

# Comparison of quality parameters of non-pelleted and newly developed pelleted lettuce seed

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**Summary:** Lettuce is one of the most common types of leafy vegetables in human diet that is grown worldwide. Narrow and very small seeds make its sowing very difficult, requiring a lot of time and labour. Also, plants produced by manual sowing are often characterized by uneven germination. Those problems could be prevented by sowing pelleted seeds which require the development of adequate pelleting technology. Absence of quality lettuce seeds in the Serbian market results in large amounts of imported pelleted seeds every year. The aim of this study was to develop a domestic pelleting procedure and examine its effects on seeds quality parameters, in order to provide seeds to local farmers at a more affordable price compared to imported commercial pelleted seeds. Pelleted and non-pelleted seeds of the Panukia F1 hybrid were compared in several quality characteristics (1000 seed weight, germination energy, germination percentage, seedling length) in laboratory and greenhouse conditions. There was no loss in seed quality with the pelleting process, although the seed weight increased 12-19 times. Pelleted lettuce seeds had very high germination energy and seed germination (97-98%). In greenhouse conditions, non-pelleted seeds sprouted unevenly in relation to pelleted seeds. These results confirm the advantages of sowing pelleted seeds in terms of uniform germination and development of lettuce plants, primarily due to the precision of mechanical sowing. By offering domestic pelleting lettuce seeds to the growers, the production process would be significantly improved and accelerated with the reduction of manual labour, and therefore the overall production cost

**Keywords:** lettuce, pelleting, quality parameters, seed, seed quality

## Introduction

Lettuce (*Lactuca sativa* L.) is a plant from the *Asteraceae* family. This vegetable has an important place in the human diet since it is a very rich source of fiber, iron, folate, vitamins (C, B<sub>1</sub>, B<sub>2</sub>, pro-vitamin A), minerals and other health-beneficial bioactive molecules, accompanied by good sensory characteristics, low calories, sodium, and fat content (de Souza et al., 2022). As a result, it is not surprising that lettuce is widely planted

worldwide, which makes it a vegetable of a high economic value (Collado-Gonzalez et al., 2022). Lettuce is an annual herbaceous plant that is produced throughout the year by combining production in the open field and greenhouses. Due to unfavourable seed appearance (small size and narrow shape) and low germination rates, it is a common practice to grow lettuce from nursery seedlings (Kangsopa & Siri, 2015). Considering the fact that seed quality is one of the critical characteristics for the sustainable plant development of both lettuce and other plants grown from seed, one of the common solutions to this problem is changing the characteristics of the seed, primarily by increasing its mass and shape. Different seed technologies for optimising seed shape are available, including priming, coating and pelleting, while pelleting and coating have often been used commercially for this purpose on many ornamentals, vegetables and some field crop plants (Taylor et al., 1997; Kim et al., 2000). Modern seed coating technologies aim to apply a wide range of active ingredients to crop seeds (mineral nutrients, plant hormones, fungicides, etc.), in order to facilitate sowing, upgrade planting ability and enhance crop

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performance (Smith & Miller, 1987; Markey, 1990; Taylor, 2003; Zelonka et al., 2005). Seed pelleting, a type of seed coating, is a process of adding inert substances (organic or non-organic) such as binding agents and a filler material (Dumanoglu & Ozturk, 2021) uniformly on the seed surface to alter the size, shape and weight (Kaufman, 1991). The material used as the filler has to fulfil several requirements. Primarily, it should not slow germination, nor impede radicle or shoot emergence, absorb water, and freely crack and dissolve, and in addition, it should be economically accessible and compatible with the binding agent (Kangsopa et al., 2018). The filler materials that are often used for pelleting include clay, calcium carbonate, limestone, bentonite, zeolite, gypsum, talc, charcoal, sawdust, vermiculite, pumice stone, diatomaceous earth, and sugar water (Taylor & Harman, 1990; Tavares et al. 2012; Kangsopa et al., 2018; Dumanoglu & Ozturk, 2021; Zhao et al, 2021). The pelleting process involves several stages. After weighing, the pelleting mass composed of filler material and the binding agent is applied to the seeds, with subsequent drying and calibration of the seeds. The use of this technology changes the shape of seeds and improves their quality. The quality of the pelleting process is affected by the size, shape, strength of pellets, and the formulation of materials used for seed pelleting (Kim et al., 2000). This technology improves lettuce seedling mechanization, and reduces the manual work input and the number of seeds necessary for plant growing (Kang, 2004). Studies comparing the characteristics of pelleted and non-pelleted lettuce seeds have been conducted by many researchers worldwide (Wurr & Fellows, 1985; Silva et al., 2002; Zdravković et al., 2006; Contreras et al., 2008; Silva et al., 2015; San Martin et al., 2016; Zuffo et al., 2017, Kadilok et al., 2019).

Lettuce production in Serbia is an important part of vegetable production, however, in the absence of quality seeds, large amounts of pelleted lettuce seeds are imported every year. The aim of this study was to develop a pelleting procedure, and to examine the effects of this procedure on the characteristics of commercial lettuce seeds, in order to provide quality lettuce seeds that would be available to local farmers at a more affordable price compared to imported pelleted seeds of the same plant species. The developed pelleting procedure can also serve as a good basis for further research.

## Material and Methods

Lettuce seeds of the Panukia F1 hybrid (Daehnefeld, Syngenta, Egypt), which have not been pelleted in Serbia so far, were provided by the Grow Rasad DOO company (Irig, Republic of Serbia) (Fig. 1). Seed pelleting was done in the rotating drum Centricoater Model CC10 (Cimbria, Thisted, Denmark). A commercially available product Covercoat B101 (Kwizda Agro GmbH, Wien, Austria) was used as a pelleting mass. Commercial product Sodium Carboxymethyl Cellulose type WALOCEL™ CRT 1.000 PA, CAS No.9004-32-4, was used as a binding agent. It is a light yellow, odourless, tasteless, non-toxic, water-soluble powder with a pH-neutral reaction. Immediately before the pelleting process, a solution of a binding agent is prepared. A powder of a binding agent is firstly dissolved in water (100 g in 10 l) with stirring, and after 24 h additional dilution is performed (1/1, v/v). Dry seeds are poured into the rotating drum of the Centricoater, and a portion of the prepared solution of the binding material is added (100 ml per 1 kg of seeds) by spraying under pressure via a disc sprayer. The remaining part of the binding



Figure 1. Lettuce seeds of Panukia F1 before (left) and after pelleting (right)

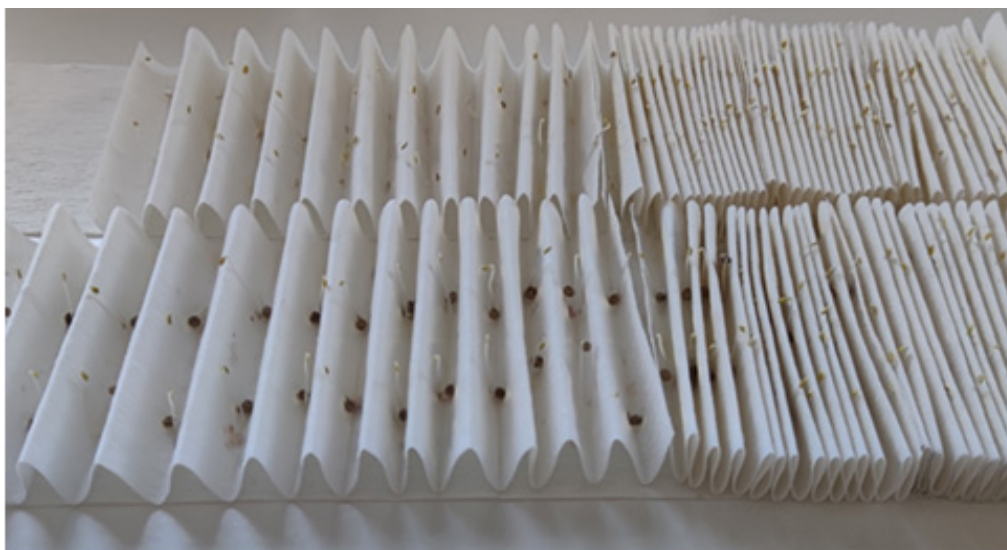


Figure 2. Lettuce seed germination test on wet filter paper

agent solution is added to the drum with alternating addition of the filler material. The entire process of the pelleting mass addition lasts for 15 minutes, whereby the seeds have a moisture content of 38%, and is shifted through a sieve with a diameter of 4 mm and deposited for drying.

Using the drying process, the moisture in the pelleted seed should be brought to the level of 8-10%. Due to the sensitivity of the lettuce seeds to high temperatures, drying is performed by airflow at room temperature interval of 18-22°C, until the necessary moisture content of the seeds is achieved. Using this procedure, pelleted seeds drying lasts for several hours (6-8 h). After the drying was finished, seed calibration was done on a hand sieve with different diameters (2.50 to 3.75 mm), in order to obtain pelleted seeds of uniform dimensions. Small seeds (diameter 2.50 to 3.00 mm) are subjected to further pelleting while larger seed pellets are washed until the seeds return to their original shape and size.

Quality characteristics of processed and pelleted seeds were initially evaluated in the seed testing laboratory, in the Sugar Beet Department of the Institute of Field and Vegetable Crops, Novi Sad, Serbia. Thousand seed weight (TSW) of different seed fractions was measured on a technical scale. Seed germination was done on wet filter paper (Fig. 2) under controlled ambient conditions (temperature of 20°C) with pre-cooling (3 days in fridge at 4°C) (Republic of Serbia, 2013). Germination energy was determined on the tested seed material on the fourth day of the germination process, while the germination percentage was evaluated on the seventh day. The

seed was evaluated as germinated in a situation where the radicle goes through the pelleted layer and pericarp. After determining germination percent seedling length of non-pelleted (control sample) and pelleted seed (fraction 3.0-3.75 mm) was measured.

Seeds parameters were also tested in the greenhouse conditions. Dried and calibrated pelleted lettuce seeds (3.00 - 3.75 mm fraction) were delivered to Grow Rasad DOO company in order to estimate its germination parameters in the greenhouse growing conditions. Pelleted and non-pelleted lettuce seeds (280) were sown in two crates in substrate cubes. Crates were placed in the germination room under controlled conditions including temperature of 20°C and relative humidity of 60% for three days. On the seventh and thirteenth day after sowing the number of sprouted lettuce plants was determined.

Statistical analysis was carried out with the program STATISTICA 13.2 (2016, StatSoft, Tulsa, OK, USA). Significant differences in means were assessed with an analysis of variance (ANOVA) using post-hoc Tukey tests,  $p \leq 0.05$ .

## Results and discussion

ANOVA results showed significant differences between non-pelleted seed and copelleted seed. Using the seed pelleting process, seed quality parameters of other pelleted seed fractions were not decreased although seed mass was increased 12-19 times. Pelleted seeds remained at high levels of germination energy and seed germination, around 98%. The biggest fraction (3.50-3.75 mm) had 1%

Table 1. Lettuce seed quality parameters tested on filter paper

Sample	1000 Seed weight (g)	Germination energy (%)	Germination percentage (%)	Seed weight increase (%)
Control sample (non-pelleted seeds)	0.86 <sup>f</sup>	99 <sup>a</sup>	99 <sup>a</sup>	-
3.00-3.25mm	10.33 <sup>c</sup>	98 <sup>a</sup>	98 <sup>a</sup>	1201
3.25-3.5mm	13.66 <sup>b</sup>	98 <sup>a</sup>	98 <sup>a</sup>	1588
3.50-3.75mm	16.04 <sup>a</sup>	97 <sup>ab</sup>	97 <sup>ab</sup>	1865
3.00-3.75mm	12.90 <sup>c</sup>	98 <sup>a</sup>	98 <sup>a</sup>	1500
Copelleted seeds 3.0-3.75	12.33 <sup>d</sup>	94 <sup>b</sup>	94 <sup>b</sup>	1434

Different letters in the columns depict the significant differences from each other (Tukey’s test, P<0.05).

Table 2. Mean value and coefficient of variation for the seedling length of pelleted and non-pelleted seeds

Sample	Seedling Length (cm)	Coefficient of Variation (%)
Control sample (non-pelleted seeds)	7.46 <sup>a</sup>	16.42
Pelleted seeds fraction 3.0-3.75 mm	7.57 <sup>a</sup>	16.11

Different letters in the columns depict the significant differences from each other (Tukey’s test, P<0.05).

lower germination energy and seed germination, however, each sample of this fraction contained 2-3 shallow seeds. Since in the pelleting process certain part of seeds remains under the required size, our research also included the germination levels of seed pellets under required dimensions that are subjected to further pelleting. This copelleted seed had a significantly lower germination rate compared to non-pelleted seeds and other fractions of pelleted seeds except fraction 3.5-3.75 mm (Table 1).

In order to assess the effect of seed pelleting on the growth and development of lettuce, after determining the germination of seeds, the seedling length was measured. There was no difference in seedling length between pelleted and non-pelleted lettuce seeds (Table 2).

*Seed quality testing in a greenhouse*

Non-pelleted seeds had uneven sprouting compared to pelleted seeds. The germination

percentage of pelleted seeds was 3.2% higher compared to the non-pelleted seeds. On the thirteenth day after sowing the difference in germination percentage between the pelleted and non-pelleted seeds decreased to 0.7%. By analysing the impact of seed pelleting on the germination potential of tomato seeds, Javed & Afzal (2018) also concluded that pelleted seeds had higher germination percentage and energy. Kaodilok et al. (2019) also acquired data in which pelleted seed treatments had better results for germination than the treatments with non-pelleted seeds. These results confirm the advantage of using pelleted seeds in terms of uniform development of lettuce plants, primarily due to the precise sowing because of bigger and uniform seed size. By performing the machine sowing, pelleted lettuce seeds are placed at the same depth, while this cannot be performed by hand sowing of non-pelleted seeds. As a result, the germination percentage of the pelleted seeds was higher than for non-pelleted seeds after 7 days (Table 3).

Table 3. Germination of lettuce seeds sown in crates in a greenhouse

Sample	Germination 7 <sup>th</sup> day (%)	Germination 13 <sup>th</sup> day (%)	Sprouting
Control sample (non-pelleted seeds)	95.7	98.2	Uneven
Pelleted seeds fraction 3.0-3.75 mm	98.9	98.9	Uniform

## Conclusion

The results obtained in this study are in agreement with Silva et al. (2002) and Kaodilak et al. (2019) who showed that there was no difference in germination level between pelleted and non-pelleted lettuce seeds. This indicates that the pelleting technology of lettuce seeds that was developed during this research can be potentially applied to the other varieties of lettuce. By offering pelleted lettuce seeds to the agricultural producers, the lettuce production process would be significantly facilitated and accelerated with the reduction in manual labour, and thus the overall production cost of this very important vegetable. The mechanical sowing of pelleted seeds, uniform in weight, size and shape, would provide a precise seed spacing in the open field production and reduce the need for plant thinning. The developed pelleting technology is rapid and simple, with the use of easily available and inexpensive pelleting materials.

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## Poređenje parametara kvaliteta nepiliranog i novostvorenog piliranog semena zelene salate

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**Sažetak:** Zelena salata je među najzastupljenijim vrstama lisnatog povrća u ljudskoj ishrani koja se uzgaja širom sveta. Nedostatak kvalitetnog semena zelene salate na srpskom tržištu uzrokuje uvoz velikih količina piliranog semena svake godine. Usko i veoma sitno seme otežava setvu i zahteva mnogo vremena i rada. Takođe, biljke proizvedene ručnom setvom semena često se odlikuju neujednačenim nicanjem. Ovi problemi mogu se sprečiti setvom piliranog semena što zahteva razvoj adekvatne tehnologije piliranja. Cilj ovog istraživanja bio je da se razvije domaći postupak piliranja semena zelene salate i da se ispita njegov uticaj na parametre kvaliteta semena kako bi se lokalnim poljoprivrednim proizvođačima obezbedilo seme po pristupačnijoj ceni u odnosu na uvozno pilirano seme. Pilirano i nepilirano seme hibrida Panukia F1 poređeno je u nekoliko parametara kvaliteta (masa 1000 semena, energija klijanja, procenat klijavosti, dužina ponika) u laboratorijskim uslovima i proizvodnim uslovima u stakleniku. Piliranje nije uticalo na gubitak kvaliteta semena iako je masa semena piliranjem povećana od 12 do 19 puta. Pilirano seme zelene salate imalo je veoma visoku energiju klijanja i klijavost semena (97-98%). U proizvodnim uslovima u stakleniku, nepilirano seme je nicalo neujednačeno u odnosu na pilirano seme. Ovi rezultati potvrđuju prednost setve piliranog semena u pogledu ujednačenijeg nicanja i razvoja biljaka, prvenstveno zbog preciznosti setve piliranog semena. Ponudom domaćeg piliranog semena zelene salate proizvođačima značajno bi se unapredio i ubrzao proces proizvodnje uz smanjenje ručnog rada, a samim tim i ukupnih troškova proizvodnje.

**Ključne reči:** zelena salata, piliranje, parametri kvaliteta, seme, kvalitet semena

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