EΓΜΕ HelAgEng

EurAgEng

PROCEEDINGS BOOK

ISBN: 978-618-82194-1-0

Agricultural Engineering challenges in existing and new agroecosystems

1-4 July 2024, Agricultural University of Athens, Greece

Organizing Committee:

General Chair: Nikolaos Katsoulas, University of Thessaly, Greece

Technical Chair: Thomas Bartzanas, Agricultural University of Athens, Greece

Spyros Fountas, Agricultural University of Athens, Greece
George Papadakis, Agricultural University of Athens, Greece
Thomas Kotsopoulos, Aristotle University of Thessaloniki, Greece
Pantazis Georgiou, Aristotle University of Thessaloniki, Greece
George Xanthopoulos, Agricultural University of Athens, Greece
Konstantinos Ferentinos, Hellenic Agricultural Organization "Dimitra", Greece
Chryssoula Papaioannou, University of Thessaly, Greece

Developing a plant for processing PGI 'Cipolla Rossa di Tropea Calabria' spring onions using compressed air

Matteo Sbaglia[a], Lorenzo M. Abenavoli[a], Bruno Bernardi[a,*]

[a]Dipartimento di Agraria, Università Mediterranea di Reggio Calabria, Reggio Calabria, Italy

* Corresponding author. Email: bruno.bernardi@unirc.it

Abstract

One of the best-known Italian products is 'Cipolla Rossa di Tropea Calabria PGI', which refers to the Allium cepa L. onion, limited to the local ecotypes of Tondo Piatta (early), Mezza Campana (medium) and Allungata (late). A mark identifying red onion bulbs in spring onion, fresh onion and onion for preserving that meet the conditions and requirements of this specification, following Regulation (EC) No 510/2006. Depending on the stage and type of product being processed, the mechanical plant plays a key role in the processing chain. In post-harvest operation, plants based on large quantities of water are widely used for processing spring onions, allowing them to be washed, rooted, and peeled simultaneously. They generally consist of cutting, peeling, and cleaning equipment. Two pairs of shearing blades usually carry out both root and leaf-cutting. Peeling is carried out by 2 pairs of rotating rollers, usually of the brush type, and during the peeling phase, washing is also carried out through a series of special sprayers. However, a problem with this type of system is that the water stagnating in the cut onions tends to spoil them, reducing their shelf life. A processing line that uses compressed air to clean the onions was developed to solve this problem. A processing line that uses compressed air to clean the onions was developed to solve this problem. This research reports on the functional structure of the realised plant.

Keywords: design, mechanical engineering, simulation, shelf life, water saving

1. Introduction

Certified with the Protected Geographical Indication (PGI) label since 2008, Tropea red onions have a supply chain of 20,000 tons of certified production, 20% of which is intended for processing, for a consumption volume of 60 million euros. Production extends over 2,000 hectares of land along the coast between Nicotera and Fiumefreddo Bruzio, in Cosenza, Catanzaro, and Vibo Valentia provinces, where these onions have been cultivated for 4,000 years (E.C. 284/2008). Among the produce types, spring onions are the first to be harvested before the bulb is fully formed (Bernardi et al., 2013). Sowing takes place from August onwards, whereas transplanting takes place from October to March depending on the ecotype. After harvest, the fresh product is mechanically sorted to prepare it for packaging. The spring onion bulbs then undergo removal of the dirty outer layer of soil and trimming of the tails with cuts ranging from 30 to 60 cm. Subsequently, the bulbs are grouped into bundles of 1.5–6 kg each and placed in boxes or crates, before being sent to the market. Therefore, the packaging of the product is crucial. Although weighing is now automated using specific machinery, various operations such as washing, peeling, and cutting are performed manually (requiring considerable manpower) or by using machines which are non-specific equipment and do not guarantee the appropriate processing of the product, resulting in large quantities of waste. Bernardi et al. (2024) discussed the operation of a spring-onion-processing plant (Figure 1) among the various commercial solutions adopted. Once collected, the spring onions are placed on a conveyor belt and lightly pre-washed before being sent to a washing tunnel. Here, the tails are cut off by using two pairs of opposing blades, and then, the tunics are partially removed by employing the alternating movement of two pairs of rollers. The first pair is equipped with brushes, whereas the second pair is made of rubber. Both have perpendicular and alternating movements with respect to the direction in which the product moves. Poonam et al. (2022) developed a peeler consisting of an aluminium drum mounted on a rotating disc. The onions were first cut and then washed for 10 min; subsequently, they were air-dried for 1–2 min to remove excess water and then placed in the peeler. This type of system still requires a large number of workers to obtain the final product. Moreover, the use of water in large amounts increases the risk of rotting because when water penetrates the tail of the spring onions, it alters the product and reduces its shelf life. To address this problem, a novel processing line that uses compressed air to clean the onions was developed. It was equipped with a single-blade cutting system with an adjustable position and a nebulisation system that prolongs the maintenance of freshness until consumption, while reducing the risk from exposure to large quantities of water.

Figure 1. Commercial onion-processing plant

2. Materials and Methods

2.1. Structure of the system

A system was designed to address the aforementioned problems, and its schematic view is shown in Figure 2. It includes a conveyor-belt-based handling system, capable of continuously transporting the spring onions towards a compressed-air cleaning system to remove tunics and soil. This is followed by a cutting and washing system that uses the nebulisation technique.

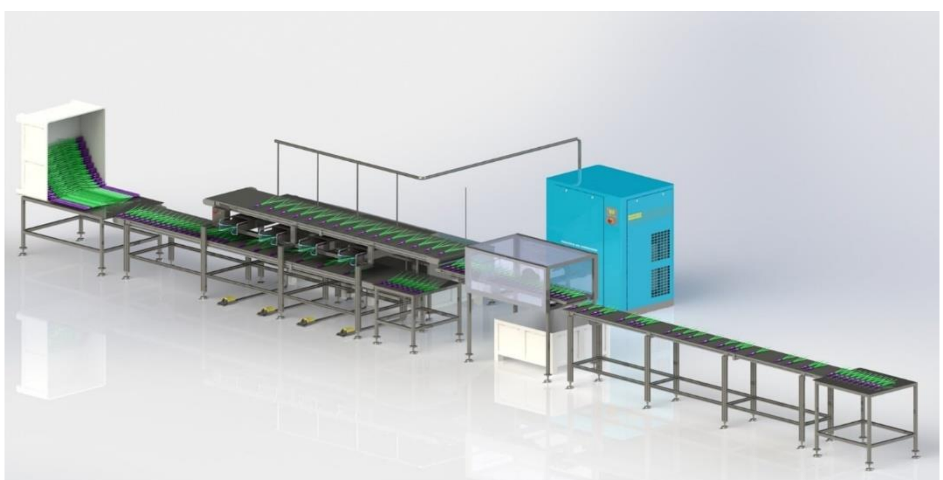

Figure 2. 3D drawing of the processing plant

The processing cycle (Figure 3) begins with the unloading of the boxes arriving from the collection site to the transport line, comprising smooth rubber conveyor belts (A), by means of a special tipper. Therefore, the spring onions arrive well-aligned at the cleaning stations, which operate with compressed air. The pneumatic system (B) consists of a compressed air production unit with a minimum output of 7000 Nl min^{-1} and a steel compressor outlet pipe with a minimum diameter of DN32. The inlet pipe of the compressed air management valve is made of steel with a minimum diameter of DN15. The 3/2 NC monostable pneumatic pedal valves have a progressive flow with a maximum flow of 1200 Nl min^{-1} at 6 bar; the air flow can be managed through these valves depending on the requirements. These values were obtained by considering two main factors, namely, pressure drop and air losses, based on the following equation:

$$D = \sqrt{\frac{4 \cdot p_a \cdot L}{\pi \cdot p_u \cdot v_{eff}}}\ [m] \tag{1}$$

where:
D= initial diameter
p_a= suction pressure
p_u= compressor output pressure
v_{eff}= effective air velocity

The effective air velocity is expressed as follows:

$$v(eff) = \frac{p_a}{p_u} \cdot \frac{T_c}{T_a} \cdot \frac{Q}{\frac{\pi \cdot D^2}{4}}\ [m\, s^{-1}] \tag{2}$$

where:
Q= air flow rate
T_c= temperature of compressed air
T_a= room temperature

Subsequently, the distributed pressure drops at the individual straight sections were calculated using the following equation:

$$\Delta P = \lambda \cdot \rho \cdot \frac{v^2 L}{2D}\ [Pa] \tag{3}$$

where:
ΔP= drop in pressure [Pa]
λ= coefficient of friction of air movement
ρ= compressed air density [kg m^{-3}]
v= flow velocity
D= internal pipe diameter [m]
L= pipe length [m]

Simplified experimental equations are often used in research. In this study, the following equation was applied:

$$\Delta P = 1.6 \cdot 10^8 \cdot \frac{Q^{1.85} L}{d^5 p}\ [Pa] \tag{4}$$

where:
ΔP= drop in pressure [Pa]
Q= air flow rate [m^3 s^{-1}]
d= internal pipe diameter [mm]
L= pipe length [m]
p= compressed air pressure [bar]

The cleaning block with pneumatic nozzles (Figure 4) comprises four semi-rigid tubes (Exair model 9268) that can be positioned by the operator; the spring onion to be processed is placed between the tubes. At the ends of the tubes, nozzles with a minimum blowing force of 360 g are located at a distance of 300 mm (Exair model 1011SS). Owing to their particular shape, the nozzles create a cone that drags in the air present in the atmosphere and amplifies the flow that reaches the spring onions. The number and arrangement of the nozzles ensure that the airflow cones act over the entire surface of the spring onions. Finally, varying the position of the nozzles widens or narrows the area in which the spring onions can be cleaned.

At this stage, the spring onions are picked manually by the operators and positioned corresponding to the pneumatic nozzles activated by the foot pedal. Here, the cleaning residue is dragged by the air flow through a secondary duct into a special container positioned on the side (C) to prevent it from spreading. The operators then place the clean spring onions, that is, free of husks and soil, on a second conveyor belt (D), which takes them to the next stage of cutting and washing (E).

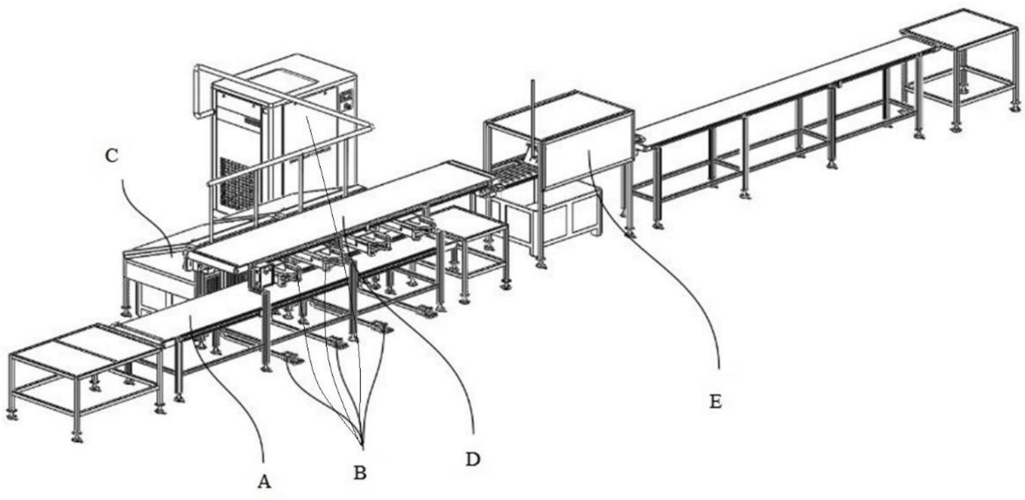

Figure 3: Processing flow. A) Conveyor belt; B) pneumatic pedal drive; C) container for collecting processing waste; D) second conveyor belt; E) cutting, washing, and drying block

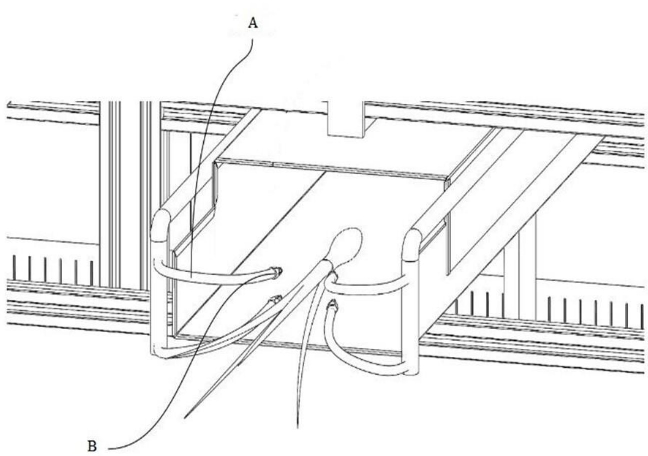

Figure 4. Pneumatic cleaning station. A) Semi-rigid hoses; B) nozzles

For the subsequent cutting and washing phases, the spring onions are moved along the second conveyor belt towards a processing block (E) that is not accessible to operators for safety reasons. The block consists of a 40 × 40 mm tubular structure and plexiglass panels. Inside this block, to maintain the freshness of the product but prevent water from entering the tails, the spring onions are humidified using nozzles having a flow rate of 1 L min^{-1} at 2 bar (Lechler series 490.403) and placed at the top with respect to the forward movement. Then, to meet production specifications, the spring onion tails are cut by using a single-tooth blade with an adjustable position (Figure 5).

Figure 5. Cutting blade

Made from stainless steel, the cutting blade has a diameter of 300 mm and a rotation speed of 200–250 rpm and is coupled to a conveyor belt with adjustable feed speed. The precise number of revolutions combined with a suitable feed speed can help to exploit the onion's inertia for a clean decisive cut. Another technical solution is adopted to make the cutting system adjustable and versatile depending on the dimensional characteristics of the product. This solution involves manual adjustment of the height of the cutting blade with a groove system to manage the effect of the contact of the rotating blade on the tail (Figure 6).

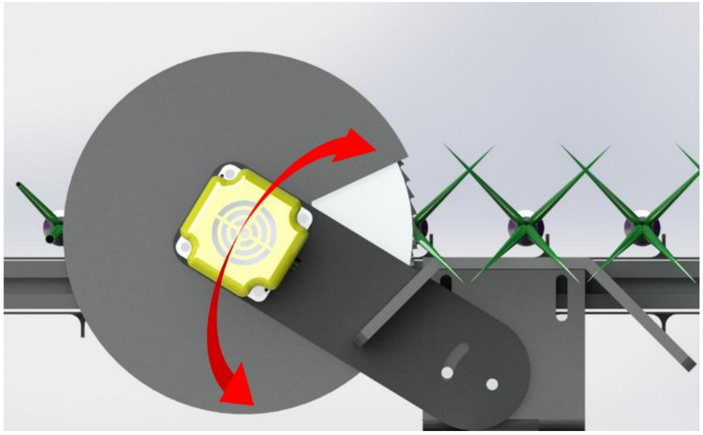

Figure 6. Blade height adjustment device

The final part of the processing line consists of an additional conveyor belt that allows operators to manually refine the product and send it to the subsequent weighing and packaging stages. These operations are then performed independent of the prototype system by using other machines already present in the facility.

3. Conclusions

As the market demand for PGI-labelled Tropea red onions is high, the lack of specialised machinery for processing these onions in the post-harvest phase should be addressed. A prototype machine, which is currently under construction, is proposed herein as a practical solution for increasing the productivity of the spring onion supply chain. The proposed machine prevents the rapid rotting of onions because it can eliminate the use of large amounts of water, which can become stagnant in the tails of the onions. Thus, the use of compressed air can extend the shelf life of the product by a few days, thereby opening up new and interesting economic prospects for operators in the sector.

Acknowledgements

This paper has been funded by "Fondo Europeo Agricolo per lo Sviluppo Rurale: l'Europa investe nelle zone rurali. PSR Calabria 2014-2020 Reg. UE n. 1305/2013 – DDG n. 3601/2018 Misura 16 Intervento 16.02.01 Progetto "Eccellenza Rossa" CUP J22C22000460005.

References

Commission Regulation (EC) No 284/2008 of 27 March 2008 registering certain names in the Register of protected designations of origin and protected geographical indications (Lingot du Nord (PGI), Cipolla Rossa di Tropea Calabria (PGI), Marrone di Roccadaspide (PGI))

Bernardi, B., Zimbalatti, G., Proto, A.R., Benalia, S., Fazari, A., Callea, P., 2013. Mechanical grading in PGI Tropea red onion post harvest operations. Journal of Agricultural Engineering, 44 (e63), 317-322, http://dx.doi.org/10.4081/jae.2013.s2.e63

Bernardi, B., Messina, G, Cilea, I., Neri, A., Sbaglia, M., Abenavoli, L.M.M., Zimbalatti, G., 2024. Assessment of Mechanical Damage to Tropea Red Onion PGI during Processing. In *Networks, Markets & People: Communities, Institutions and Enterprises towards post-humanism epistemologies and AI challenges*. Reggio Calabria, Italy, May 22-24. Lecture Notes in Networks and Systems (In Press)

Poonam, Manisha Verma, Raja Ram Bunker and Subhita Kumawat (2022). Post-Harvest Management in Onion: Deserve Concern. Biological Forum – An International Journal, 14(4a): 608-612

AgEng 2024

1-4 July 2024
Athens-Greece

PROFESSIONAL CONGRESS ORGANIZER
convin
www.convin.gr

MEMBER OF
IAPCO ACCREDITED
ICCA Member

YOUR FLEXSTABILITY PARTNER!!