BUL 1099

Storage Management of Rainier Russet Potatoes

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Introduction

RAINIER RUSSET IS A MULTIPURPOSE, medium-to-late maturing potato variety released in 2020 by the Northwest Potato Variety Development Program. It produces attractive blocky tubers with a heavy russeted skin and creamy white flesh. Total yields are slightly less than Russet Burbank and Ranger Russet; however, marketable yields are greater than both Russet Burbank and Ranger Russet with a higher percentage of tubers above 10 ounces in size. Rainier Russet tubers have specific gravities ideal for processing, similar to Ranger Russet. Unlike Russet Burbank and Ranger Russet, Rainier Russet has been shown to be less susceptible to sugar ends, environmental stress, and problematic potato diseases, including common scab, foliar early blight, and dry rot. It is more susceptible to cold-induced sweetening and blackspot bruising. Rainier Russet nitrogen requirements are approximately 5%–10% less than Russet Burbank (Blauer et al. 2024).

Growing and managing new varieties in the field and storage and for processing can be daunting—a risk that many growers may not want to take, given the thin margins often associated with agriculture. To help increase grower confidence and knowledge, this study was undertaken to provide some basic direction on how to manage Rainier Russet in storage and what to consider during processing.

About This Study

Rainier Russet and Russet Burbank seed potatoes were planted at the University of Idaho Kimberly Research and Extension Center in 2020–22. Following harvest, potatoes were placed in storage and allowed to cure at 55°F and 95% relative humidity for approximately two weeks. The temperature was then decreased at a rate of 0.5°F per day to holding temperatures of 42°F, 45°F, and 48°F. The potatoes were subsequently stored for nine months at these temperatures.

Potatoes used in analyses of fry color, mottling, sugar content, disease susceptibility, and weight loss were treated with a thermal aerosol application of chlorpropham (CIPC) at 22 ppm approximately sixty days after harvest. Potatoes used in assessing dormancy length were not treated with a sprout inhibitor.

Sugar and Fry Color

Glucose, sucrose, and fry-color data were collected each month in storage from three replications of ten tubers per variety and storage temperature. Glucose and sucrose concentrations were determined using a YSI model 2700 Biochemistry Analyzer in 2020 and a YSI model 2900 Biochemistry Analyzer in 2021 and 2022 and expressed on a percentage fresh-weight basis. Fry color analysis was performed concurrently with sugar extraction using the same tubers. Fry color was determined for ten fry planks (1.2 inches x 0.3 inches) per sample after cooking the planks in canola oil at 375ºF for 3.5 minutes. Percent reflectance was read with a Photovolt Reflectometer Model 577 on the stem and bud ends of each plank. The planks were also scored subjectively for mottling and incidence of sugar ends. Mottling is defined as thin, thread-like areas of dark coloration found in the cortex of the fried potato tissue. Each fry plank was subjectively evaluated for mottling on a scale of 1–4, where 1 = no mottling, 2 = mild, 3 = moderate, and 4 = severe mottling and either the presence or absence of sugar ends.

Reflectance readings are presented together with corresponding United States Department of Agriculture (USDA) fry-color standards. The USDA colors correspond to the reflectance ranges:

- USDA 1 >44% reflectance
- USDA 2 = 35%–44% reflectance
- USDA 3 = 26%–34.9% reflectance
- USDA 4 <25.9% reflectance
- Higher reflectance readings indicate a lighter fry color. Fry colors higher than a USDA 2 are typically deemed unacceptable by the frozen processing industry.

Fusarium Dry Rot

To evaluate Fusarium dry rot infection, potatoes were first bruised and then inoculated with *Fusarium sambucinum* (50/50 mixture of thiabendazole sensitive to resistant). Following inoculation, potatoes were cured at 55ºF and 95% relative humidity for approximately two weeks and then stored at 45ºF. After approximately three months in storage, tubers were evaluated for the percentage of dry rot decay and the incidence of the disease, expressed as the percentage of tubers evaluated having more than 5% decay.

Weight Loss

Samples, averaging 10 pounds per sample, replicated three times, of Rainier Russet and Russet Burbank were weighed monthly and the weight loss results averaged over three storage seasons (2020–22).

Bruise

To assess bruise susceptibility, tubers were impacted soon after harvest using a device that dropped a 100-gram steel weight from a 7-inch (2020–22) or 12-inch height (2021 and 2022) to deliver a uniform impact on both the bud and stem ends of a stationary tuber. Pulp temperatures of tubers were 55°F at the time of impact and held for twenty-four hours at 70°F until impacted areas were peeled and evaluated for blackspot bruise severity, bruise depth, incidence of blackspot bruise, and incidence of shatter bruise. Blackspot bruise severity was rated on the darkest color observed on a scale from 1 to 4: 1= no color; 2 = light gray color, not severe but discoloration occurred; 3 = dark gray color, severity is moderate, dark but not extreme; and 4 = dark gray/black color, extreme severity. Blackspot bruise depth was evaluated by recording the number of slices (1.27 mm per slice) removed by the peeler until no bruise was present.

Dormancy

Dormancy was defined as the number of days after harvest until sprout elongation (at least 0.2 inches) occurred in 80% of tubers in the sample. This definition was used because the length of time between initial sprout development (peeping) and

sprout elongation varies greatly among potato varieties. Ten tubers (replicated three times) that had not been treated with a sprout inhibitor were assessed on a 1–4 scale, where 1 = no sprout, 2 = peeping, 3 = pointed (<0.2 inches), and 4 = sprouted (>0.2 inches). Each variety was evaluated each month at two storage temperatures (45°F and 48°F) for sprout growth until the tubers reached 80% sprouted.

Results

Glucose

Potatoes intended for frozen or dehydration processing must meet specific color criteria, often set by the customer. Elevated concentrations of the reducing sugar glucose can produce an unacceptably dark fried product when exposed to the high temperatures required for producing frozen fried product or dehydrated potato flakes. Potato varieties that maintain glucose concentrations below 0.1% fresh weight (FW) at colder temperatures throughout storage and processing are often considered to be cold-sweetening resistant and usually produce a light-colored final product acceptable to consumers. Sucrose, which is converted into reducing sugars through physiological processes, is monitored throughout the storage season to aid in predicting increases in glucose and subsequent color shifts for the finished product; it may also provide insight into the maturity of the crop for that year.

Mean glucose concentrations at harvest (ten days after harvest for 2021 and 2022 and thirty days after harvest for 2020) for Rainier Russet were 0.03% FW in all three years. These concentrations were significantly lower than Russet Burbank, whose three-year average glucose concentration was 0.04% (Figure 1A). Glucose concentrations in Rainier Russet increased during storage, reaching maximum values around 135 days after harvest at all three temperatures. At 42ºF, glucose values during 2020 were variable while glucose values during 2021 and 2022 followed a similar trend to Russet Burbank, albeit with a lower glucose concentration (Figure 1A). Lower glucose concentrations in processing potatoes are desirable throughout the storage term due to the relationship with light-colored French fries.

Figure 1 shows data collected monthly from tubers stored at 42ºF, 45ºF, and 48ºF during 270 days in storage. Rainier Russet data is shown by year, Russet Burbank as a three-year mean. **Image A**, Mean tuber glucose concentrations in units of percent fresh weight (% FW) for Rainier Russet and Russet Burbank. The red reference line indicates 0.1% glucose. Varieties that maintain glucose concentrations below this level are generally considered to be cold-sweetening resistant. **B**, Mean tuber sucrose concentrations (% FW). **C**, Stem-end reflectance values represent the color of fry planks, with higher numbers representing lighter-colored fries. Red lines indicate USDA color standards with USDA 1 > 44% reflectance, USDA 2 = 35%– 44% reflectance, and USDA 3 = 26%–34.9% reflectance. **D**, Subjective mottling score: thin, thread-like areas of dark coloration found in the cortex of the fried potato tissue called mottling were scored subjectively on a 1–4 scale, with 1 being none and 4 severe. **E**, Sugar ends were either present in the fry plank or not.

- At 48ºF storage temperature, average glucose concentrations for Rainier Russet reached a maximum of 0.05% FW over the course of 270 days in storage and across three years of trials. Russet Burbank had an average maximum glucose concentration of 0.07% FW after approximately 119 days after harvest, across three years of trials (Figure 1A).
- At 45ºF, glucose concentrations remained below 0.08% FW during the nine-month storage season across the three years of testing for Rainier Russet. Glucose concentration was similar to Russet Burbank, however Russet Burbank reached a maximum of 0.1% FW after approximately 119 days after harvest.
- At 42ºF, average glucose concentrations for Rainier Russet remained below 0.18% FW during the three storage years. Although the trend was similar throughout the storage season, average glucose concentrations for Rainier Russet were lower than those of Russet Burbank. Based on the data, neither Rainier Russet nor Russet Burbank are considered cold-sweetening resistant and would benefit from being stored at temperatures between 45ºF and 48ºF.

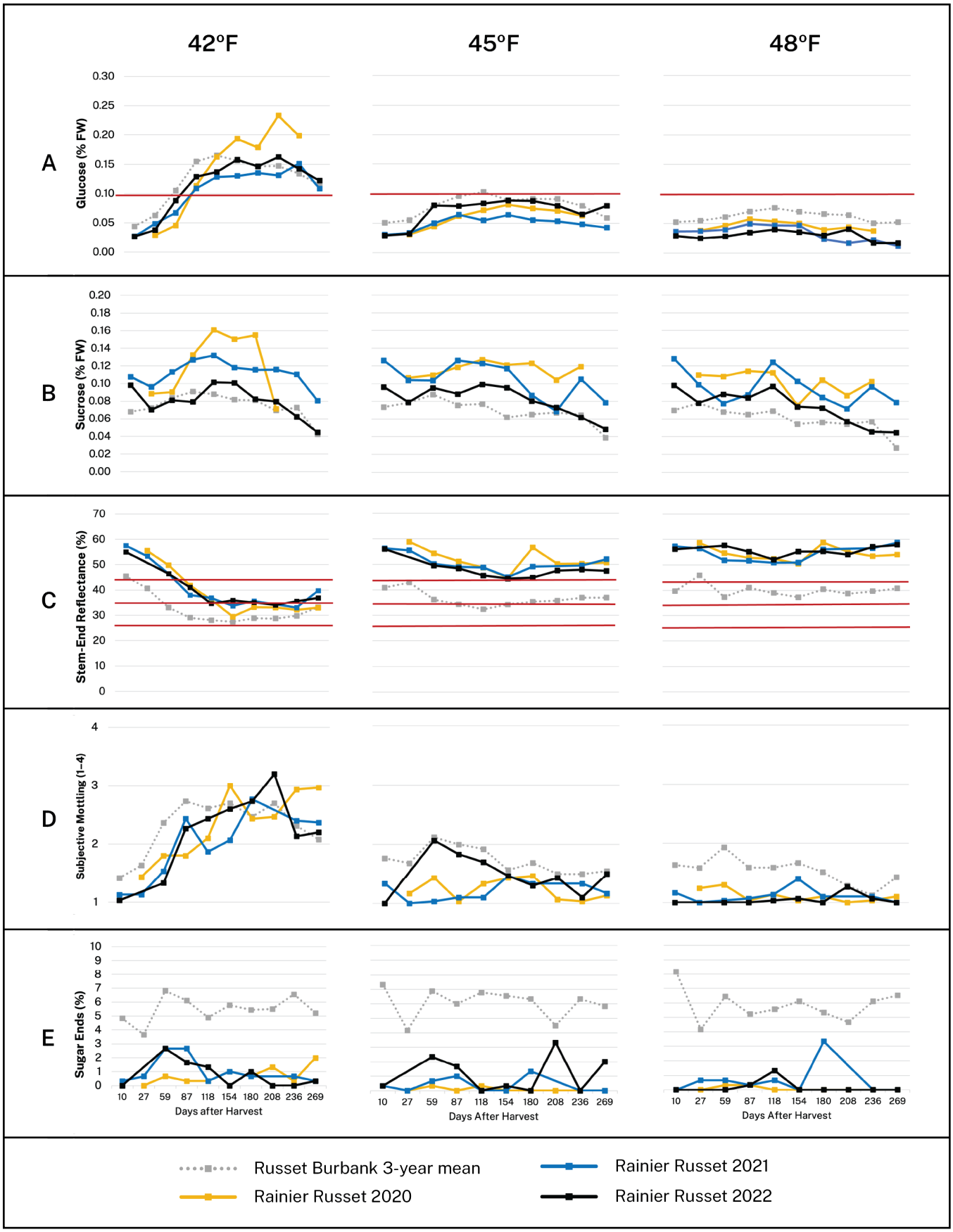
42°F
45°F
48°F
A
Glucose (% FW)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
B
Sucrose (% FW)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
C
Stem-End Reflectance (%)
70
60
50
40
30
20
10
0
D
Subjective Mottling (1–4)
4
3
2
1
E
Sugar Ends (%)
10
9
8
7
6
5
4
3
2
1
0
10 27 59 87 118 154 180 208 236 269
Days after Harvest
Days After Harvest
Russet Burbank 3-year mean
Rainier Russet 2020
Rainier Russet 2021
Rainier Russet 2022

Figure 1

Sucrose

Sucrose concentrations for Rainier Russet at harvest (ten days after harvest for 2021 and 2022 and thirty days after harvest for 2020) showed little variability between years with concentrations of 0.8%, 1.0%, and 0.7% for 2020, 2021, and 2022, respectively. Sucrose decreased over the course of the storage season at all temperatures, although regardless of temperature, potatoes experience an increase in sucrose during the first hundred days after harvest. Sucrose concentrations for 2020 appeared to have greater variability than 2021 and 2022 (Figure 1B). Mean sucrose concentrations for Rainier Russet were significantly greater than sucrose concentrations for Russet Burbank during 2020 and 2021, but similar to the three-year average for Russet Burbank during 2022.

Fry Color

Glucose concentrations are typically a good indicator of fry color because higher glucose concentration often results in darker fry color. The processing industry generally uses samples of fried product in the form of planks, strips, or discs instead of measuring tuber glucose concentrations due to the increased time, cost, and equipment associated with sugar testing. Variations in fry color in a potato are generally most noticeable between the stem and bud ends of the tuber. The stem end (end closest to the plant where the stolon attaches) often has the highest levels of sugars and the darkest color which may be exacerbated by storage temperature.

Stem-end reflectance values for Rainier Russet were higher, indicating a lighter fry color, than Russet Burbank at 42ºF, 45ºF, and 48ºF across all three years of the study (Figure 1C). Fry colors for Rainier Russet were consistently light compared to Russet Burbank and showed little deviation between years. Both varieties produced French fries that would be classified as USDA 3 at 42ºF later in storage, but acceptable fry color at 45ºF and 48ºF. At 42ºF, Russet Burbank fry color dropped to a USDA 3 by fifty days after harvest while Rainier Russet fry color dropped to a USDA 3 after one hundred days after harvest. At 45ºF, Russet Burbank also produced USDA 3 color after one hundred days in storage while Rainier Russet maintained USDA 1 color for the entirety of the storage season.

- Storage at 48ºF: Fry color for Rainier Russet was significantly lighter in color throughout the storage season than Russet Burbank. The mean fry color was well above the USDA 1–2 metric and lighter than the three-year mean of Russet Burbank, which maintained a USDA 2 except for the second sampling date.
- Storage at 45ºF: Fry color for Rainier Russet was above the USDA 1 metric for the duration of the storage season compared to the three-year mean of Russet Burbank, which showed fry colors of USDA 2s and 3s for the entire storage season.
- Storage at 42ºF: Rainier Russet maintained light fry colors (USDA 1 and 2) until 119 days after harvest, when the color decreased to a USDA 3 and remained until the last sampling date. Despite this, fry color for Rainier Russet was lighter compared to the three-year average for Russet Burbank.

Mottling and Sugar Ends

Similar trends were seen for mottling in Rainier Russet and Russet Burbank, although mottling was less severe in Rainier Russet than Russet Burbank at all three temperatures (Figure 1D). Mottling scores for Rainier Russet and Russet Burbank ranged from none to mild at 45ºF and 48ºF. At 42ºF, both varieties ranged from mild mottling early in storage and increasing to moderate mottling for the remainder of the storage season (Figure 1D). Incidence of sugar ends was significantly lower for Rainier Russet than Russet Burbank at all three temperatures (Figure 1E).

Fusarium Dry Rot

Because Fusarium dry rot is an important storage disease in potatoes, new varieties are screened for susceptibility to this disease. To provide an entry point for the pathogen, potatoes were first bruised and then inoculated with *Fusarium sambucinum* to evaluate dry rot susceptibility. Results averaged over three years indicate that Rainier Russet was less susceptible to Fusarium dry rot decay compared to

Russet Burbank (Table 1). The percentage of tuber decay due to dry rot in Rainier Russet was 13% with a 42% incidence (potatoes with > 5% decay), compared to 36% decay and 71% incidence for Russet Burbank.

Weight Loss

Rainier Russet had weight loss comparable to Russet Burbank at all three temperatures (Table 2).

Bruise Susceptibility

During harvest and handling, potatoes encounter physical impacts that can result in a blackspot or shatter bruise. Variety susceptibility to two levels of impact (7- and 12-inch drop height of a known weight) was assessed (Table 3). The incidence of blackspot bruise and severity and depth of the blackspot bruise was higher in Rainier Russet compared to Russet Burbank. Rainier Russet and Russet Burbank had comparable levels of shatter bruise at both drop heights. Rainier Russet showed a higher incidence of blackspot bruise on the stem end compared to the bud end at both drop heights, which is common among most varieties (data not shown).

Dormancy

Without sprout inhibitors, dormancy length for Rainier Russet was 20–30 days longer than Russet Burbank (Table 4).

Storage Recommendations for Rainier Russet

Harvest Handling Conditions

Although Rainier Russet tends to be less susceptible to Fusarium dry rot than Russet Burbank, it bruises more easily. Additional bruises may result in higher incidence of Fusarium dry rot. It is advisable to minimize tuber drops and impacts to lower the incidence of dry rot entering the storage.

Storage Conditions

Curing

Curing begins when the crop is harvested and put into storage. This study showed that curing at 55ºF and 95% relative humidity for fourteen days were adequate conditions for wound healing. If the crop is

Table 1. Percent decay (severity) and incidence of potatoes with greater than 5% decay of Fusarium dry rot in bruised and inoculated Rainier Russet and Russet Burbank potatoes.

Cultivar	% Decay	% Incidence (Potatoes with >5% Decay)
Rainier Russet	13 a	42 a
Russet Burbank	36 b	71 b

Values are means of three storage seasons (2020–22). Values followed by the same letter were not significantly different ($\alpha < 0.05$) within a column.

Table 2. Percent weight loss of Rainier Russet and Russet Burbank tubers after 270 days in storage, averaged across three years (2020, 2021, 2022).

Variety	42ºF	45ºF	48ºF
Rainier Russet	8.7 a[1]	8.3 a	9.2 a
Russet Burbank	6.0 a	7.5 a	7.2 a

[1] Values followed by the same letter are not significantly different.

Table 3. Effects of drop height on blackspot bruise incidence, severity, depth, and shatter bruise incidence for tubers impacted at **7-inch drop height** (2020–22) and **12-inch drop height** (2021 and 2022) of Rainier Russet and Russet Burbank.

Cultivar	Blackspot Bruise Incidence (%)	Blackspot Bruise Severity Rating (1–4)[1]	Blackspot Bruise Depth (mm)	Shatter Bruise Incidence (%)
7-inch drop height				
Rainier Russet	73 b	2.3 b	3.8 b	4 a
Russet Burbank	46 a	1.7 a	2.2 a	5 a
12-inch drop height				
Rainier Russet	91 b	2.8 b	5.2 b	23 a
Russet Burbank	67 a	1.9 a	3.2 a	25 a

Values followed by the same letter were not significantly different ($\alpha < 0.05$) for each drop height within a column.

[1] Blackspot bruise severity was rated on the darkest color observed on a scale from 1 to 4: 1 = no color; 2 = light gray color, not severe but discoloration occurred; 3 = dark gray color, severity is moderate, dark but not extreme; and 4 = dark gray/black color, extreme severity.

Table 4. Mean dormancy length in days after harvest (DAH) across three years (2020–22) of Rainier Russet and Russet Burbank tubers at two storage temperatures.

Variety	45ºF	48ºF
Russet Burbank	195 DAH	185 DAH
Rainier Russet	230 DAH	210 DAH

harvested above 55ºF, include this time in storage as curing and reduce the amount of time at curing temperatures. Maintain 95% relative humidity throughout storage regardless of storage temperature.

Frozen Processing

Holding tubers at 45ºF–48ºF provides acceptable French fry color and minimizes mottling. Mottling was similar to Russet Burbank with more mottling seen at 42ºF than at 45ºF and 48ºF. Compared to Russet Burbank, Rainier Russet displayed fewer sugar ends.

Fresh Market

Hold tubers at 42ºF–48ºF. Lower temperatures could be used although they were not assessed in this study.

Dehydration Processing

Hold at 42ºF–48ºF.

Sprout Inhibition

Rainier Russet displays a longer dormancy than Russet Burbank by approximately thirty days. Apply CIPC before dormancy break but after curing.

- **42ºF**: Apply CIPC between 2 and 15 weeks after harvest
- **45ºF**: Apply CIPC between 2 and 13 weeks after harvest
- **48ºF**: Apply CIPC between 2 and 12 week after harvest

Storage Duration

Quality persists throughout at least nine months after harvest.

Further Reading

Blauer, J. M., V. Sathuvalli, B. A. Charlton, S. Yilma, C. C. Shock, N. Baley, R. Qin, E. Feibert, R. G. Novy, J. L. Whitworth, M. J. Pavek, N. R. Knowles, L. O. Knowles, N. Fuller, J. C. Stark, R. R. Spear, M. K. Thornton, N. Olsen, S. Jayanty, D. A. Navarre, M. J. Feldman, and I. Vales. 2024. "Rainier Russet: A Dual Use Russet Potato with Long Tuber Dormancy, Excellent Process Quality, and High Early Harvest Packaging Efficiency." *American Journal of Potato Research* 101: 17–33. https://doi.org/10.1007/s12230-023-09935-1.

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