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Research Article

Effects of cold and room temperature storage on the sprouting and marketability of early-grown spring potatoes

Heon-Seop Won[1†], Kyusuk Han[1†], Young Hun Lee[2*]

[1]*Potato Research Institute, Gangneung 25437, Korea*
[2]*Well-being Agro Information Institute, Gangneung-Wonju National University, Gangneung 25457, Korea*

Abstract Three spring potato varieties (*Atlantic*, *Chubaek*, and *Superior*) were cultivated for 80, 90, and 100 days and compared in terms of their total and marketable yields and specific gravities. Subsequently, changes in the quality parameters (weight loss, sprouting rate, disease incidence, dry weight, and specific gravity) of potatoes cultivated for 100 days were monitored during two-month storage in improved and semi-underground warehouses at 4℃ and room temterature. The productivities of *Atlantic*, *Superior*, and *Chubaek* were maximized at cultivation periods of 100, 100, and 〉90 days, respectively. In all cases, cold storage resulted in 〈5.3% weight loss and no marketability loss. However, two-month room temperature storage resulted in pronounced marketability loss due to weight loss (6.2, 7.3% and 10.9% for *Atlantic*, *Superior*, and *Chubaek*, respectively) and sprouting (in ~13%, 〉75%, and 99% of *Atlantic*, *Superior*, and *Chubaek* tubers, respectively). The marketability of *Atlantic*, *Superior*, and *Chubaek* during cold storage was maintained for 〉2, ~2, and 〈2 months, respectively. All varieties were characterized by rapid sprouting, low dry weight and specific gravity, and rapid marketability loss during storage.

Keywords postharvest quality, cold and room temperature storage, *Solanum tuberosum*, sprouting, weight loss

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†These authors contributed equally to this study.

***Corresponding author**
Young Hun Lee
Tel: +82-33-640-2913
E-mail: hunly@gwnu.ac.kr

1. Introduction

Potatoes are among the top four food crops cultivated in South Korea, the other three being rice (which ranks first in terms of cultivation area and production volume), soybeans, and sweet potatoes (KOSIS, 2023). The area used for potato cultivation (21,745 ha) accounts for 1.3% of the domestic cultivated land and 2.4% of the land occupied by food crops, with the total annual domestic production of potatoes (554,893 tons) dominated by spring potatoes (379,671 tons, i.e., 68.4%). The Gangwon Province is a representative potato production region with a cultivation area of 5,715 ha and production volume of 172,869 tons, accounting for 26.3% and 31.2% of the total domestic values, respectively. Highland potatoes, which account for 〉99% of the total potato cultivation area (3,883 ha) and annual

production (118,084 tons), are almost exclusively grown in the Gangwon Province (KOSIS, 2023).

Atlantic is a midseason domestic potato variety with a growing period of ~110 days, which can be shortened to 90 days when cultivation is performed in the spring. *Superior*, an early midseason variety, has a growing period of 90-100 days, and *Chubaek*, an extremely early season variety, can be harvested after only 80 days (Kwon et al., 2005). Early season and early midseason potatoes typically have a short dormancy period and low storability, although these metrics depend on the potato type (Kwon et al., 2005).

The quality and marketability of fresh potatoes and other agricultural products decrease during storage because of concomitant moisture loss, respiration, and the conversion and breakdown of starch into sugars (Kuyu et al., 2019), which collectively result in weight and external appeal loss, sprouting, and physiological and pathological damage (Khanal and Bhattari, 2020).

Given that cold storage helps maintain potato quality and hinders sprouting (Sonnewald and Sonnewald, 2014), it is the basis of various sprout suppression treatments (Şanli and Karadoğan, 2019). The optimal storage conditions for maintaining potato quality correspond to a relative humidity (RH) of >90% and temperatures of 3.3, 3.3-4.4, and 7.2-12.8℃ for seed, regular fresh, and processing potatoes, respectively (MacNeil, 2013; Voss et al., 2001).

For long-term preservation, potatoes are typically stored at low temperatures, with fresh edible varieties typically maintained at 4℃ within domestic settings. Spring potatoes are used to adjust the circulation volume during the summer off-season and are therefore stored for short time periods in semiunderground warehouses without refrigeration systems in the highland cultivation areas of the main production region (Gangwon Province), a practice dating back to the 1990s. Potato storage in semiunderground warehouses is used on individual farms and in village units in the highlands; however, accurate statistical data on the status and potato storage volumes of these warehouses are not available (Han et al., 2003).

Although potatoes are a major staple and horticultural crop in South Korea, research on their postharvest management is scarce, particularly for the short-term storage strategies used to manage supply during the summer off-season, and the dependence of storability on the cultivation period adjustments used to boost production is underexplored. To bridge this gap, this study analyzes the effects of two-month cold (4℃) and room temperature storage on the quality of *Chubaek*, *Superior*, and *Atlantic* potatoes grown for 100 days, revealing useful trends.

2. Materials and methods

2.1. Materials

The productivity of each variety was investigated in 2021 at cultivation periods of 80, 90, and 100 days. The measured parameters included the total yield (production of potatoes per 1,000 m^2), marketable yield (production of tubers with individual fresh weights of >51 g per 10 are), marketability rate (100% × marketable yield/total yield), weight of tubers per plant, and specific gravity.

Based on the results of productivity testing, all three varieties were planted at the end of April 2022 in a field located in Sacheon-myeon, Gangneung City, cultivated for 100 days, and harvested in early July. Fertilization and pesticide application during cultivation followed standard farming practices. The harvested potatoes were cleaned and sorted, and

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tubers with visible damage or poor growth conditions were removed.

2.2. Postharvest treatment and storage

The harvested potatoes were cured for 12 days at 18℃ and ~90% RH in a curing-specific room and then stored in improved and semiunderground warehouses. The improved warehouse, a potato-specific storage facility located at the Gangwon Provincial Agricultural Research Institute in Gangneung City (Gangwon Province), was used for cold (4℃, 90% RH; refrigeration system) and room-temperature (no refrigeration system) storage. The semiunderground warehouse, a cave-shaped potato-specific storage facility located at an elevation of 260 m in Wangsan-myeon, Gangneung City, was used for room temperature storage (no refrigeration system). Potatoes were packed into polyethylene (PE) boxes with a capacity of 20 kg, sorted by variety, and stored at the designated facilities.

2.3. Quality parameters

Quality indicators (internal RH and temperature of the storage facility, weight loss, sprouting rate, specific gravity, and disease incidence) were monitored over two months of storage. The internal and external RH and temperature of the semiunderground warehouse were monitored throughout the storage period using a temperature and humidity recorder installed inside the facility. The appearance and elongation of sprouts (size ≥3 mm) were investigated according to the standards provided by the Rural Development Administration (Kim, 2005). Sprouting was investigated using three boxes per treatment (90-100 tubers per box). Weight loss was calculated as 100% × (weight loss during storage / initial weight). Specific gravity was measured using a specific gravity meter (MDS 300, Alfa Mirage Co., Tokyo, Japan) and converted to starch content (Kwon et al., 2005). Disease incidence was calculated as 100% × weight of diseased tubers / weight of healthy tubers for 10 boxes with a loading of 12 kg/box. Starch discoloration on the tuber surface after the iodine reaction was examined by naked-eye and optical microscopy (magnification 100×) observations.

2.4. Statistical analysis

Statistical analysis was performed using three replicates, each based on a PE box unit. Data were processed using the SPSS (v. 12.0.1) and Excel (Microsoft Office Professional Plus 2016, Redmond, WA, USA) programs, and significance tests for treatment averages were performed by the analysis of variance (ANOVA) followed by Duncan's multiple range test at the 5% level.

3. Results and discussion

3.1. Effects of cultivation period on the qualities

Table 1 lists the yields and quality characteristics of potatoes cultivated for different periods. For *Atlantic* and *Superior*, an increase in the cultivation period led to statistically significant increases in total and marketable yields and tuber weight per plant, with the respective total yields at 100 days reaching ~4.2 and ~4.3 tons. For *Chubaek*, total yields of ~3.6 and ›4.0 tons were achieved at 80 and ›90 days, respectively, with no significant difference observed between 90 and 100 days. Marketable yield followed a trend consistent with that of total yield. The marketability rate exceeded 90% at cultivation periods of 100 days (*Atlantic*), ›90 days (*Chubaek*), and 80 days (*Superior*). Thus, whereas the optimal cultivation periods for *Atlantic* and *Superior* were identical to those reported previously, *Chubaek* exhibited increased productivity when

Table 1. Productivity of fresh potatoes including *Atlantic*, *Chubaek*, and *Superior* varieties according to growing period during spring cultivation in 2021

Variety	Growing period (day)	Total yield (kg/10a)	Marketable yield (kg/10a)	Rate of marketability (%)	Tubers weight (g/plant)	Specific gravity	Starch (%)
Atlantic	80	3,637$^{c1)}$	2,988^{c}	82^{b}	742±63^{c}	1.080^{a}	13.94^{a}
	90	4,086^{b}	3,540^{b}	87^{ab}	834±96^{b}	1.080^{a}	13.94^{a}
	100	4,429^{a}	3,992^{a}	90^{a}	904±47^{a}	1.078^{a}	13.51^{a}
Chubaek	80	3,621^{b}	3,169^{b}	86^{b}	759±56^{b}	1.060^{a}	9.65^{a}
	90	4,044^{a}	3,693^{a}	91^{a}	847±65^{a}	1.061^{a}	9.86^{a}
	100	4,197^{a}	3,759^{a}	90^{ab}	879±66^{a}	1.060^{a}	9.65^{a}
Superior	80	3,667^{c}	3,368^{b}	92^{a}	756±67^{c}	1.071^{ab}	12.00^{ab}
	90	4,049^{b}	3,692^{ab}	92^{a}	835±72^{b}	1.068^{b}	11.36^{b}
	100	4,322^{a}	3,947^{a}	91^{a}	891±71^{a}	1.072^{a}	12.22^{a}

[1)]All values are mean (n=3). Means with different superscript letters ($^{a-c}$) in the same column are significantly different ($p<0.05$) by Duncan's multiple range test.

cultivated for >5 days beyond the generally used period of 80-85 days (RDA, 2020).

Across all varieties, the specific gravity, reflecting starch content at harvest, did not follow a consistent trend upon a cultivation period increase from 80 to 100 days; however, varietal differences were observed. *Atlantic* and *Superior*, recognized for their processing quality, exhibited higher specific gravities (~1.080 and 1.070, respectively), consistent with a previous report (Kwon et al., 2005), while *Chubaek* featured a lower value of ~1.060. Thus, productivity (total and marketable yields) was maximized at ~100 days of cultivation for *Atlantic* and *Superior* and at 90 days for *Chubaek*.

3.2. Effects of storage environment on the qualities

Table 2 lists the storage-induced weight losses of the three varieties. *Atlantic* and *Superior* experienced weight losses of 3.0-3.6% after one month of storage in the improved warehouse at both temperatures, with both having no statistically significant effect. For *Chubaek*, however, the weight loss was higher (3.4-4.2%) and increased with increasing temperature. Storage in the semiunderground warehouse for one month induced a weight loss of 1.2-1.5% in all varieties, with no significant differences observed between them. By the second month of storage, the weight loss of all three varieties increased up to 2.5-fold. For the improved warehouse, the weight loss increased with increasing storage temperatures for all varieties. However, storage in the semiunderground warehouse for two months resulted in the lowest weight loss among the three storage conditions, similar to the case of one-month storage. *Chubaek* showed a significantly higher weight loss than *Atlantic* and *Superior* in the two other storage environments, excluding cold storage. Although the exact cause of this behavior is unclear, the increased weight loss may be due to an increased tuber maturity caused by the extension of the *Chubaek* cultivation period by 15 days beyond the typical value, which could have led to the weakening of tissue structures. Additionally, the 13 days of rainfall observed in the last month before harvest, especially the four days of continuous rainfall before harvest, probably resulted in the

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Table 2. Weight loss (%) of fresh potatoes grown in spring including *Atlantic*, *Chubaek*, and *Superior* varieties during storage according to types of traditional warehouses in 2022

Variety	Warehouse	Temperature (℃)	Storage period (month)	
			1 (%)	2 (%)
Atlantic	Common	4	3.5±0.6[b1)]	4.9±0.6[d]
		Room temperature	3.0±0.4[b]	6.2±0.6[c]
	Semi-underground[2)]	Room temperature	1.2±0.7[c]	2.5±0.7[e]
Chubaek	Common	4	3.4±0.4[b]	5.3±0.8[cd]
		Room temperature	4.2±0.4[a]	10.9±3.2[a]
	Semi-underground	Room temperature	1.5±0.8[c]	4.4±1.7[d]
Superior	Common	4	3.3±0.6[b]	4.8±1.0[d]
		Room temperature	3.6±1.5[b]	7.3±1.6[b]
	Semi-underground	Room temperature	1.4±0.8[c]	2.7±0.8[e]

[1)]All values are mean (n=3). Means with different superscript letters ([a–d]) in the same column are significantly different ($p<0.05$) by Duncan's multiple range test.
[2)]Cave type on 260 m altitude without cooling system.

bulking and specific gravity issues in *Chubaek* being more pronounced than those in other varieties. This hypothesis is consistent with the increased susceptibility of immature (Makani et al., 2017) and overmature (Iritani and Sparks, 1985) tubers to weight loss during storage. Despite its higher temperature, the semiunderground warehouse maintained high humidity, and storage in this facility resulted in a weight loss lower than that achieved in the improved warehouse. In the latter facility, the periodic operation of the refrigeration system increased air circulation and thus enhanced transpiration, whereas in the former dirt-floor facility, the storage period coincided with the summer monsoon season, and the RH was maintained at near-saturation levels (Fig. 1), which inhibited transpiration. Given that the critical weight loss leading to decreased marketability is ~7% (Kays, 1991; Kays and Paull, 2002), the marketability of *Superior* and *Chubaek* could be compromised after two months of room- temperature storage in the improved warehouse. Although storage in the semiunderground warehouse induced a significantly lower weight loss than that in the improved warehouse, an opposite trend was reported in a previous study (Park et al., 2007), which was rationalized as follows. In our study, the storage period included the summer monsoon season, and the RH inside the storage facility exceeded 99%. However, in the study conducted by Park et al. (2007), storage began during the dry autumn season, leading to a lower internal RH, especially at the beginning of the storage period.

During the first month of cold storage, none of the three varieties showed sprouting (Table 3). However, sprouts of ≥3 mm developed in both warehouses at room temperature (Fig. 2), with the sprouting rates of *Atlantic*, *Superior*, and *Chubaek* determined as ~13%, 〉75%, and ~99%, respectively. By the second month of room temperature storage, the above values increased to ~90%, ~98%, and 100%, respectively. After two months of cold storage, the sprouting rates of *Superior* and *Chubaek* equaled ~8% and 13%, respectively. Sprouting was fastest for

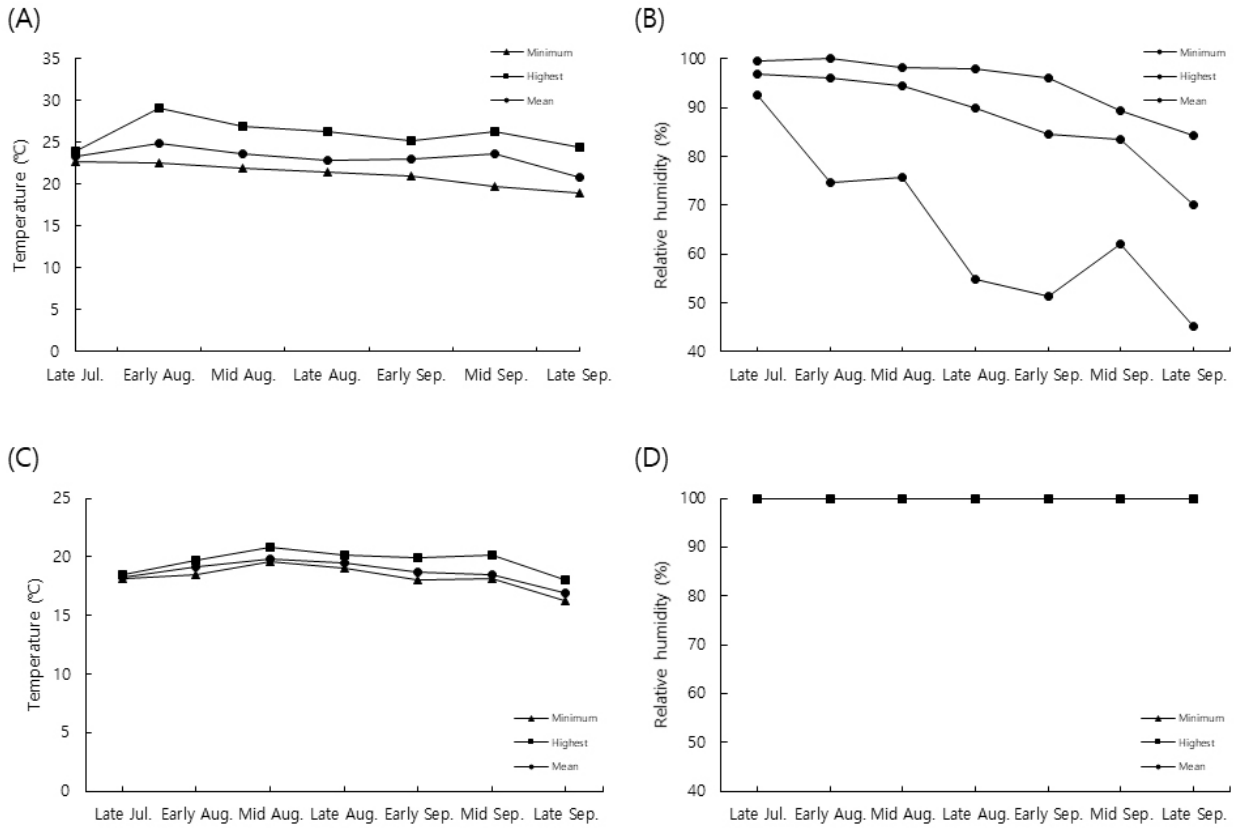

Fig. 1. Changes in room temperature (A, C) and relative humidity (RH) (B, D) in a common traditional (A, B) and a cave type of semi-underground traditional (C, D) potatoes warehouses without running of cooling systemes located on Gangneung area during storage of potatoes in 2022.

Table 3. Sprouting rate (%) of fresh potatoes grown in spring including *Atlantic*, *Chubaek*, and *Superior* varieties during storage according to types of traditional warehouses in 2022

Variety	Warehouse	Temperature (℃)	Storage period (month)	
			1 (%)	2 (%)
Atlantic	Common	4	0.00$^{e1)}$	0.00^{d}
		Room temperature	13.49^{d}	92.57^{b}
	Semi-underground$^{2)}$	Room temperature	12.44^{d}	89.70^{ab}
Chubaek	Common	4	0.00^{e}	12.56^{c}
		Room temperature	98.76^{a}	100.00^{a}
	Semi-underground	Room temperature	99.75^{a}	100.00^{a}
Superior	Common	4	0.00^{e}	7.69^{c}
		Room temperature	75.25^{c}	98.23^{a}
	Semi-underground	Room temperature	87.80^{b}	97.40^{a}

$^{1)}$All values are mean (n=3). Means with different superscript letters ($^{a-d}$) in the same column are significantly different ($p<0.05$) by Duncan's multiple range test.
$^{2)}$Cave type on 260 m altitude without cooling system.

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Atlantic *Chubaek* *Superior*

Fig. 2. Appearance of sprouting on fresh potatoes including *Atlantic*, *Chubaek*, and *Superior* varieties after one month of storage in cave type warehouses.

Chubaek and slowest for *Atlantic*. Generally, the dormancy period is 80-90 days for *Atlantic* and *Superior* and 60 days for *Chubaek* (Kwon et al., 2005). Despite the curing period of 12 days, all three varieties showed sprouting within ~40 days of storage at room temperature. *Atlantic* and *Superior* were reported to require more than three months of storage at 5℃ to begin sprouting (Choi et al., 1999), and no sprouting was observed during up to seven months of storage at 3.5℃ (Leach, 1987). Herein, we observed sprouting in *Superior* within ~70 days after harvesting, i.e., after 12 days of curing and two months of storage at 4℃. The early sprouting observed for *Chubaek* agrees with that observed for overmature tubers (Iritani and Sparks, 1985). Even considering the above, all three varieties featured very early sprouting times, which suggests that sprouting may have been accelerated by the extremely poor growing conditions during the later growth and harvest stages and the resulting maturity and quality degradation. However, the precise mechanism remains unclear because of the underexplored effects of reduced sunlight and soil waterlogging due to monsoon rains during cultivation on the sprouting of stored potatoes.

Despite the overlap of the late growth and harvest periods with the monsoon season, the disease incidence during two-month storage remained very low, with diseases mostly corresponding to dry rot along with some cases of rotten potatoes (Fig. 3). After two months of room temperature storage in the improved warehouse, disease incidences of 0.3%, 1.4%, and 0.8% were observed for *Atlantic*, *Superior*, and *Chubaek*, respectively (Table 4). No diseases were observed for cold and semiunderground storage. Postharvest curing is the most basic and common treatment used to inhibit disease incidence during storage (Hide and Cayley, 1983; Hide and Cayley, 1987; Olsen et al., 2006; Voss et al., 2022). Although curing is generally performed at RH=85%-95%, the recommended temperatures vary between 12-15℃ (Holcroft, 2018) and 15-18℃ (Wang et al., 2020). The low disease incidence was attributed to the thorough curing in the dedicated curing room

Unidentified decay Dry rot

Fig. 3. Appearance of diseases on fresh potatoes stored in common warehouse at room temperature in summer season 2022.

Table 4. Diseases occurrence rate (%) of fresh potatoes grown in spring including *Atlantic*, *Chubaek*, and *Superior* varieties during storage according to types of traditional warehouses in 2022

Variety	Warehouse	Temperature (℃)	Storage period (month)	
			1 (%)	2 (%)
Atlantic	Common	4	0.00[b1)]	0.00[c]
		Room temperature	0.05[b]	0.25[bc]
	Semi-underground[2)]	Room temperature	0.00[b]	0.00[c]
Chubaek	Common	4	0.00[b]	0.00[c]
		Room temperature	0.05[b]	0.88[ab]
	Semi-underground	Room temperature	0.00[b]	0.07[c]
Superior	Common	4	0.00[b]	0.00[c]
		Room temperature	0.21[a]	1.43[a]
	Semi-underground	Room temperature	0.00[b]	0.00[c]

[1)]All values are mean (n=3). Means with different superscript letters ([a–d]) in the same column are significantly different ($p<0.05$) by Duncan's multiple range test.
[2)]Cave type on 260 m altitude without cooling system.

for 12 days after harvesting and the preceding removal of tubers with signs of damage or diseases during sorting. Additionally, dry rot was probably inhibited because storage was performed for a short period of two months during the summer season, especially at 4℃.

For all three varieties, the dry weight at harvest was below 16%, with the minimum observed for *Chubaek* (13.7%; Table 5), whereas a value of 19.9% has been reported for *Superior* (Kwon et al., 2005). This finding disagrees with a report suggesting that irrigation at 1.2 times the conventional amount leads to a decrease in specific gravity but does not affect dry weight (Wenzel, 2020). During storage,

Table 5. Dry weight (%) of fresh potatoes grown in spring, including *Atlantic*, *Chubaek*, and *Superior* varieties, during storage according to types of traditional warehouses for potatoes in 2022

Variety	Warehouse	Temperature (℃)	Storage period (month)		
			At harvest (%)	1 (%)	2 (%)
Atlantic	Common	4	15.78[a1)]	16.81[ab]	15.51[bc]
		Room temperature	15.78	16.38[ab]	17.84[a]
	Semi-underground[2)]	Room temperature	15.78	17.95[a]	14.88[bc]
Chubaek	Common	4	13.71[a]	15.63[ab]	13.81[cd]
		Room temperature	13.71	15.65[ab]	15.85[b]
	Semi-underground	Room temperature	13.71	14.88[b]	12.21[d]
Superior	Common	4	14.85[a]	15.06[b]	15.55[bc]
		Room temperature	14.85	15.35[b]	15.55[bc]
	Semi-underground	Room temperature	14.85	15.81[ab]	13.09[d]

[1)]All values are mean (n=3). Means with different superscript letters ([a–d]) in the same column are significantly different ($p<0.05$) by Duncan's multiple range test.
[2)]Cave type on 260 m altitude without cooling system.

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the dry weight of all three varieties increased after one month but decreased after two months of storage in the semiunderground warehouse. The dry weight of *Atlantic* and *Chubaek* stored at 4℃ in the improved warehouse returned to the harvest levels, while that of *Superior* stayed at the one-month mark. The dry weight of potatoes stored at room temperature in the improved warehouse stayed at the one-month level for all three varieties, increasing only for *Atlantic*. During storage, the dry weight of *Atlantic* and *Superior* was reported to remain stable at their harvest values of 21% and 18%, respectively (Choi et al., 1999), while the respective moisture contents were reported to remain stable at 79.7% and 82.0% during storage at 77%-78% (Youn et al., 1999). Herein, the dry weights at harvest and during storage were significantly lower than those reported previously, possibly because the monsoon rains during the 2022 harvest period resulted in a soil moisture content significantly higher than that reported by Wenzel (2020). Tuber weight loss during storage is caused by transpiration and the consumption of respiratory substrates, with moisture loss being the primary factor (Butchbaker et al., 1973; Hol, 2018). This study also suggests that moisture loss during storage probably induced an increase in dry weight.

Starch content is one of the most important factors used to classify potatoes into those intended for general consumption and processing. By observing starch accumulation in potatoes through the iodine reaction, we revealed that *Chubaek* had a lower starch content even immediately after the reaction (Fig. 4). Once the surface of the cut tuber dried after the iodine reaction, we determined that starch content followed the order of *Atlantic* 〉 *Superior* 〉 *Chubaek*, which agreed with the results of Kwon et al. (2005). Starch granules observed within the tuber cells by optical microscopy had various sizes (diameter within 50 μm) and were present in different numbers across all three varieties (Fig. 2). The starch content of variable-size potatoes is typically reported in relative form (calculated based on specific gravity) to facilitate comparison. Herein, the initial specific gravities (1.066 for *Atlantic*, 1.052 for *Chubaek*, and 1.061 for *Superior*) were lower than those previously reported for *Atlantic* (1.076) and *Superior* (1.067) and those observed for the harvest of 2021 (Table 6). These results were ascribed to the late growth period and the 2022 harvest coinciding with the monsoon season, which resulted in excessive soil moisture and, hence, increased tuber water content and decreased starch content. Furthermore, this trend was consistent with the previously reported decreases in (i) starch content upon an irrigation increase to 1.2 times the standard amount (Wenzel, 2020) and (ii) specific gravity and, hence, processing yield, upon an increase in irrigation amount (Taylor, 2019). During room temperature storage in the improved and semiunderground warehouses, the specific gravities of all three varieties remained similar to the corresponding at-harvest levels. However, an increase in specific gravity was observed after one month of cold storage in the improved warehouse. This behavior was ascribed to the fact that the operation of the refrigeration system promotes periodic air circulation, enhancing transpiration and consequently resulting in a moisture loss higher than that observed for room temperature storage, despite the inhibitory effect of low temperatures on respiration.

4. Conclusions

This study investigated the yields and specific

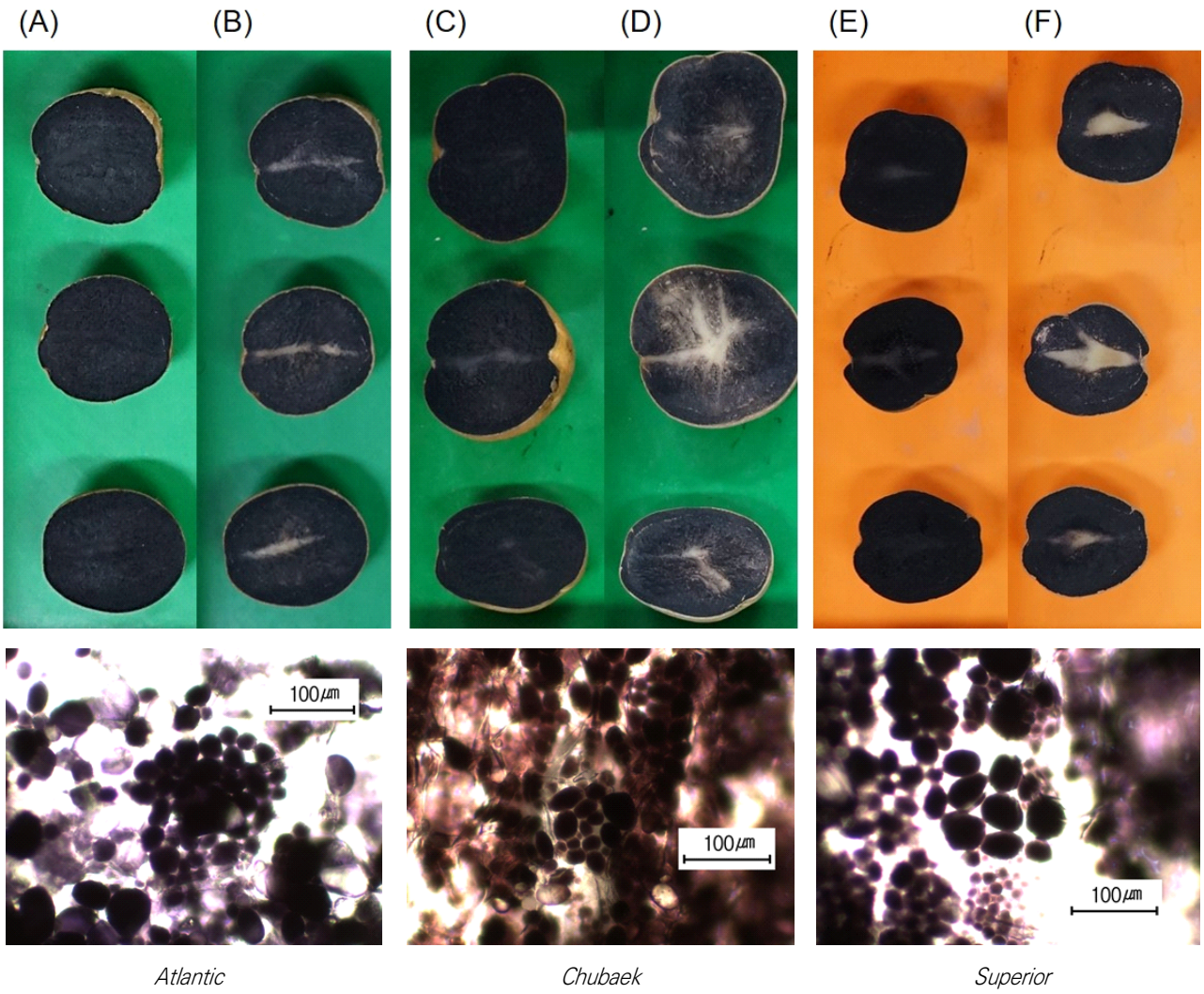

Fig. 4. Tuber appearances (upper) and starch granules (lower) after reaction with iodine solution of potatoes *Atlantic* (A, B), *Chubaek* (C, D), and *Superior* (E, F) varieties cultivated for 100 days in Spring 2022. The cutting surface after wiping of reacting solution (A, C, E) and after complete drying (B, D, F).

gravities of spring potatoes (*Atlantic*, *Superior*, and *Chubaek* varieties) cultivated for 80, 90, and 100 days and examined the effects of cold (4℃) and room temperature storage in improved and semiunderground warehouses on the selected quality parameters of potatoes harvested after 100 days of cultivation. Peak productivity was reached after 90 days of cultivation for *Chubaek* and at 100 days for *Atlantic* and *Superior*. For all three varieties, cold storage resulted in weight losses of 〈5.3%. However, for *Superior* and *Chubaek*, room-temperature storage for two months resulted in weight losses of 7.3% and 10.9%, respectively, thus causing marketability losses. During the first month of cold storage, no sprouting occurred in any variety, whereas room temperature storage caused sprouting (in ~13%, 〉75%, and 〉99% of *Atlantic*, *Superior*, and *Chubaek* tubers, respectively) and, hence, marketability loss. After two months of room temperature storage in the improved warehouse,

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Table 6. Specific gravity of fresh potatoes grown in spring, including *Atlantic*, *Chubaek*, and *Superior* varieties, during storage according to types of traditional warehouses for potatoes in 2022

Variety	Warehouse	Temperature (℃)	Storage period (month)		
			At harvest	1	2
Atlantic	Common	4	1.066[a1)]	1.072[a]	1.072[a]
		Room temperature		1.065[b]	1.064[bc]
	Semi-underground[2)]	Room temperature		1.067[bc]	1.069[ab]
Chubaek	Common	4	1.052[b]	1.060[cd]	1.060[cd]
		Room temperature		1.054[ef]	1.054[e]
	Semi-underground	Room temperature		1.049[f]	1.052[e]
Superior	Common	4	1.061[a]	1.064[bc]	1.066[b]
		Room temperature		1.058[de]	1.059[d]
	Semi-underground	Room temperature		1.058[de]	1.059[d]

[1)]All values are mean (n=3). Means with different superscript letters ([a–d]) in the same column are significantly different ($p<0.05$) by Duncan's multiple range test.
[2)]Cave type on 260 m altitude without cooling system.

disease incidence was low in all three varieties, and no disease incidence was observed during cold or semiunderground storage. The at-harvest dry weights of all varieties were below 16%, and *Atlantic* exhibited the highest specific gravity (1.066). Notably, the dry weights and specific gravities were lower than those observed previously. No significant changes in dry weight and specific gravity were noted during storage. During cold storage, the marketabilities of *Atlantic*, *Superior*, and *Chubaek* were maintained for 〉2, ~2, and 〈2 months, respectively. During room temperature storage, *Atlantic* retained its quality for about a month, whereas *Superior* and *Chubaek* lasted less than a month. All three varieties demonstrated early sprouting, lower dry weight and specific gravity, and a shortened marketability period. For all varieties, especially for *Chubaek*, the storability period was significantly lower than the dormancy period. This behavior was ascribed to the overlap of the monsoon season with the late growth and harvest periods, leading to insufficient sunlight and excessive soil moisture, which degraded tuber maturity and quality, accelerated sprouting, and significantly decreased storability.

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Conflict of interests

The authors declare no potential conflicts of interest.

Author contributions

Conceptualization: Han K. Formal analysis: Won HS, Han K. Validation: Lee YH. Writing - original draft: Won HS. Writing - review & editing: Lee YH.

Ethics approval

This article does not require IRB/IACUC approval

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ORCID
Heon-Seop Won (First author)
https://orcid.org/0009-0000-6103-1001
Kyusuk Han (First author)
https://orcid.org/0000-0001-8760-957X
Young Hun Lee (Corresponding author)
https://orcid.org/0000-0002-7718-8887

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