THE MEASUREMENT OF SPECIFIC GRAVITY

by
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INTRODUCTION

Specific gravity incentive clauses in the contracts for processing potatoes have created a flurry of interest in the methodology and reliability of specific gravity measurements. Simply by changing certain techniques and conditions, it is possible to have a difference in specific gravity of up to .005, this with the same potatoes. Thus, it is extremely important to use proper equipment, good technique, and standardized conditions so as to eliminate or at least reduce possible errors in the measurement of specific gravity.

DEFINITION

Specific gravity is defined as the ratio of the weight of a substance (potatoes) to that of an equal volume of water at a specified temperature. Specific gravity can also be defined by the following formula:

$$\text{Specific Gravity} = \frac{\text{Weight in Air}}{(\text{Weight in Air} - \text{Weight in Water})}$$

METHODS

1. Weight in Air - Weight in Water
2. Potato Hydrometer
3. Brine (Salt) Solutions

Weight in Air - Weight in Water

This is the classic method and the one most used by the processing industry in the Northwest. It requires scales of sufficient capacity and precision, a wire basket which is suspended from the scale by a chain or wire, (string or other material which will absorb water must not be used) and a water tank. The scales are tared with all apparatus in place. The potatoes are then weighed in air and then transferred to the basket in water and weighed while submerged in water. The water tank into which the basket is suspended must be of sufficient size to prevent any appreciable change in the water level, and the basket must not come into contact with the tank. The specific gravity is then calculated using the formula found in the introduction.

Potato Hydrometer

A hydrometer designed and calibrated for determining the specific gravity of potatoes has been developed and is available from the Potato Chip Institute. The device consists of a float ball with a plastic tube on top and a hook on the bottom for attaching a wire basket. To use this device, weigh exactly eight pounds of potatoes into the wire basket. Lower the basket, potatoes, and the bulb apparatus into a container of water of sufficient size to allow the entire apparatus to float freely. The deeper the apparatus sinks, the higher the specific gravity which is read directly from a calibrated chart in the tube.

Brine Solutions

Brine (salt) solutions are useful in estimating the range (variation) of specific gravity and for separating potatoes into specific gravity groupings.

The method is based on the principle that potatoes will either float or sink in salt solutions depending on the density of the solution and the specific gravity of the potatoes. In use, a series of brine (salt) solutions are made up to known specific gravities (Table 1). Potatoes with a specific gravity equal to the specific gravity of the solution will barely float, potatoes with higher specific gravities will sink, and potatoes with lower specific gravities will float. Thus, by moving potatoes from low to high specific gravity brine solutions, one can separate a group of potatoes according to their specific gravities. The closest separation possible in routine work is about .005, i.e., 1.075-1.080-1.085, etc.

Twelve Factors That Affect Specific Gravity Measurements

1. % Dry Matter: This is what we are trying to estimate when we determine specific gravity and what the processing industry is really interested in. Normally, the higher the dry matter, the higher the specific gravity. This relationship is not perfect and conversion tables developed in different areas of the world do differ. Some work done in Washington on this relationship indicates that considerable variation does exist between individual tubers and possibly within the growing areas in Washington. Nevertheless, as a general indicator of dry matter content, the determination of specific gravity has much merit and is widely used by the processing industry to assess quality because of its ease of measurement.

2. Accuracy of Weighings: If a sample weighs exactly 5,000 grams in air, an error of four grams (a piece of chewing gum with wrapper weighs about four grams) will result in an error in specific gravity of about .001 (Figure 1). A sample which weighs exactly 400 grams in water with an error in the air weight of 50 grams, an average size seed piece, will result in an error in specific gravity of about .001 (Figure 2).

3. Clean vs. Dirty Tubers: Tubers used for specific gravity determinations must be relatively clean. The effect of debris in or on the sample is variable, depending on the amount and type of soil or other debris.

4. Wet vs. Dry Tubers: The data shown in Figure 3 is based on numerous determinations conducted during the fall of 1979 on Washington-grown Russet Burbanks. Apparently the "corky" structure of russet-type skins contain many small air pockets. When dry tubers are immersed in water, the air pockets create a buoyancy effect and a lower specific gravity. Simply wetting tubers prior to the start of the weighings will displace many of these air pockets and readings will be more consistent. If tubers are soaked in water, specific gravity will increase for up to 1-1/2 hours. This effect of soaking will be less if potatoes are wet when the soaking process begins.

5. Tuber Temperature: As the pulp temperature of potato tubers increases and water temperature is held constant, there is a decrease in specific gravity of about .0012 for each 10°F (Figure 4).

6. Water Temperature: As the temperature of the water increases and tuber temperature is held constant, the specific gravity will increase about .001 for each 10°F (Figure 5).

7. Tuber and Water Temperature Interactions: When both water and tuber temperatures are the same, the temperature effect is reduced to .0004 for each 10°F. Thus, it is good technique to have both water and tuber temperature nearly equal (Figure 6).

8. Hollow Heart: Physically, hollow heart is simply an air space in the interior of a tuber. The effect of hollow heart is an increase in buoyancy and a decrease in specific gravity. The total effect of hollow heart on specific gravity depends on the frequency and severity of the hollow heart.

9. Rots, Cuts and Bruises: Tubers with rots or severe cuts and/or bruises should not be used in the sample selected for specific gravity determination.

10. Peeled vs. Non-peeled Tubers: Peeling potatoes just prior to specific gravity determinations has not been a common practice, however, it does have some advantages. Peeling potatoes eliminates both the clean vs. dirty and wet vs. dry differences.

11. Intercellular Air Spaces: In our laboratory, it has been possible to increase the specific gravity by placing tubers in water and pulling a vacuum, thus displacing some of the intercellular air spaces with water. While this factor does not have any practical application in the routine measurement of specific gravity, it is certainly a factor in dry matter-specific gravity relationships.

12. Quality of the Water: Water should be relatively clean. Water with high salt concentration should not be used.

SUMMARY

A difference of .005 in specific gravity could result from differences in technique. Starting with dry tubers, a water temperature of 50°F and a weighing error in water of minus four grams, we determine the specific gravity to be 1.080. However, if we wet the tubers, increase the water temperature to 70°F, and have no weighing errors, the indicated specific gravity will be 1.085. This certainly illustrates the magnitude of possible error, however, with a little care and proper equipment, the error can be held within ± .001. Thus, despite some shortcomings, specific gravity is still an excellent tool in estimating certain aspects of potato quality.

The figures presented on water and tuber temperature were derived from data supplied by Dr. W. M. Iritani.

Table 1.

PREPARATION OF BRINE SOLUTIONS:

Salt Solutions of Sodium Chloride[1]

Specific Gravity	Grams/ Liter	Pounds/ Gallon
1.070	106.03	0.848
1.075	113.75	0.910
1.080	121.49	0.971
1.085	129.20	1.033
1.090	137.06	1.096
1.095	144.92	1.158

[1]Sodium Chloride (NaCl) is common table salt.

Figure 1. Effect of weight in water when weight in air is constant at 5,000 grams.

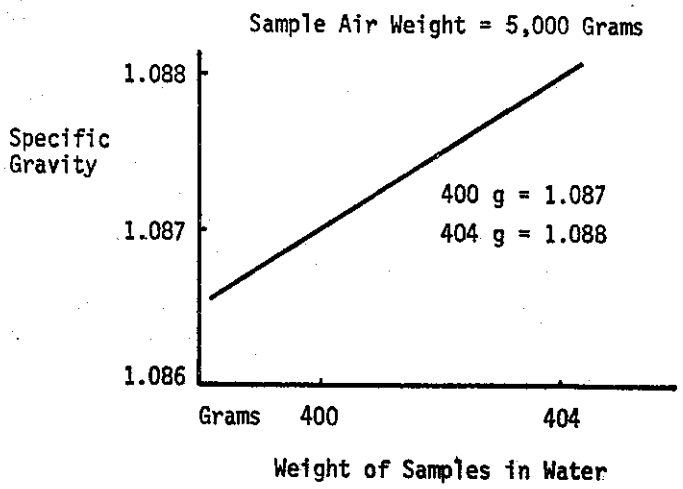

Figure 2. Effect of weight in air when weight in water is constant at 400 grams.

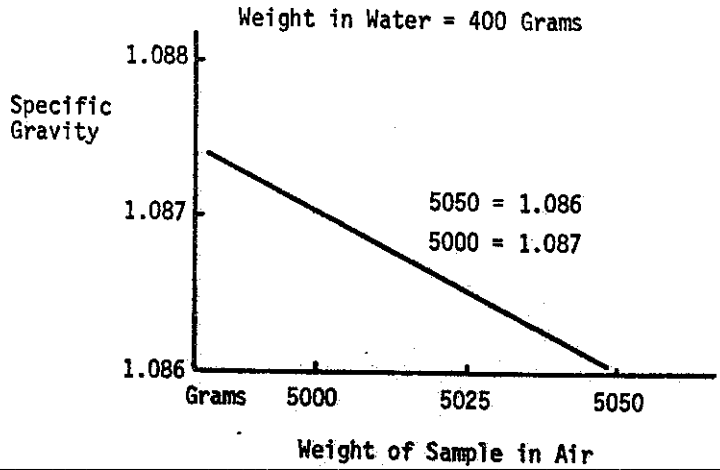

Figure 3. Effect of wet vs. dry tubers.

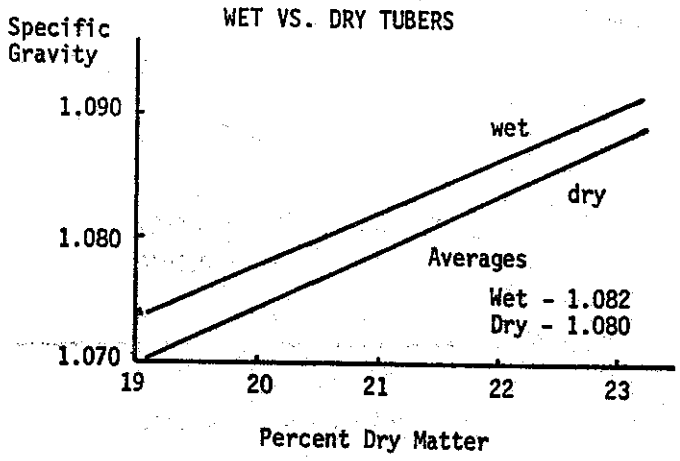

Figure 4. Effect of tuber temperature on specific gravity.

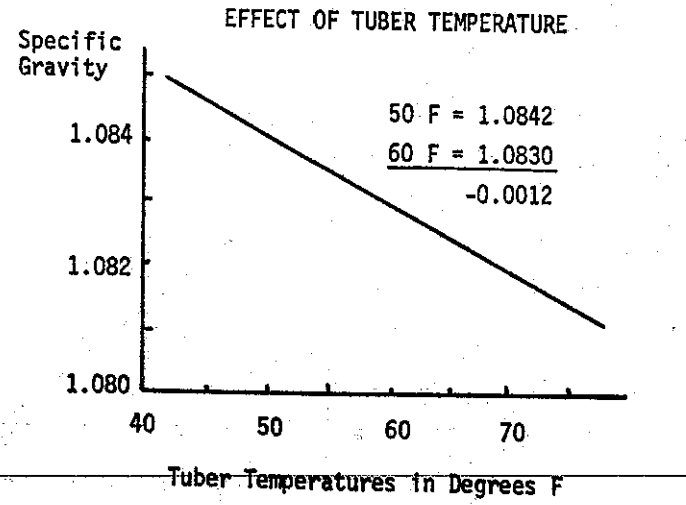

Figure 5. Effect of water temperature on specific gravity.

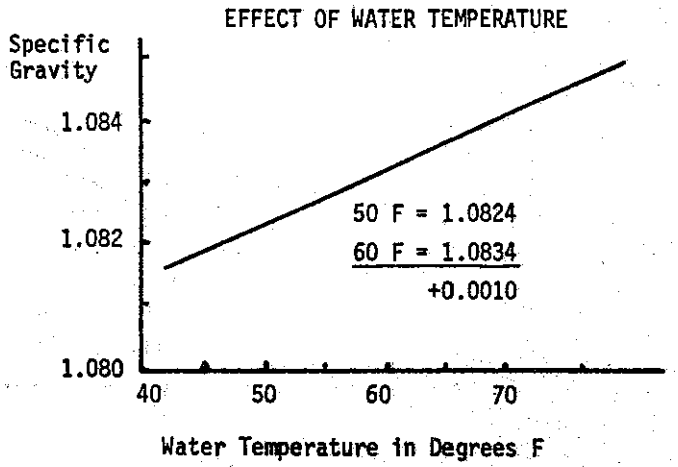

Figure 6. Effect on specific gravity when tuber and water temperatures are identical.