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SPES-456P

Edamame in Virginia III: Handling and Processing from Harvest to Package

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Introduction

Edamame usually has a narrow harvest window (see Virginia Cooperative Extension publication SPES-455P, Edamame in Virginia II: Producing a High-Quality Product); therefore, a large number of pods will be picked during a short period, leading to the oversupply of edamame in the market and a reduction in its value. Fresh edamame also has a short shelf life. The pods may easily turn yellow at room temperature, flavor and nutrition decline, and beans shift to more of a lima-bean flavor and texture. Thus, many edamame companies process, transport, and sell edamame as a frozen product. Currently, most edamame eaten in the U.S. is imported frozen from China.

Food processing technologies are broadly applied to edamame and help to improve edamame value, reduce post-harvest losses, and prolong sale and storage life. Proper processing management is essential to ensure the high-quality and extended shelf life of frozen edamame. The processing operations for edamame roughly include selection, washing, blanching, cooling, quick freezing, and packaging, all of which are completed within several hours after harvest to preserve the freshness and sweetness of the vegetable (fig. 1). Although the critical aspects of edamame processing are widely known (Carneiro et al. 2020), parameters like quick-freeze processing of edamame and techniques related to quality control are still under investigation. This publication describes in detail the processing steps, the equipment, and the critical parameters (e.g., blanching temperature and time) during edamame processing.

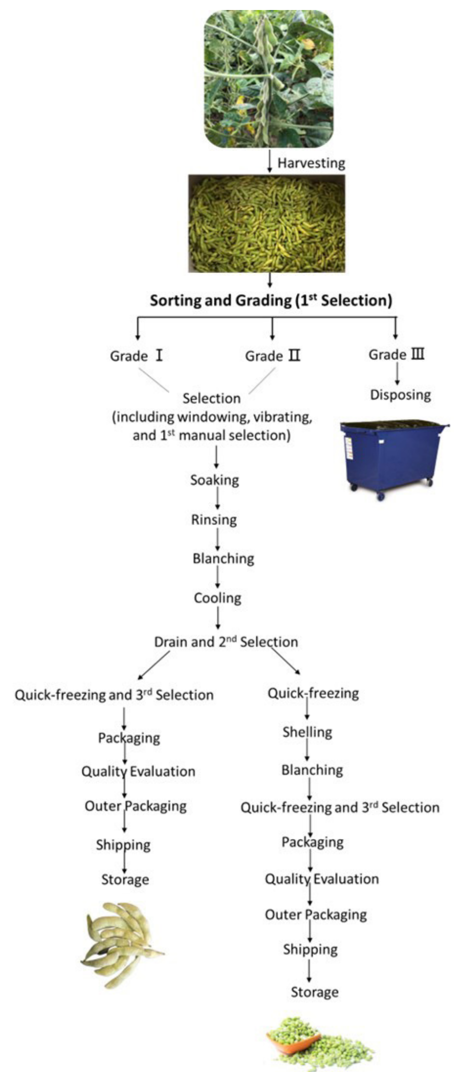

Figure 1. Processing flowchart for frozen edamame by quality grade.

Selection

Step 1. Windowing selection: Harvested pods should be transported under low temperature directly from fields to the processing location. High-quality raw edamame pods are essential for processing. Overly mature, yellow, or unripe pods should be removed. The pods are put on a stainless-steel windowing machine to blow off leaves, dust, branches, pods that are not completely filled, and nonplant impurities.

Step 2. Vibrating selection: A vibratory screener designed to meet the minimum pod size requirement can be used to sift out the pods that do not meet the size requirement.

Step 3. Manual selection: Manual selection is conducted on a conveyor belt where the sorters stand or sit at both sides to pick out undesirable products. Pods with yellow color, insect and disease damage, spots, and deformed beans are removed at this step. Pods are sorted into three grades (I, II, and III) according to quality (table 1) (You, Ding, and Xie 2007). Grade I pods are the best quality and can be further processed as frozen pod products. Grade II pods may be lighter green, slightly spotted, injured, malformed, short, one-seeded, or have small seeds, but they still have green, unblemished beans. These can be processed into other edamame products such as edamame beans. Grade III pods are culled due to low quality.

Table 1. Grading standards of raw edamame pods.

Grades	Description
I	Edamame pods should be fresh, full of beans, at the best stage of maturity, bright green crescent shaped (more than 1.38 inches in length and should be about 0.39 inches in width), with light pubescence (white to gray); The pods contain two to three large green beans. No mechanical injury or split of the pods. No pest or disease damage.
II	Edamame pods should be fresh with green beans; Each pod should have at least one plump bean. No insect or disease damage.
III	Edamame pods are overmature and yellow; Beans are not fully developed in the pods or deformed; There are obvious disease and insect damages on the pods and/or beans.

Note: the grading standards are cited from You et al., 2007.

Manual sorting is time-consuming. Since edamame has a narrow harvest window, a large number of pods need to be sorted within a short amount of time. It is important to have enough labor available at this moment. Since the conveyor belt is in continuous operation, it is necessary to have trained sorters working in shifts. The speed of the conveyor belt needs to be adjusted properly to avoid visual fatigue that will result in sorting mistakes. In addition, as bruising and damage occur easily on pods during mechanical harvest, a large percentage of pods might be classified into a low grade. A previous study reported that an edamame sorting machine was being developed that uses images to detect defective pods based on pod shape and color; this machine was 10 times faster than manual sorting, but the sorting accuracy, which was 80% inferior to manual sorting, needs to be improved (Konosu et al. 2014). After this first sorting and grading of the product, the processing becomes grade specific for grade I and II products (fig. 1).

Soaking and Rinsing

Soaking is the next step for raw edamame processing. The pods fall into a soaking pool with 2% salt water for 15 minutes to expel insects from pods and help decrease pesticide residues (Bajwa and Sandhu 2014). Then pods are drained on a screener and transferred to a rotary drum washer by the conveyor belt. Pods are rinsed with potable water and the rotating barrel turns pods over again and again with the water flow, which helps to remove dirt and debris from the pods. Some companies prefer to not only clean pods but also sanitize the pod surface in a rotary drum washer by using 1,500 ppm sodium hypochlorite solution before pods are rinsed.

Blanching

Blanching Importance

Blanching is a critical step in edamame processing; this process deactivates enzymes and prevents deterioration of quality through fatty acid oxidation, discoloration, and development of peculiar smells and undesirable tastes after harvest. Blanching also reduces microorganisms and pesticide residues attached to the pod surface (Xiao et al. 2017), thus extending shelf life. Moreover, proper blanching can eliminate the air in plant tissues, making the green color of blanched then frozen edamame brighter than that of raw edamame (Xu et al. 2012).

Blanching Methods

There are three main methods to blanch vegetables: boiling water, steam, and microwave. Boiling-water blanching is most commonly used in large-scale edamame processing, as it ensures uniform heating of pods and complete blanching within a short period of time. Steam blanching is also effective as it causes less nutrient leaching and loss (Saldivar et al. 2010). Microwave blanching may not be effective in edamame processing because uneven heating does not consistently inactivate enzymes, leading to off-flavors and loss of desirable texture and bright color.

Blanching Techniques

Edamame can be blanched using a spiral continuous blanching machine (see vegetablesmachinery.com/characteristics-and-pre-cooked-form-of-spiral-continuous-blanching-machine/) or a blanching tank when fewer pods are processed (see shipin.huangye88.com/xinxi/s09urjvd68140.html). Blanching water temperature is commonly held between 208.4 F and 212 F. If the temperature is too high, edamame pods may burst; if the temperature is too low, the blanching time is longer, causing pods to be soft and less sweet (Song, Gil-Hwan, and Chul-Jai 2003).

Blanching time varies by water temperature, pod size, and the quantity processed. Both blanching time and temperature must be controlled to reach a balance between the destruction of enzymes and the maintenance of good pod texture. Normally, edamame is properly processed at 208.4 F to 212 F for 70-125 seconds. The temperature and time of blanching should be evaluated every 90 minutes during continuous processing. In addition, the blanching water must be kept clean and frequently replaced, as the organic acids leaked from pods and the heat can degrade chlorophyll into pheophytin, making pods gradually become yellowish-brown. Companies also use 2% sodium carbonate to maintain the pH of the blanching water between 7.6 and 8.5. It is also important to monitor pH every 90 minutes with a pH meter or pH test paper. The enzyme test (i.e., inactivation degree of peroxidase and polyphenol oxidase) should also be conducted on blanched pods using random sampling to make sure the temperature and time are appropriate for blanching (Xu et al. 2012).

Temperature, time, raw edamame pod quantity, and machine speed can be adjusted according to the previously discussed checks and appearance of the blanched pods. If blanching is insufficient, the pods will float in cold water, taste crispy, and be astringent. When blanched properly, the pods slowly sink in the water, have a bright green color, and taste crisp and sweet. If blanching is overdone, the pods are yellow, quickly sink to the bottom of the water tank, and feel soft with no sweetness (Luo 2007). The quantity of pods blanched should be consistent in the whole process as it significantly influences the effectiveness of blanching. Moreover, color retention agents, including 0.06% zinc acetate and 0.14% ascorbic acid, are sometimes used to stabilize pod color during storage (Sun, Yu, and Zhang 2012).

Cooling, Draining, and the Second Manual Selection

To prevent additional heating effects and maintain the bright green color of the pods, edamame pods are sprayed with high-pressure cold water immediately after they exit from the blanching machine. Then the pods are immersed in a cooling tank filled with flowing cold water before being transferred to an ice-water tank to continue cooling the pods. Cooled pods are transferred by conveyor belt to a vibrating screen to drain water. At the same time, sorters cull low-quality product — including the yellow, damaged, and other poor-quality pods — to complete the second manual selection. The pods are then dried with an air dryer.

The temperature of the cold-water tank and the ice-water tank should be checked frequently with a thermometer to keep the cooling water temperature below 68 F and the ice water temperature below 41 F. After drying, edamame pods are visually inspected for color, tasted for quality, checked for temperature of the pod, and checked for water removal on the pod's surface.

Quick-Freezing and the Third Manual Selection

Edamame pods are now evenly scattered on a conveyor belt and enter an individual quick freezing (IQF) machine for freezing. The pod surface is dried and pre-cooled with strong, cool wind. Then the pods fall on the freezing conveyor belt for quick freezing.

The quick-freezing process is critical for maintaining the quality of frozen edamame, and there are several key management techniques. The inside of the quick freezer should be rinsed and disinfected with a high-pressure water gun before each use. The temperature of the freezing zone should not be higher than -14.8 F. Pod thickness affects the amount of time needed in the IQF machine. Pod temperature upon exit of the machine should not be higher than -0.4 F, and pod color should remain bright green. The temperature can be checked by the fixed thermometers at the frozen zone and at the center of the outlet of the machine. Moreover, the color and shape of the frozen edamame at the outlet need to be checked visually.

For processing edamame bean, first quick freeze the pods at 14 F to 23 F using the IQF machine to make the hull of the pod hard and brittle (Xie et al. 2015). An automatic green-pea sheller machine threshes the pods, and bean kernels fall into a bubble cleaning machine to remove the debris of kernels. The beans are then blanched according to the instruction described previously for 45-55 seconds, cooled, drained, and sent to the IQF machine to complete the quick-freezing step according to the instructions for processing pods.

Quick freezing can effectively prevent large ice crystals from forming on edamame pods/beans, which causes vegetables to burst and the loss of cell juice after thawing. This freezing method can help to maintain edamame pod/bean shape, color, taste, and nutrients. Quick-freezing inhibits respiration, which delays pod/bean aging and browning and reduces the growth and reproduction of microorganisms on pods/beans.

As the frozen edamame pods/beans are discharged from the IQF machine, they are moved to a vibrating screen to remove additional frost and debris from pods/beans. Then the pods/beans fall on a conveyor belt where sorters manually remove defective product with damages, deformities, and discoloration, as well as pick out pod or bean debris. At this point, the third manual selection is complete.

Automatic Measuring Packaging and Quality Evaluation

Frozen pods and beans are sent to a cold room where the temperature is maintained at 23 F. Bagging, weighing, sealing, metal detection, and packing will take place here. When edamame pods or beans are weighed, an additional 2% of weight required is usually added into the total weight. Polyethylene film, which has low temperature resistance and low air permeability and is nontoxic, odorless, moisture-vapor resistant, durable, and leak-proof, is commonly used to package bagged edamame. Proper packaging preserves quality by keeping moisture in and air out. Loss of moisture causes pods and beans to dry and discolor, which results in food toughness and off-flavors (Garden-Robinson 2021).

Bags are then passed through a weight inspection machine and an X-ray machine to verify the weight of each package and to check for metal residues or foreign material in bags. Microbiological inspection can be conducted with a microbial laboratory testing that complies with the standards published previously (Institute of Medicine and National Research Council 2003). Pesticide residue can be evaluated by many techniques, such as liquid chromatography-tandem mass spectrometry and gas chromatography-mass spectrometry (Saka 2018).

Outer Packaging, Shipping, and Storage

The packing machine quickly and correctly puts bags into a double corrugated paper box, seals the box, and prints the product label on the outside of the box. An example of a good moisture-proof barrier is a moisture-proof layer of oiled paper on the surface of the box lined with one layer of clean wax paper.

The finished product can be temporarily stored in a warehouse freezer before shipping. Maintain storage temperature between -13 F and -0.4 F, with a temperature fluctuation no more than 3.6 F and relative humidity between 95% and 100% (You, Ding, and Xie 2007). If the temperature fluctuates too much, small ice crystals formed between edamame bean cells will repeatedly melt and recrystallize, forming large ice crystals, which destroy cell structure and reduce edamame quality during storage. Frozen edamame can be stored for up to 12 months under optimal storage conditions (Tong, Zhao, Tang 2018).

Conclusions

Nowadays, there is an expanding domestic frozen market as well as a large international market for edamame. Proper edamame processing will ensure a high-quality, safe product for U.S. consumers and will assist in making domestic edamame more competitive in the international market. Management of all processing steps is critical to ensure the high quality of frozen edamame.

Acknowledgements

This work was supported by USDA-NIFA (Grant No. 2018-51181-28384; Accession No. 1016465), awards of USDA-SCBGP 419441, and Virginia Tech Translational Plant Science Center 119815.

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Produced by Virginia Cooperative Extension, Virginia Tech, 2023

VT/423/SPES-456P