# WHY IS SPECIFIC GRAVITY IMPORTANT

by
Jim Munyon
Carnation Company, Moses Lake

In addressing the issue of specific gravity no new research is offered, but rather, a discussion of several of the rationals behind the use of the specific gravity method as employed by the potato industry, and in particular, the french fry portion of that industry.

The specific gravity of potatoes, as determined by either weight in air/weight in water or the potato hydrometer method, is an indirect measure of the total solids or dry matter content of potatoes. The strong correlation of the specific gravity to dry matter content has been demonstrated by research studies and processors alike.

Well then, if the specific gravity is a method that is used to determine the dry matter content, then what is our interest in dry matter content in the first place.

This discussion can be approached from two directions:

1. Finished quality considerations - primarily texture.
2. Recovery or yield considerations.

Let's start first with finished quality consideration, concentrating on finished texture. Just what are we looking for in the way of finished texture of french fries? The characteristics most often sought by the trade include the following:

1. Internal mealiness without separation.
2. External crispness without toughness.
3. Lack of sogginess and oiliness.
4. Consistency.

These desirable characteristics of good texture have a significant correlation with the starch content of the raw tuber. The starch content in turn shows a close relationship to dry matter content.

This relationship between starch content and total dry matter exists for two reasons:

1. Starch is the major component of dry matter, making up approximately 70% of the total.
2. Non-starch solids are relatively constant at approximately 6%.

Starch's role in producing good textured product is primarily associated with the gelatinization process that occurs during water or steam blanching. During gelatinization, the starch absorbs water and swells.

In potatoes with high starch content, the cells tend to round off and to some extent separate, filling cellular voids and the results are less oil uptake, non soggy and mealiness. Excessive separation will, however, result in sloughing.

In potatoes with low starch content, the cells keep their original shape. The net result of low starch potatoes following processing is sogginess and increased oil uptake. Attempts to overcome these problems of low starch potatoes by processing to extremes results in either a gummy texture as cells are ruptured or hollow units by too much frying.

It should be said that while starch content is the major component controlling texture, it is not the only factor. Pectic substances play some role in proper texture. It is suggested that this relates to the holding of the cell wall together as starch swells during blanching.

While it is commonly held that high total solids, and therefore high starch, will provide better finished product texture than does low-solids potatoes, the uniformity of solids within a given lot is also important. Extremes in solids variation will adversely affect texture, oil uptake and color.

Nevertheless, some variation is ever present. Distribution of solids varies within the different tissue zones of individual tubers. The pith or center zone has the lowest starch content while the cortical zone has the highest.

Also, potatoes from the same lot and field will vary in their solids content even under the most controlled conditions. All of this is inherent to potatoes, and as it relates to finished texture quality, some allowance for this natural variability is provided in the finished grading practices. The USDA system will allow up to 10% scorable units in the finished product and still assign an A-grade or top grade to the product. As variation becomes excessive or solids are low, the percent of undesirable texture units increase and the product cannot be sold as a top grade product.

While texture is the predominant quality factor related to total solids, other factors area also related. There exists a relationship between solids and sugar accumulation in storage. Numerous studies have shown that high solids lots accumulate less reducing sugars in storage than low solids lots of the same variety. Increased reducing sugars often have adverse affects on color scoring, thus reducing the finished grade of the product. High levels of sugar can also impact texture as well.

A third consideration is the defect loading, which generally has more effect on recovery than finished quality. Higher solids are more susceptible to bruising; in most cases this is handled by increased trimming.

It is obvious that many factors and variables are at work that will affect the finished product quality. A high solids lot of potatoes, in itself, does not guarantee that the finished product will have good texture. However, in almost every case, a low solids lot of potatoes will not make the good finished texture needed for top grade product.

Figure 1 attempts to put some parameters around the processor's experience as it is affected by total solids.

| | |
|---|---|
| 1.069 or below | - This area offers very little hope of successful processing. |
| 1.070 - 1.074 | - This area offers very limited success in producing a high grade product. |
| 1.075 - 1.090 | - Generally successful conventional processing, |
| 1.080 - 1.090 | - Generally necessary for high solids finished products -- such as 1/4" shoestring french fries. |
| 1.091 or above | - Will process, but often have high sloughing; can results in some recovery reduction and processing problems. |

It should be recalled that these brackets are not absolute and that overlapping does occur between them.

In this next section, specific gravity will be addressed from a purely economic aspect; i.e. total raw solids as it affects yield. A discussion in this area may best be served by an example. In order to keep this example from becoming too cumbersome, we must make some simplifications and assumptions, nevertheless, the general theme will still be apparent. Let's assume we are processing two identical lots of potatoes, with the exception of different raw total solids.

-- One lot will have 20.6% total solids (1.080).
-- The other 21.7% total solids (1.085).
-- We will be processing to make french fries that will meet a finished solids requirement of 34.0%. Finished solids are made up of the original potato solids and the added oil solids.
-- As we discussed earlier, generally less oil is absorbed by higher solids potatoes. This can be described and handled in our example as the ratio of oil solids to total finished solids. These ratios are controlled by several variables, including fryer time and temperature, cut size and shape, type of oil, and composition of dry matter content. Nevertheless, all other things being equal, higher solids potatoes absorb less oil. For our example, these ratios will be assigned the value of:

1.080 = .21
1.085 = .20

In Figure 2, we narrow in on the effects of these assumptions on the frying step, where water is removed from the strip and oil cooked in.

Starting with 180 pounds of raw potatoes from both lots, we arrive at the fryer with 100 pounds of strips with the losses up to this point due to peeling, trimming, cutting and sizing.

Frying both strips to a constant 34.0% finished solids and using our oil ratios, we arrive here with our finished strips. We now have 76.7 pounds from Lot #1 and 79.8 pounds finished from Lot #2.

So that we can concentrate only on the effect of total raw solids on yield, we must first remove the oil content. This gives us 71.2 pounds from Lot #1 and 74.4 pounds from Lot #2 (Figure 3).

Recovery based on these values would be 39.6% and 41.3% respectfully. Using the recovery and starting with a constant finished base of 100 pounds, we can now see the effect of different raw solids levels on yield. It would take 252.5 pounds of useable raw to make 100 pounds finished from the 1.080 lot, but only 242.0 pounds of useable raw to make 100 pounds finished from the 1.085 lot (Figure 4).

This is a savings of 10.7 pounds raw and at 3.5¢/pound raw price would be 37.8¢. This translates to $3.12/ton raw.

This then demonstrates how total raw solids differences translate to increased yield. It should again be said that not every lot performs in this fashion; but that this trend does prevail.

The bulk of our discussion thus far has been concerned with starch content as it relates to texture quality and total raw solids as it relates to yield -- and yet we use specific gravity, an indirect method, to indicate both starch and total solids! A method, as everyone will agree, that has some limitations. Among these limitations is the fact that structural variations, such as hollow heart and intercellular spaces, will have some effect on any correlation between specific gravity and total solids.

A second factor is that differences in internal composition can have some effect, as the amount of chemical components, such as starch, vary.

Other factors include the variety of potato, area of growth and analytical technique used to analyze total solids.

Given these factors and the inherent variability of potato raw solids, a single test of specific gravity can be very misleading. However, there are several positive aspects for supporting the use of specific gravity when properly performed. The main fact is, of course, that is has been repeatedly demonstrated that there exists a close correlation among specific gravity, total solids and starch content.

A second advantage is that specific gravity method is a rapid, simple method that processors can use to screen and select lots to match raw lots to finished quality requirements.

A third advantage is that relatively large samples can be measured. As discussed earlier, variability of solids is inherent with the tubers. Having the ability to take large, multiple samples reduces the chance of a false reading and increases the accuracy and test of total solids. Normal procedures for measuring specific gravity calls for at least 3 to 5 kilogram composite samples, which are averaged together to arrive at relatively accurate specific gravity values.

These then are the major limitations and advantages of using specific gravity. In concluding, it can be said that even though equating specific gravity with potato solids has limitations, no more accurate or practices methods have yet to be demonstrated.

Figure 1.

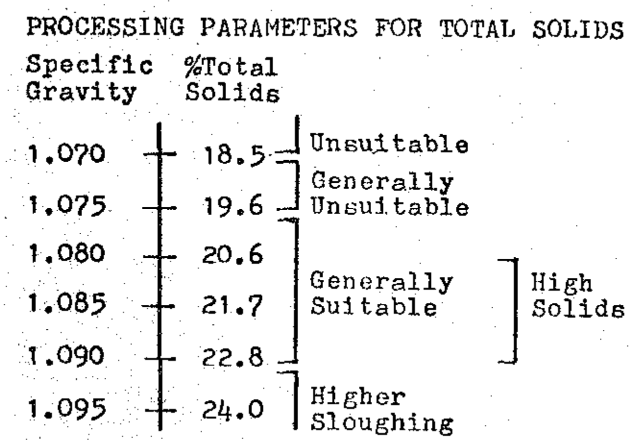


Figure 2.

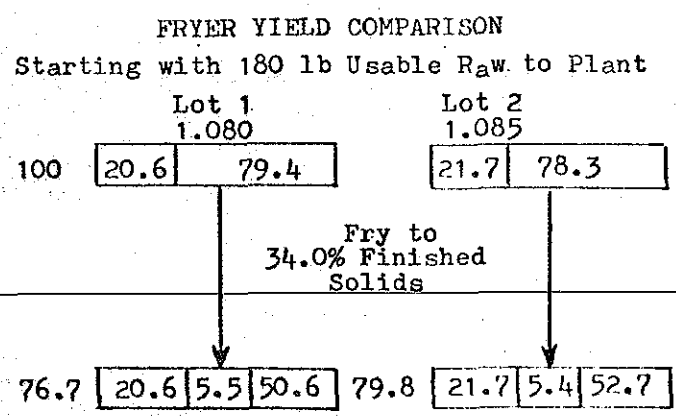

Figure 3.

FRYER YIELD COMPARISON

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 76.7 | 20.6 | 5.5 | 50.6 | 79.8 | 21.7 | 5.4 | 52.7 |

20.6 lb Potato Solids
50.6 lb $H_2O$
71.2 lb

21.7 lb Potato Solids
52.7 lb $H_2O$
74.4 lb

Figure 4.

RAW REQUIRMENTS TO PRODUCE 100 lb FINISHED

$\frac{100 \text{ lb Finished}}{39.6\% \text{ Recovery}} = 252.5$ lb Raw

$\frac{100 \text{ lb Finished}}{41.3\% \text{ Recovery}} = 242.0$ lb Raw