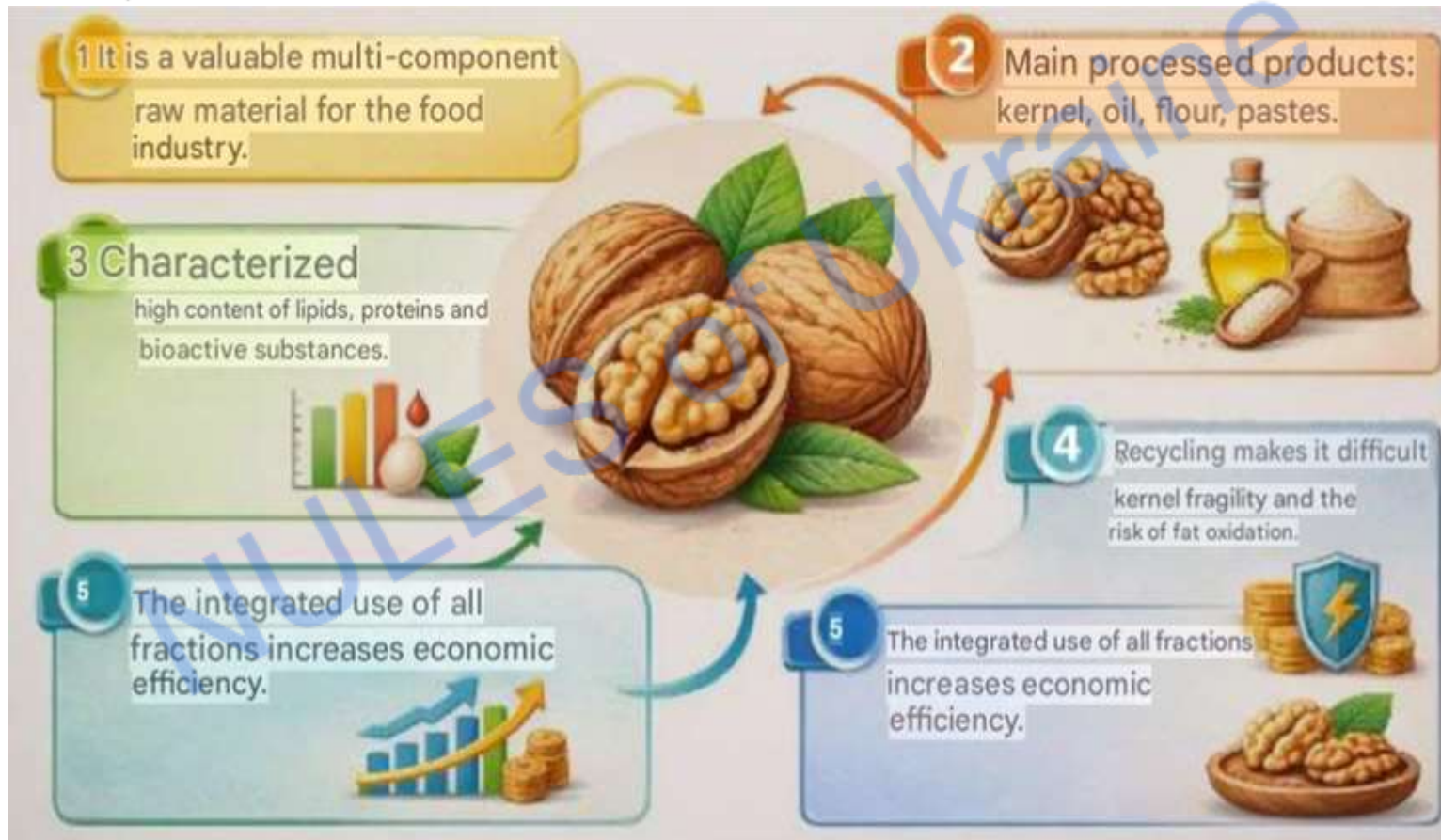
If the moisture content of the kernels exceeds 5–8%, ideal conditions are created for fungal spores to germinate. Damage to the shell - such as cracks - allows microorganisms to easily penetrate the nutritious kernel.

When oxidized, nuts become rancid, creating a favorable environment for bacteria and fungi.

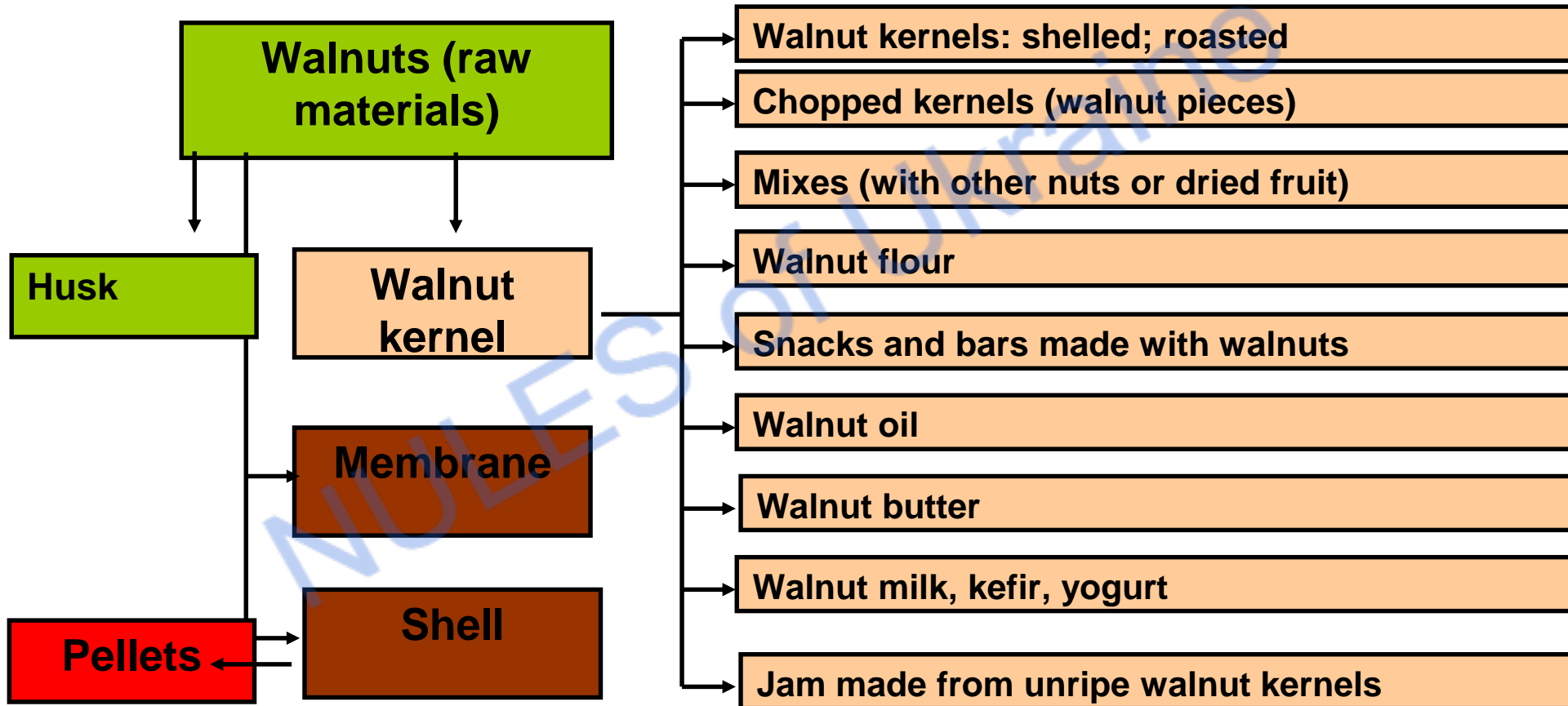
To prevent the growth of microorganisms, it is recommended to store nuts at a relative humidity of 60–70% and a temperature between -5 and +10°C.



Walnuts as a raw material



Comprehensive processing of walnuts



Flowchart for producing walnut kernels



Walnut kernels

Walnut kernels (shelled walnuts). Shelled kernels are significantly more expensive than walnuts in the shell, as extracting the kernels is a labor-intensive process.

Kernels are sorted by size: $\frac{1}{2}$ (halves) – whole kernel halves. This is the most valuable category, especially if the kernels are light in color and undamaged. Large halves are in the highest demand among confectioners and exporters.



$\frac{1}{4}$ (quarters) – one-fourth of a walnut (a half broken into two pieces). This is also a fairly valuable product, though it is less expensive than halves.

“2–4” (large pieces) – a mix of large kernel pieces ranging in size from about a quarter to a half. These are essentially crushed walnuts, where a single kernel is split into 2–4 pieces. The price is slightly lower than for halves, but higher than for small crumbs.

Walnut kernels

“4–8” (medium pieces) – kernels split into 4–8 pieces. A medium-sized fraction used in confectionery production (fillings, toppings). It is priced lower than larger fractions.

“6–8” (small pieces) – very small pieces, practically “chips,” where a single kernel is broken into 6–8 small fragments. This fraction is purchased for making nut fillings, nut paste or oil. The price is low.

Crumbs – the smallest kernel particles and nut dust. Sorting waste used for nut flour, oil or feed additives. The cost is the lowest.



Mix – a blend of different kernel fractions. If the nut has not been sorted by size but is sold as a mixture of pieces, it is priced lower because the buyer receives both large and small pieces.



Factors that influence the color of the nut kernel

- ✓ - nut variety;
- ✓ - presence of diseases or pests during the ripening period;
- ✓ - timing of harvest;
- ✓ - timing of removing the green husk from the nut;
- ✓ - drying conditions.



Flowchart for producing walnut milk



Sorting walnut kernels



Washing with cold water



Soaking for 8–12 hours and blanching



Wet grinding (1:5–1:10)



Extraction and separation



Filtration



Homogenization for a uniform texture



Pasteurization at 72–75 °C for 15–30 seconds



Cooling to 4 °C, sterile bottling and packaging



→ Walnut pulp



Features of nut yogurt production

Walnut milk with a nut content of 5–8%

Normalization of composition

(sugar 1–2%, stabilizer 0.3–0.6% (pectin, agar) + homogenization (15–20 MPa))

Heat treatment

(pasteurization at 85–90 °C for 5–10 minutes to inactivate enzymes and destroy microorganisms)

Cooling, inoculation and fermentation

(38–42 °C; *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus*; 6–10 hours until the pH reaches 4.4–4.6)

Cooling and packaging

(temperature 4–6 °C and an oxygen-free environment to prevent oxidation)

Features of walnut kefir production

Walnut milk with a nut content of 3–6%

Composition adjustment

(sugar 1–2%, stabilizer 0.2–0.4% (pectin, agar) + homogenization (15–20

M_{Pa})

Heat treatment

(pasteurization at 90–95 °C for 5 minutes or UHT for shelf stability)

Cooling, inoculation and fermentation

(20–25 °C; mixed cultures (lactic acid bacteria + yeast); 12–24 hours until a pH of 4.5–4.8 is reached, with the formation of CO₂ and trace amounts of ethanol (<0.5%)

Cooling, packaging and storage

4–6 °C, shelf life up to 5–7 days

Features of Walnut Butter Production

Preparation of raw materials

Shell removal, sorting, drying to 6–8%, removal of defective

Heat treatment

100–130 °C for 10–20 minutes to develop flavor and inactivate enzymes

Grinding

Coarse and fine grinding; 45–60 °C; formation of a paste-like consistency

Homogenization

Achieving a creamy texture; adding sweeteners and stabilizers (pectin, etc.)

Deaeration and packaging

Removal of air to prevent oxidation; glass or PET containers; storage at 4–18 °C

Features of walnut oil production

Raw Material Preparation

Hulling, drying to 6–8%, shelling and kernel separation, sorting; rapid processing after shelling is required to prevent oxidation



Grinding

Grinding the kernels into coarse particles or a paste (particles 0.5–2 mm in size), conditioning at 30–40 °C, minimizing contact with oxygen; an inert atmosphere is recommended; premium oil



Pressing

Cold pressing: $\leq 40\text{--}50\text{ }^{\circ}\text{C}$; screw or hydraulic presses; oil yield: 35–45%; maximum preservation of bioactive compounds (tocopherols, PUFAs); lower yield but higher product price

Hot pressing: 80–120 °C; oil yield up to 50–55%; more intense aroma, but partial loss of heat-sensitive compounds

Features of walnut oil production

Filtration

Decantation for 3–7 days, filtration through paper or membrane filters or centrifugation. Natural cloudiness may occur due to the presence of small phospholipids

Refining

Degumming, neutralization, deodorization. For walnut oil, the unrefined variety (premium segment) is more commonly used, as refining reduces the aroma and nutritional value.

Bottling and Storage

Dark glass bottles, temperature 4–10 °C, protected from light and oxygen. The high content of linoleic and α -linolenic acids causes the oil to go rancid quickly (6–12 months)

The unripe walnuts application

In terms of vitamin C content, young walnuts exceed the most well-known vitamin C-rich fruits (rose hips, black currants, etc.). The flesh of unripe fruits is rich in vitamin C (up to 3,000 mg/100 g) and vitamin P, and contains sugar, malic and citric acids, and tannins. Therefore, unripe fruits are used to make jams, spirits, and vodka.



Features of walnut pellet production

Crushing and sorting

The shells are crushed into a fine fraction (3–5 mm) to ensure uniformity and better density of the finished pellets



Drying

reducing moisture content to 10–15% for effective pellet formation



Pressing / Pelletizing

The material is forced through a die under high pressure to form pellets. It is best to make pellets from a mixture of nut shells and an additive.



Cooling and Packaging

The finished pellets are cooled, sorted by quality and packaged for storage or distribution

Caloric content of walnut shell pellets

Walnut shell pellets are a high-calorie biofuel due to their high lignin content and low moisture content after drying.

The calorific value of such pellets averages 17–19 MJ/kg (\approx 4,000–4,500 kcal/kg), which is comparable to that of wood pellets:
16.9 MJ/kg for pellets made from pure shells;
19 MJ/kg – for blended pellets with other biomass.

The dense structure of the shell provides a higher energy value than that of pellets made from straw or sunflower husks.

The low ash content (approximately 1–2%) promotes more efficient combustion and results in less waste.

Their high calorific value makes these pellets a promising alternative to fossil fuels for industrial and residential boilers.

Non-HFC technologies in walnut processing



The primary source of HFCs at these facilities is the cold storage rooms used to store nut kernels.

Replacement of refrigerants.

Replacing R-404A or R-134a with ammonia (NH₃), carbon dioxide (CO₂), or propane.

Use of CO₂.

The use of two-stage CO₂ compression enables efficient cooling of products with zero ozone depletion potential and minimal GWP (global warming potential).

Off-grid power supply for walnut processing

Solar power plants. Installing solar panels on the roofs of warehouses and processing facilities. Since the harvest and initial processing season often falls during the sunniest months, this significantly covers daytime consumption peaks.

Energy storage. Use of industrial storage systems to balance energy from renewable sources (solar/biomass) and ensure uninterrupted equipment operation.

Waste gasification. The thermal decomposition of shells in the absence of oxygen to produce pyrolysis gas. This is a cleaner way to generate energy compared to direct combustion.



The use of reusable packaging in walnut processing

Reusable containers. Using sturdy plastic or wooden boxes instead of disposable bags when transporting nuts from the orchard to the processing plant.

Reusable bags. Using products made from industrial hemp or jute that can withstand dozens of cycles of washing and disinfection.

Airtight vacuum containers. For storing shelled kernels, reusable containers with an air-pumping mechanism are used instead of disposable vacuum bags, which prevents fat oxidation.

Digital inventory management. Implementation of QR codes on each piece of packaging to track its movement, monitor its service life, and prevent packaging loss.

Standardization of sizes. Transition to a single European packaging standard (Euro pallets and Euro boxes), which allows for maximum loading density and reduces the carbon footprint.



The use of biofuel in walnut processing



Processing shells into pellets and briquettes. Shells have high density and low moisture content, making them ideal for producing fuel pellets. In terms of calorific value, they are comparable to coal and surpass wood biomass.

Energy self-sufficiency in production. Modern plants install solid-fuel boilers that burn nut shells. This allows the facility to fully meet its heat requirements for drying nuts and heating buildings, while minimizing gas consumption.

Biochar production. The use of pyrolysis (thermal decomposition in the absence of oxygen) allows for the production of activated carbon or biochar. This is not only a fuel but also a means of improving soil fertility, thereby closing the ecological cycle.

Reducing CO₂ emissions. Since nut biomass is a renewable resource, its combustion is considered carbon-neutral (it releases as much CO₂ as the tree absorbed during its growth).

The use of biogas in walnut processing



Raw materials. The main substrate for biogas production is the green husk, which accounts for 40–60% of the crop's mass.

Anaerobic digestion. The waste is loaded into bioreactors without oxygen access. Under the action of bacteria, organic matter decomposes, releasing a mixture of gases (primarily methane, CH₄).

Energy self-sufficiency. The biogas produced is burned to generate:
Thermal energy (for drying walnuts in their shells, which is the most energy-intensive stage).
Electricity (to power the sorting lines and lighting at the facility).

Production of biofertilizers. The residue from fermentation is a high-quality organic fertilizer rich in nitrogen, potassium, and phosphorus. It is returned to the orchard, closing the nutrient cycle.

Environmental impact. The technology prevents waste from rotting in landfills, thereby avoiding methane emissions into the atmosphere and groundwater contamination with tannins (yuglone).

Recycling of water in walnut processing



Multi-stage filtration. The water used to rinse the nuts to remove the green husks passes through a system of filters and settling tanks to remove solid particles, allowing it to be reused for washing.

Use in cooling systems. The treated water is directed to equipment cooling systems where potable water quality is not required.

Sludge collection and processing. The sludge formed during water circulation is rich in organic matter, so it is collected for composting or biogas production, minimizing discharges into wastewater.

Reduction of “fresh” water intake. Implementing a closed-loop system allows facilities to reduce fresh water consumption by 60–80%, which is critically important for regions with limited water resources.

The Use of Eco-Friendly Packaging in Walnut Processing



Biodegradable and compostable materials. Replacing traditional plastic with bags made from cornstarch, cellulose, or sugarcane, which fully decompose under natural conditions.

Paper and cardboard packaging. Using packaging made from recycled cardboard (kraft paper), which ensures the restoration of forest resources.

Minimalism in design. Eliminating unnecessary layers of packaging and using fewer materials (“lightweighting”) to reduce weight and volume during transport.

Eco-friendly labeling. Using plant-based inks (such as soy-based) instead of synthetic ones to print logos and information on packaging.

Smart packaging. Using eco-friendly barrier materials that provide protection against moisture and oxygen, extending the shelf life of the nuts without the use of preservatives.

The use of electric vehicles in walnut processing



Eco-friendly logistics in orchards. Use of electric tractors and harvesting platforms. This eliminates CO₂ emissions directly in the tree-growing area and reduces noise levels.

In-plant transportation. Replacement of diesel forklifts with electric stackers and pallet jacks inside processing facilities.

Charging with biomass. Using energy generated from burning walnut shells (pyrolysis or biogas) to charge the batteries of our own electric vehicles. This creates a closed-loop energy cycle.

Reduced operating costs. Electric vehicles require fewer expenses for lubricants and maintenance, which lowers the cost of the final product.

Rainwater collection during walnut processing



Reduced groundwater consumption. Walnut production requires large volumes of water (especially for shell removal). Collecting rainwater helps conserve the scarce resources of artesian wells.

Initial washing and cleaning. Rainwater is ideal for the first stage of cleaning nuts to remove the green husk and dirt, where drinking water quality is not required.

Irrigation of plantings. Excess water collected or reused (after light treatment) is used to irrigate orchards or tree belts around the facility, creating a closed-loop system.

Economic benefits. The installation of rainwater storage tanks allows the facility to avoid high water supply and wastewater disposal rates during peak processing seasons.

Monument to the Walnut in Ukraine



A unique monument to the walnut has been installed in Ukraine in the village of Voloske, Dniprovskyi District

Thank you for your attention!

