University of Idaho
College of Agriculture
Cooperative Extension Service
Agricultural Experiment Station

Current Information Series No. 488
August 1979

Translucent-End of Potatoes

G. E. Kleinkopf

Translucent-end, also called sugar end or jelly end, is a serious physiological breakdown of the potato tuber, found mostly in tubers grown in areas of southwestern Idaho. Affected tubers are usually irregularly shaped with pointed stem ends. Affected potato tissue is low in starch content, has a translucent or "glassy" appearance and has become soft and spongy. Quality analyses of the tuber tissue shows high sugars and low solids. During storage the translucent tissue may decay, forming jelly-end rot.

Although translucent-end occurs to some extent in all years, it was particularly severe in 1961, 1967, 1976 and 1977. Potato growers and processors have lost several million dollars because of translucent-end and the problems associated with blending, processing and quality loss.

Available information suggests that translucent-end in potatoes results from stress placed on the growing crop some time during the season. This stress can be caused by moisture deficiencies, high temperatures

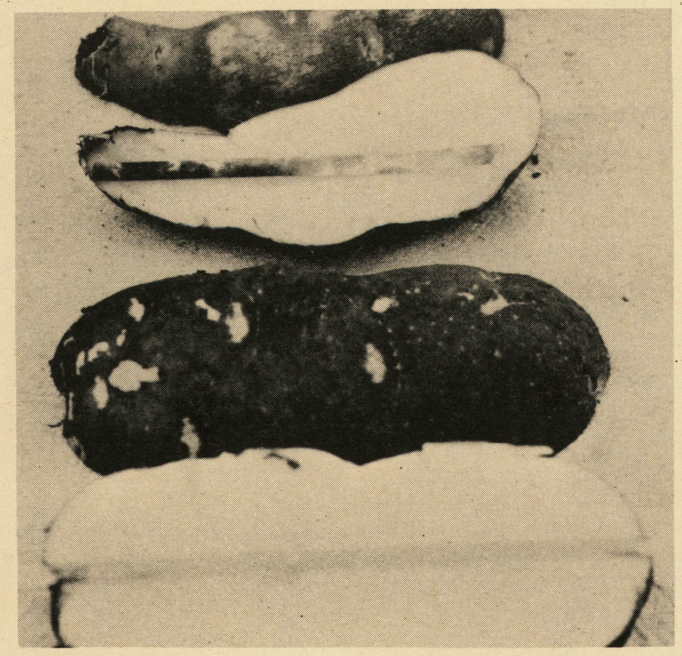

Fig. 1. Normal vs. translucent-end tuber. Tape placed on cut surface of normal tuber shows no sugar. Tape on translucent-end tuber shows high sugar which will fry dark and yield a low grade french fry.

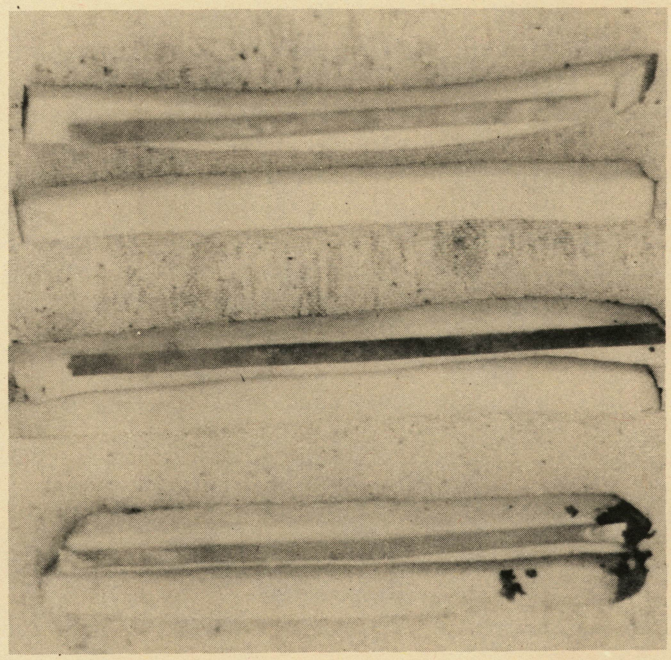

Fig. 2. French fry strips cut from normal and translucent-end tubers. Center fry shows high sugar from translucent-end tuber.

and excess fertilization. Stress during the wrong time of the season may cause translucent-end formation. This publication discusses some reasons why this problem occurs and some ways that potato growers can prevent or reduce it.

Physiology of Translucent-End Formation

Three physiological processes provide for much of the normal growth and development of the potato plant (Table 1). Reaction 1 is *photosynthesis* where carbon dioxide in the atmosphere is converted to sugars and starch which are stored in the leaves and stems. This is the only synthetic reaction available to green plants for the storage of energy and it is this reaction which provides the dry matter for tuber bulking. In the second reaction, *respiration*, some of the sugars and starch are converted back to carbon dioxide, releasing the stored energy for growth and development of the plant. The third reaction is *translocation*, where the excess sugars and starch from the leaves are translocated to the tubers or the storage organs of the plant.

Periods of stress for low moisture decrease the conversion of carbon dioxide to sugars in photosynthesis. High temperatures also decrease this photosynthetic reaction, thereby reducing the overall amount of stored product available for respiration and for translocation into the storage tubers. However, as temperatures increase, the respiratory activity increases.

Under normal conditions 10 to 30% of the products from photosynthesis are used in respiration. As long as photosynthesis input exceeds the respiratory requirement of the plant, sugars are available for translocation to the tubers, thereby increasing the tuber size. If the photosynthetic rate is less than the respiratory requirement, then sugars and starches stored in the storage areas of the plant will be used in respiration. When these conditions occur, tuber bulking ceases and translucent-ends may be formed.

Table 1. Physiological reactions occurring in the plant.

Photosynthesis	
1. Carbon dioxide in the atmosphere	sugars, starch stored in the leaf
Respiration	
2. Sugars, starch, from the leaf	Carbon dioxide and energy for growth
Translocation	
3. Excess sugars and starch	Starch stored in the tubers

Factors that contribute to translucent-end formation in the field include temperature, moisture and soil type and nitrogen.

Temperature

The effects of temperature on the photosynthetic rate are shown in Table 2. As temperature increases from 60 to 80°F, photosynthesis exceeds the respiratory requirement and the growth rate is maximum. As the temperature continues to increase, the net photosynthetic rate declines and the respiratory need for sugars and starch to provide energy increases. At 96°F, the respiratory requirement equals the photosynthetic input. If air temperatures increase above 96°F, the respiratory requirement may become greater than the photosynthetic input and the sugars and starch required for respiration must then be obtained from the storage organs — the stems and tubers. Starches that have been deposited in the tuber may be translocated to the sites of respiration. This re-translocation process results in a decreased starch content in the stem end of the potato tuber or translucent-end. The synthesis of starch may also be impaired by the high temperature. The longer the high temperatures remain, the higher the percentage of affected tubers.

High temperature stress is very detrimental to plant growth. Temperature stress in combination with moisture stress can be the mechanism triggering formation of translucent-end. High temperature and low moisture combinations are probably the most severe environmental conditions causing decreased growth, resulting in stress conditions in the plant.

Moisture and Soil Type

Moisture, or more importantly, the lack of moisture, is probably the most important single factor contributing to translucent-end. Moisture stress prevents optimum growth rate and prevents tuber bulking in adequate amounts. The result is decreased yields and lowered quality with many malformed tubers.

Some soil types have been implicated in the translucent-end problem. Heavy soils may cause the formation of translucent-end tubers because they have very low water infiltration rates. This low rate of soil water

Table 2. Effect of increasing air temperatures on the photosynthetic rate of potatoes.*

Temp °F	50	59	68	77	86	96
Net carbon fixed (relative rates)	120	150	150	100	7	0

*Data from Burton 1975.

movement can lead to moisture deficiency or moisture stress conditions in the plant, especially during periods of high temperatures when more water is required. Translucent-end also develops in sandy soils. The primary problem with sandy soils is their lack of water holding capacity. The formation of translucent-end in potatoes growing in sandy soils is a result of moisture stress during periods of high temperature since the soil may not maintain a critical supply of water for the plant.

Nitrogen

Nitrogen has been implicated in causing translucent-end. High nitrogen fertilization increases growth rates in the plant. This requires adequate soil moisture, normal temperatures and proper levels of other nutrients. If the plant is not able to maintain a high growth rate due to high temperature and low moisture, the plant becomes stressed and translucent-end formation may result.

Research Results

Recent research provides supporting evidence for stress-related causes of translucent-end formation.

Table 3 shows the percent solids and reducing sugars resulting from 4 different moisture treatments in the field. At Moisture Level 1, soil moisture was allowed to deplete to 25% available moisture and held at that point throughout the season. At Moisture Level 2, available soil moisture was allowed to decrease to 25% early in the growing season and was maintained at 65% available moisture or above for the remainder of the season. Moisture Level 3 had the stress late in the season, but adequate moisture early, i.e., 65% of available moisture early in the season, 25% available moisture late. Moisture Level 4 was maintained as a control, with adequate moisture available for the entire season.

Table 3. Preharvest quality of Russet Burbank potato tubers.*

Treatment	% reducing sugar	% total solids
Soil moisture percentage (Early-Late)		
25-25 (stressed all season)	0.42	19.9
25-65 (early stress)	0.40	20.2
65-25 (late stress)	0.34	20.0
65-65 (adequate moisture)	0.36	20.4
Nitrogen applied (lb/acre)		
60 lb. below recommendations	0.38	20.6
U of I recommendation	0.40	20.5
120 lb. above	0.41	20.4
240 lb. above	0.43	20.0

*Data from Painter et al. (1975).

Percent solids content of tubers from the stress treatments were lower than from the control treatment. Percent reducing sugars increased with early stress. Adequate moisture conditions throughout the growing season produced the lowest sugar content or better quality tubers. These data indicate that less than 65% available moisture during the early part of the growing season is responsible for quality deterioration such as high reducing sugars and lower solids, factors associated with translucent-end.

Table 3 shows the effect of nitrogen fertilization on percent total solids and percent reducing sugars when adequate moisture was maintained all season. High levels of nitrogen fertilization — 120 and 240 pounds N above the recommended amount — decreased the percent solids and increased the amount of reducing sugar. Both of these factors are associated with translucent-end and inferior quality tubers.

These results show that adequate moisture availability throughout the season, and particularly during periods of high temperature, is extremely important in reducing the incidence of translucent-end. Applications of nitrogen higher than the fertilizer recommendations have also reduced yields and quality. Most evidence indicates that brief moisture and temperature stress occurring early in the season before the tubers are about 1 inch in diameter apparently have little physiological effect on the tuber. However, if the tubers have reached about 1 inch in diameter when environmental stress conditions occur, then translucent-end is more likely.

Not all varieties of potatoes are as prone to translucent-end as the Russet Burbank. Environmental conditions which cause translucent-ends appear to have a more detrimental effect on the elongated tuber shapes. Varieties that have a more round or blocky shape apparently are not as prone to translucent-end. Several varieties and advanced lines from the Aberdeen breeding program — Butte, A66107-51, A68678-1 — show some resistance to translucent-end.

In 1977, Russet Burbank and Butte were compared in plots at the Southwest Idaho Research and Extension Center. The Butte variety was more resistant to translucent-end than Russet Burbank under water stress conditions (Table 4). Butte graded out higher U. S. No. 1 (higher quality) but also seemed to have more sensitivity to water stress as shown by the 31% yield reduction in the moisture stress treatments.

In a field test at Parma in 1978, Butte and 2 new lines showed more resistance than Russet Burbank to conto conditions favoring translucent-end formation. Higher quality tubers were produced by Butte,

Table 4. Effect of temperature and water stress on potato quality.

Variety	Treat- ment*	Yield cwt/ acre	% yield loss **	% trans- lucent- end	% US No. 1
Russet	1	532	0	30.4	24
	2	495		18.0	36
Butte	1	401		0	71
	2	579	31	0	74

*Treatment 1—Soil moisture reduced to 40% available during early tuber growth.

2—Soil moisture maintained at 65% available.

**% yield loss is the yield reduction of the dry (no. 1) compared to wet (no. 2) treatment.

A66107-51 and A68678-1. Though percent solids were high in all varieties, the number of translucent-end and malformed tubers was greatest for Russet Burbank. Average fry color (a measure of total sugar content of the fry strips) was somewhat elevated in Butte and A66107-51, but adjustments for higher sugars at the processing plants could still provide high quality products. A68678-1 was the best producer in terms of quality. The low numbers of translucent-end tubers, low sugars coupled with high solids indicate that the use of A68678-1 may significantly reduce translucent-end losses.

Recommendations

1. To reduce the incidence of translucent-end, moisture must be maintained above 50% available throughout the season. High temperature conditions do occur, but are beyond our control. However, maintaining adequate moisture through proper application of irrigation can reduce the incidence of translucent-end even under high temperature conditions.
2. Follow the University of Idaho nitrogen fertilization guide for potatoes. The quality of the tubers can be increased by avoiding excess nitrogen applications.
3. In areas where translucent-end is a major problem, significant increases in yield and quality can be realized with a new variety such as Butte. A good variety resistant to translucent-end may be the best overall solution to this problem.

Literature Cited

1. Burton, W. G. 1975. Crop processes in controlled environments. Edited by Rees, Cockshaull, Hand and Hurd. Academic Press, London and NY. p. 217.
2. Painter, C. G., D. O. Everson, A. J. Walz, R. R. Romanko, Anderzej Czernik, J. R. Jaeger, W. A. Henninger and C. D. Gross. 1975. Translucent-end potatoes in Southwestern Idaho. Univ. of Idaho Misc. Series No. 24.

The Author — G. E. Kleinkopf is associate research professor of plant pathology at the University of Idaho Research and Extension Center, Kimberly.

Issued in furtherance of cooperative extension work in agriculture and home economics, Acts of May 8 and June 30, 1914, in cooperation with the U. S. Department of Agriculture, James L. Graves, Director of Cooperative Extension Service, University of Idaho, Moscow, Idaho 83843. We offer our programs and facilities to all people without regard to race, creed, color, sex or national origin.

4M 8-79

10 cents per copy