RAW PRODUCT CHARACTERISTICS FOR PROCESSING POTATOES

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Introduction: When speaking of either fresh market or processing potatoes we think in terms of quality. Quality means different things to different people, and what it means depends upon how the potatoes are to be used. The merchant wants a potato with eye-appeal which includes such factors as size, symmetry, color, uniformity and freedom from internal and external blemishes. He also wants a variety with a good quality reputation which comes from an area with a good shipping history. Processors are interested in high yields per acre, high dry matter (except for canning) and low sugar content potatoes that require a minimum of hand trimming. Within the processing group are the "chippers" and "fryers" who must have a potato that fries to a uniform golden-brown color. The color problem is more critical for "chips" than "fries" but, nevertheless, the factors which are important for one are also important for the other.

There has been a tendency for some processors to "cream off" the best tuber types and sell them on the fresh market and then process the rest. It should be recognized that the volume of potatoes needed to meet fresh market needs is becoming a smaller per cent of the production and that this trend is likely to continue. Between 1959 and 1969 the use of fresh potatoes dropped by 12 %, the total use of processed potato products increased by 136%. Of the processed potato products, frozen French fries increased 240%, dehydrated potatoes 50% and chips 70%. The trends from 1956 through 1968 are in Figure 1. The divisions of the Washington crop and the projected amounts are in Figure 2. This could mean that higher yielding and higher dry matter varieties than are currently being grown might prove more profitable to all segments of the processing industry. The yields of some promising selections are in Figure 3.

The quality which a housewife wants in fresh potatoes is similar to that desired in a processed product (and do not forget the housewife - she buys it). Flavor and aroma are difficult to evaluate. People become accustomed to certain flavors and aromas, and deviations therefrom are often unacceptable until a re-education process has taken place.

A good practical indicator for texture of cooked and processed products is available, namely specific gravity measurements which indicate the dry matter content of the potatoes. The higher the specific gravity of the potatoes (high dry matter) the better they are for baking, mashing, chipping, French frying and processing in general. These same potatoes tend to fall apart and slough when boiled or fried. The lower the specific gravity (low dry matter) of the potatoes the better they are for boiling, frying, canning and salads.

The U.S. grading system which scores mechanical injuries and internal discolorations is a good indicator of paring waste. Neither specific gravity nor U.S. grades are completely satisfactory in themselves because a lot of potatoes with a very high specific gravity, but having a large paring waste, may not be as good a buy as a lot of potatoes with a low specific gravity which is subject to very little paring waste. High trimming labor costs can offset the value of potatoes with high dry matter content, and low specific gravity may be offset by low trimming costs as long as the finished product is of high quality. No entirely suitable standard for measuring the suitability of potatoes for highest quality of processed product has been established.

Specific Gravity: Specific gravity is a measure of how much dry matter is present, but it does not differentiate amongst starch, sugar or cellular material. It also indicates how much water must be evaporated in the dehydration process, and how much fat will be absorbed in the frying process. A difference in specific gravity of .005 amounts to an extra pound of chips per 100 pounds of potatoes and 2 1/2 gallons of water per ton. Differences in specific gravity of the tubers among potato varieties is common (Table 1).

Uniform specific gravity among tubers and within tubers is highly desirable. Tubers of greatly different specific gravities require adjustments in the processing procedures. Unfortunately every group of tubers contains a range in specific gravities. This is as true for varieties which are classed as high dry matter as those classed as low dry matter varieties (Table 2). Extreme differences in dry matter exist among tubers growing on the same plant and even among the different parts of the same tuber. There also exists the problem of obtaining a sample which reflects the specific gravity of a given lot of potatoes. Specific gravity samples taken at random from the same field or truck load of potatoes may vary widely.

Mechanical means are available for separating potatoes into specific gravity groups, but they have not been developed sufficiently to meet the capacity requirements of present-day processing plants. Even if they were sufficiently developed, some problems of logistics would result such as double handling of potatoes or simultaneous operation of two processing lines, each set to handle different specific gravity potatoes.

The specific gravity of any given lot of potatoes may vary from week to week, both in the field and in storage. In the field, specific gravity can increase quickly because of photosynthesis. Water absorption by the roots in excess of that needed for transpiration causes specific gravity to decrease. Loss of water by transpiration in excess of that absorbed by the roots causes specific gravity to increase. Specific gravity of potatoes may decrease as a result of respiration if they are left in hot soil, or are stored at warm temperatures. Specific gravity can also increase if water is lost faster than dry matter is oxidized in the tuber respiratory process. In the field all of these processes may be occurring simultaneously and the net outcome is unpredictable unless the net rate of each process is known. Specific gravity approximates the end result.

Tubers of the same specific gravities do not always cook or process the same. There are varietal differences and there are differences within the same variety. Two potatoes may have identical specific gravities but process differently because one had a high specific gravity because of normal growth and photosynthesis, and the other had high specific gravity because of partial dehydration either in the field or in storage. Another complicating factor occurs when potatoes are to be sold fresh and for processing. The fresh market requires that the potatoes meet a minimum maturity regulation, measured by the loss of skin that occurs during harvesting and handling. To set the skins for a July market often involves some kind of vine killing. The results are given for an experiment using rotobeating as the vine killer in 1969. The results for the July harvest are in Figure 4. Leaving the tubers in the ground for 2 weeks after the vines were beaten off and while the skins were setting resulted in an increased yield of about 40 cwt/acre. This is a substantial increase and would certainly be to the grower's advantage. There was, however, a drop of about .007 in specific gravity which would be to the processor's detriment. Excessive quantities of fertilizer reduced the yield and greatly reduced the specific gravity.

No increase in yield resulted from leaving the tubers in the ground for two weeks after the vines were beaten off September 2, but specific gravity was greatly reduced. The reduction in specific gravity due to excess fertilizer is also evident (Figure 5).

When harvest was delayed until mid-October, at which time the vines were dead, no change in yield occurred between October 15 and 27. A minor decrease in specific gravity was evident. As on the previous two harvest dates, increasing the amount of fertilizer decreased the specific gravity (Figure 6).

The maximum yield in July was slightly over 300 cwt/acre and was produced with 625 lbs/acre of fertilizer (Figure 4). In September a maximum of about 750 cwt/acre was produced with 1875 lbs/acre of fertilizer (Figure 5). A maximum yield of about 850 cwt/acre was produced in October with 2500 lbs/acre of fertilizer (Figure 6).

The effect of fertilizer on the specific gravity of Russet Burbank potatoes is shown in a differei way in Figure 7. As fertilizer was increased specific gravity decreased. It was lowest in July, next lowest in October and highest in August and September. The results were different for the Kennebec variety (Figure 8). For Kennebec, the specific gravity was highest in October. The tendency of heavy fertilization to reduce specific gravity, again, is evident.

So far the use of the term specific gravity has been used as a more or less fixed value. A singl determination can be very misleading as illustrated in Table 3. These varieties were planted the sam day, fertilized the same and subjected to the same cultural practices. Still, large differences occurr ed in different parts of the field.

In most of our studies high levels of fertilization have reduced the specific gravity but years of study have failed to demonstrate that high fertility has a detrimental effect on either chip or French fry color.

Tuber size: Small potatoes are good for canning, dehydration and chips for small packages. Large tubers are good for dehydration and French fries. Large tubers (over-sized tubers) are more inclined to have uneven surfaces and hollow heart than smaller ones. Round and oblong varieties tend to have large pith areas, and fry-cuts from the pith are inclined to be limp after frying. Russet Burbank, a long variety, has a small pith which minimizes the limp fry problem and at the same time makes long, premium length French fry cuts. Cultural practices which increase yield usually increase tuber size, thus reducing the problem of small size tubers but increasing the problems associated with oversize tubers. There is no relationship between specific gravity and tuber size.

Tuber type: Standard round potato varieties seldom cause serious grade problems because of tuber type. Russet Burbank, however, is noted for its pointed ends, dumbbell shapes and curved, knobby tubers. If potatoes are to be processed into flakes or granules, tuber type is of little significance, but if the potatoes are to be cut into French fries, irregularly shaped tubers increase the number of slivers which sell at a reduced price. In addition, Russet Burbank tubers develop "sugar end".

At one time it was believed that temperatures below 50° F were primarily responsible for high reducing sugars in potatoes. It is now known that moisture stress within the plant can also cause high reducing sugars. When a tuber undergoes sufficient moisture stress to result in a build-up of reducing sugars something also happens to the enzyme system responsible for converting sugars to starch, because the tubers do not "cure-out" when subjected to reconditioning temperatures for a reasonable length of time and they cause off-colored and off-flavored products.

Moisture stress also causes many malformed tubers. Russet Burbank potatoes have graded out 83% No. 1's at one end of the field and only 45% No. 1's 384 feet further down the row.

Paring waste: Yield, specific gravity and grade defects must be considered together. Grade defects determine the amount of hand labor required to prepare the potatoes for processing. Processor - grower contracts are negotiated on a grade basis and the factors which affect grade are tuber size, tuber type, growth cracks, hollow heart, green ends and internal discolorations such as heat necrosis, net necrosis, vascular necrosis, black-spots and mechanical injuries.

The use of culls other than for starch: It is commonly believed that potatoes of any size, shape, color or description if unacceptable for the fresh market can be funneled into some form of food processing. Nothing could be further from the truth; though all colors, shapes and sizes of tubers can be dehydrated, poor potato quality of all kinds reduces the appearance, affects the flavor and increases the cost of the processed product.

Table 1. Specific gravity distributions of some reputedly high and low specific gravity potato varieties.

	Specific Gravity[1]															
	35	40	45	50	55	60	65	70	75	80	85	90	95	100	Total Tubers	Sp.Gr. Mean
Variety	Number of Tubers															
No. 1 Burbank	0	0	0	0	2	6	5	37	60	66	37	13	1	1	228	76
No. 2 Burbank	0	0	1	5	12	15	19	50	44	54	20	3	1	0	224	72
Kennebec	0	0	0	2	0	6	10	36	65	28	7	1	0	0	155	72
Katahdin	0	1	0	0	3	6	11	32	66	24	12	1	0	0	156	70
Triumph	0	0	2	9	19	29	24	125	44	4	0	0	0	0	256	66
DeSoto	1	5	7	62	58	96	55	63	18	2	0	0	0	0	367	61
Pontiac	1	10	17	50	57	58	21	25	3	2	0	0	0	0	244	59
Total	2	16	27	128	151	216	145	368	300	180	76	18	2	1	1630	

[1] Coded by omitting 1.0

Table 2. Differences in yield, specific gravity and chip color[1] existing among potato varieties.

Variety	cwt/a	Sp. Gr.	Chip Color
396.55-3	1003	1.082	5.6
A503-42	976	93	6.0
Red Skin	964	79	7.0
Kennebec	895	87	5.8
Golden Chip	889	90	5.0
Russet Burbank	790	96	5.6
Russet Burbank	701	90	6.0

[1]Values of 4, 5 and 6 are acceptable.

Table 3. Variations in specific gravity which result in different parts of the field.

Variety	Blocks 1	2	3	4	5	Mean
1	1.086	1.080	1.080	1.083	1.088	1.083
2	96	85	95	92	91	92
3	85	93	80	93	90	88
4	93	96	84	91	91	91
5	89	86	88	89	88	88
Mean	90	88	85	90	90	

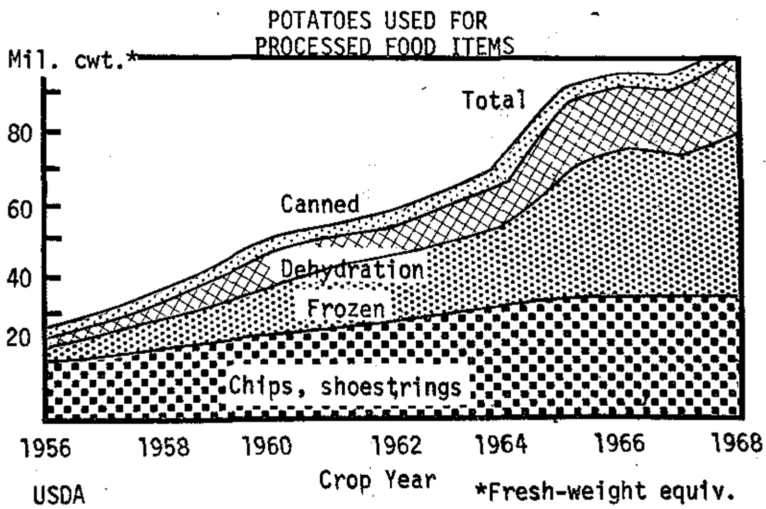

Figure 1. Trends in the production of processed potatoes between 1956 and 1968.

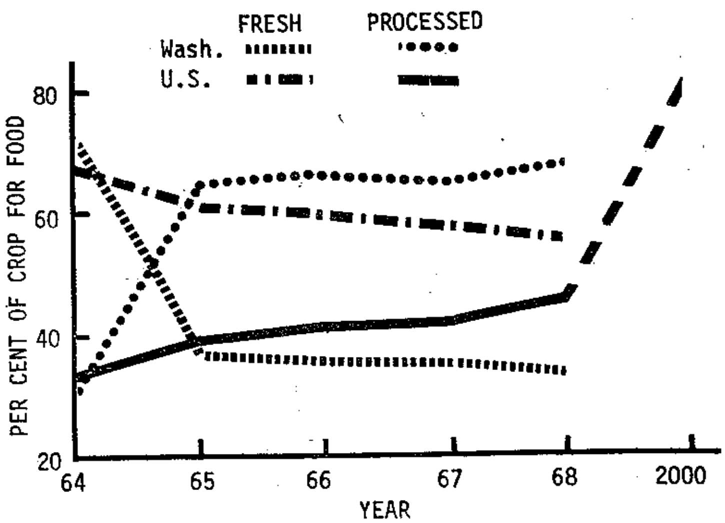

Figure 2. Utilization of the Washington potato crop and the projected needs for processed potatoes in the U.S. by the year 2000.

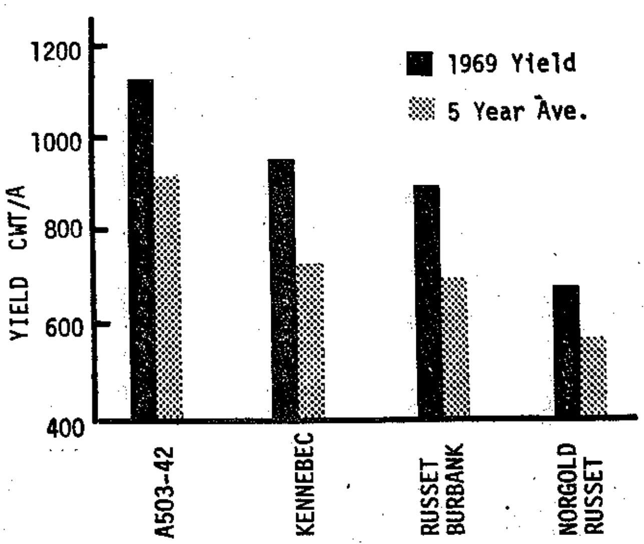

Figure 3. The yield of a promising potato selection in comparison to some currently grown potato varieties.

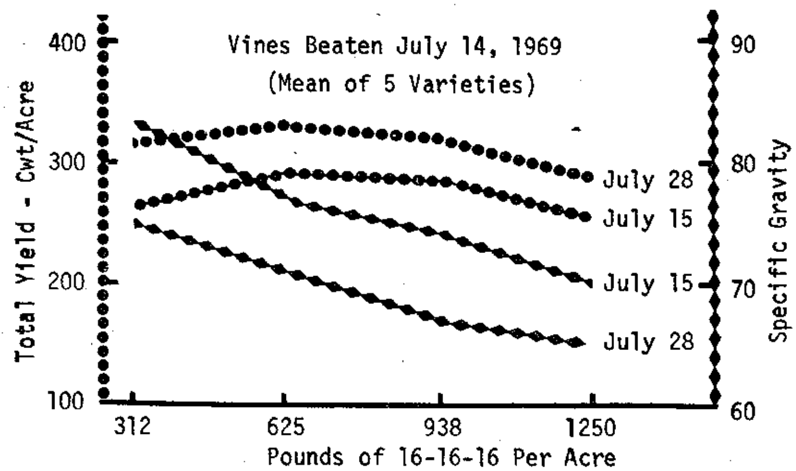

Figure 4. Changes in yield and specific gravity as influenced by fertilizer and time after roto-beating in July.

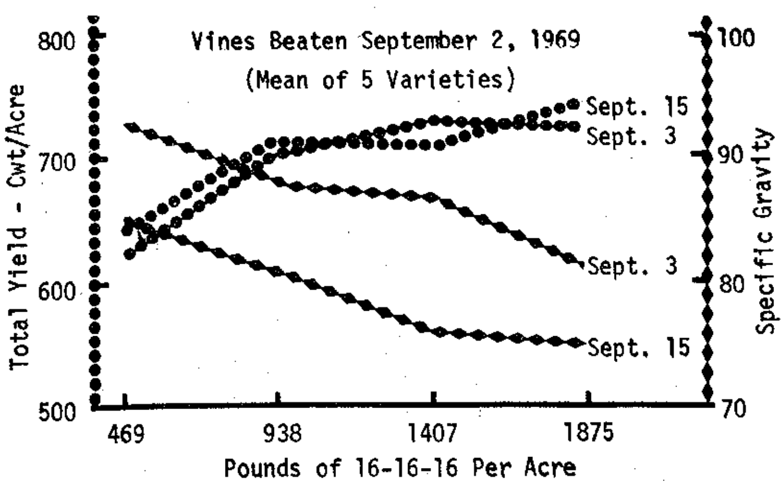

Figure 5. Changes in yield and specific gravity as influenced by fertilizer and time after roto-beating in September.

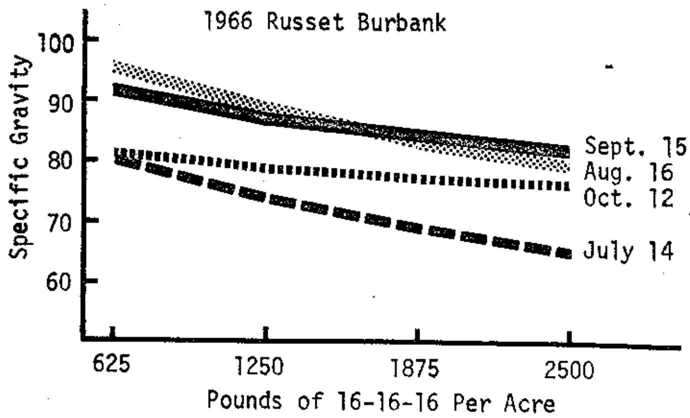

Figure 7. Effect of amount of fertilizer and time of harvest on the specific gravity of Russet Burbank potatoes in 1966.

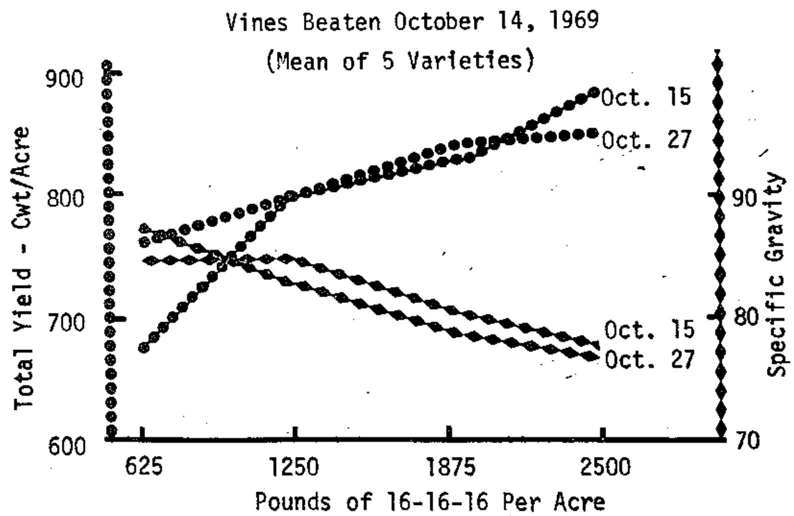

Figure 6. Changes in yield and specific gravity as influenced by fertilizer and time after roto-beating in October.

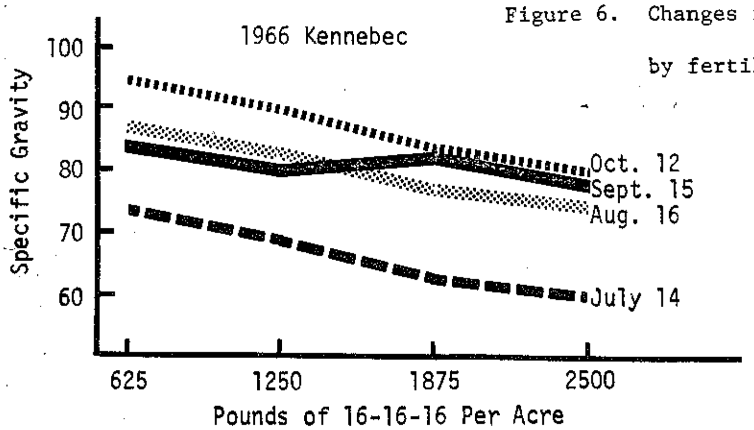

Figure 8. Effect of amount of fertilizer and time of harvest on the specific gravity of Kennebec potatoes in 1966.