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Physical Characteristics

Seed Count

Seed Count is also offered as a component of the **Tofu and Soymilk Process Test.**

Seed count is a measure of soybean seed size. Some soybean processors have strong preferences for particular seed sizes. For instance, tofu manufacturers often prefer very large beans. Natto beans are very small.

The test is performed by randomly selecting 100 representative intact seeds. The seeds are weighed and reported as seeds per pound.

Possible Values 1200-4600 seeds per lb Typical Results 2400-3200 seeds per lb.

Foreign Material and Splits

Foreign material and splits are part of the GIPSA Official United States Standards for Grain grading criteria. Foreign material in soybeans is defined as all matter that passes through an 8/64 round-hole sieve and all matter other than soybeans remaining in the sieved sample after sieving according to procedures prescribed in FGIS instructions. Splits are defined as soybeans with more than one-fourth of the bean removed and that are not damaged.

Damage

Damage is part of the GIPSA Official United States Standards for Grain grading criteria for soybeans. A damaged soybean is defined as one that is materially damaged by weather, insects, fungus, disease, etc. Such damage is detrimental, particularly in food uses.

Moisture Content

Moisture Content is also offered as a component of the **Tofu and Soymilk Process Test** and **Seed Count**.

Moisture content is a critical factor for the long-term storability of soybeans. Soybeans should be dried in the field or artificially to 13% moisture for storage up to 6 months, 12% for storage up to one year, and 11% for over one year. Over-drying of soybeans wastes energy, money, and time. Overdrying soybeans will also lead to an increase in splits.

The test involves filling the moisture meter with 250 grams of soybeans. A reading is obtained from the meter which correlates to a specific moisture content at the testing temperature. The moisture content is reported as an “as is”, or “wet basis”, percentage.

The ideal Moisture Content for further soybean testing is between 10 and 13%.

Possible Values 5-35% Typical Results 8-15%

Chemical Components

NIR Proximate Analysis - Soybean

NIR Proximate Analysis is also offered as a component of the **Tofu and Soymilk Process Test**.

Proximates are the major components of the grain. For soybeans, the NIR Proximate Analysis includes Oil Content, Protein Content, Fiber Content, and Moisture Content. The test does not include Ash Content. This procedure is nondestructive to the soybeans. Proximate Analysis is also available using wet chemistry methods for protein content, oil content, and moisture content but the sample must be ground.

Various end users have different demands for soybean composition. A tofu manufacturer will usually want very high protein levels. Operators of a large soybean crushing plant may want to balance the protein and oil content to fit processing needs.

Results (other than Moisture Content) are reported on a dry basis percentage (percent of non-water material). Moisture Content is reported "as is" (percent of total sample weight).

Oil Content	Possible Values 16-25%	Typical Results 18-23%
Protein Content	Possible Values 36-50%	Typical Results 38-45%
Fiber Content	Possible Values 3.5-5.6%	Typical Results 4.0-5.0%
Moisture Content	Possible Values 5-35%	Typical Results 8-15%

Protein Content – Combustion Method

The Combustion (Dumas) Method can be used to measure the protein or nitrogen content in a wide range of substances. It has replaced the slow, dangerous, and environmentally unfriendly Kjeldahl procedure for most applications. The combustion method is an approved method and has become the most common reference ("wet chemistry") method for NIR calibrations for protein content. The combustion method is typically employed for samples for which no NIR calibration exists. The IPG lab does offer protein content for soybean using NIR. There are situations in which the combustion method may not be suitable.

In this test, a 50-300 mg representative sample (liquid or ground solid) is burned at high temperature in a sealed system. The nitrogen in the sample is converted to nitrogen gas, separated from the other chemical components, and measured by thermal conductivity. The nitrogen content can be converted to protein content by using a conversion factor (typically 6.25 x nitrogen) to obtain the "as is" protein percentage. This test is performed in duplicate, and the moisture content in the original sample is determined by the air oven method to convert the protein content to dry basis.

Protein contents measured by the combustion method can range from very low 0.1% to 90+%.

Oil Content – Ether Extraction

Ether Extraction can be used to quantify the amount of fat or oil in a sample. The ether extraction method is an approved method and is a common reference ("wet chemistry") method for NIR calibrations for oil content. The ether extraction method is typically employed for samples for which no NIR calibration exists. The IPG lab does offer oil content for soybeans using NIR. There are situations in which ether extraction may not be a suitable method for oil measurement.

In this test, a representative sample is ground and extracted in refluxing petroleum ether. Extracted oil is captured in the boiling flask. The oil is separated from the ether and weighed to determine the percentage of the original

sample weight collected as oil to obtain the “as is” oil percentage. This test is performed in duplicate, and the moisture content in the original sample is determined by the air oven method to convert the protein content to dry basis.

Oil contents measured by the ether extraction method can range from very low 0.2% to 50+%.

Moisture Content – Air Oven

The Air Oven method can be used to quantify the amount of water in a sample. The air oven method is an approved method and is a common reference (“wet chemistry”) method for NIR calibrations for moisture content. The air oven method is typically employed for samples for which no NIR calibration or other reliable rapid method (NIR or Moisture Meter) exists. There are situations in which the air oven method may not be a suitable method for moisture measurement.

In this test, a representative sample (liquid or ground solid) is weighed into a tared cup and placed in an oven. Oven temperatures and residence times vary by substance. The dried sample is cooled in a dessicator and the weight of the remaining material is recorded. The weights may be used to determine the amount of water removed in the oven. Moisture content is reported as the amount of water removed from the original sample. Solids content is the weight of material remaining after drying divided by the original sample weight. Moisture content and solids content are reported as an “as is”, or wet basis percentage.

They are related by the equation: ***Moisture Content (as is) + Solids Content (as is) = 100%***

Sugar Profile - High Performance Liquid Chromatography

The sugar profile measures the quantities of seven sugars in a sample. While applicable for a number of products, soybeans are the most common request for the IPG lab. For soybeans, sugar contents are expressed on dry basis:

Sucrose	Possible Values	3.0-9.0%	Typical Results	4.0-7.0%
Glucose (dextrose)	Possible Values	0.0-0.5%	Typical Results	0.0-0.1%
Maltose	Possible Values	0.0-0.5%	Typical Results	0.0-0.3%
Lactose	Possible Values	0.0%	Typical Results	0.0%
Fructose	Possible Values	0.00-0.1%	Typical Results	0.0-trace%
Raffinose	Possible Values	0.2-1.6%	Typical Results	0.5-1.2%
Stachyose	Possible Values	2.0-6.5%	Typical Results	3.5-5.5%

High levels of sucrose (“table” sugar) are often desired to mask the beany flavor in soyfoods. Low amounts of the oligosaccharides raffinose and stachyose are wanted. These sugars are not digested in the upper digestive system and are fermented in the intestine. The gases produced in fermentation can cause the discomfort and flatulence associated with some foods from soybeans.

Amino Acid Profile - High Performance Liquid Chromatography

The High Performance Liquid Chromatography (HPLC) method can be used to quantify the amount of various amino acids in a sample. The HPLC method is an approved method and is a common reference (“wet chemistry”) method for NIR calibrations for amino acid contents. The HPLC method is typically employed for samples for which no NIR calibration exists. The IPG lab does offer amino acid profile for soybeans using NIR.

Various procedures must be employed depending on the amino acids of interest. The moisture content in the original sample is determined by the air oven method to convert the amino acid contents to dry basis.

Fatty Acid Profile - Gas Chromatography

The Gas Chromatography (GC) method can be used to quantify the amount of various fatty acids in a sample. The GC method is an approved method and is a common reference ("wet chemistry") method for NIR calibrations for fatty acid contents. The GC method is typically employed for samples for which no NIR calibration exists. The IPG lab does offer fatty acid profile for soybeans using NIR.

Various procedures may be employed depending on the fatty acids of interest. The moisture content in the original sample is determined by the air oven method to convert the fatty acid contents to dry basis.

Processing Characteristics

Tofu and Soymilk Process Test

The Tofu and Soymilk Process Test gives a soybean processor information on the yield and quality of the products they could expect from a particular variety or sample of beans. Data is collected from the raw soybeans, the soymilk made from those beans, and the silken (non-pressed) tofu product made from that soymilk.

The whole soybeans are evaluated using the NIR Proximate Analysis and Seed Count tests. A sample of the beans are ground into a powder and blended with hot water. The resulting slurry is steam-cooked and put through a juice extractor. Insoluble solids (okara) are removed by filtration through a series of cloths and refrigerated. The total volumetric yield is determined after the sample has sat overnight and warmed to room temperature. The solids content of the soymilk is also measured using the Air Oven Method and reported.

A portion of the soymilk is mixed with a coagulant and cooked in a hot water bath to make the tofu product. Glucono-delta-lactone (GDL) is the standard coagulant, although the traditional nigari (magnesium chloride) is available as an option. The finished tofu is weighed to measure product yield and the moisture content is determined using the Air Oven Method.

The color of the soymilk and tofu are measured using the Hunter Lab color scale:

L – measure of lightness (0 = black to 100 = white)
a – measure of greenness (larger negative number) to redness (higher positive value)
b – measure of blueness (larger negative number) to yellowness (higher positive value)

The protein content of the soymilk and tofu are measured using the combustion method.

Soymilk Yield (liters per kg of dry soybeans)	Possible Range	4.7-6	Typical Results	5-5.5
Soymilk Protein (d.b)	Possible Range	38-57%	Typical Results	41-51%
Soymilk Solids	Possible Range	10-11.5%	Typical Results	10.5-11.3%
Soymilk Color L	Possible Range	70-85	Typical Results	77-82
Soymilk Color a	Possible Range	(-2.0)-(-0.3)	Typical Results	(-1.7)-(0.75)
Soymilk Color b	Possible Range	10-15.5	Typical Results	12-15
Tofu Yield (kg per kg of dry soybeans)	Possible Range	5-7	Typical Results	5.5-6.5
Tofu Protein (d.b)	Possible Range	36-58%	Typical Results	41-52%
Tofu Moisture	Possible Range	87-89.5%	Typical Results	87.5-89%
Tofu Color L	Possible Range	77-81.5	Typical Results	78-81
Tofu Color a	Possible Range	(-1.5)-0.7	Typical Results	(-1.0)-0.4
Tofu Color b	Possible Range	11-15	Typical Results	12-14

Nitrogen Solubility Index (NSI)

The Nitrogen Solubility Index, or NSI, is a measure of the solubility of soybean protein in water. High solubility is very important to manufacturers of soymilk and tofu, as their job is to extract as much protein from the soybean as possible.

For this test, a sample of soybeans is ground, mixed in a specific ratio with water, and stirred at a set speed (120 rpm) in a constant-temperature (30°C) water bath for a specific time (2 hours). The nitrogen content of the ground soybeans and of the extract are determined using the combustion method. The NSI value is the quotient of the nitrogen content of the extract divided by the nitrogen content of the original bean.

Possible Values 50-95 Typical Results 70-90

Protein Dispersibility Index (PDI)

The Protein Dispersibility Index, or PDI, is another measure of the solubility of soybean protein in water. High solubility is very important to manufacturers of soymilk and tofu, as their job is to extract as much protein from the soybean as possible.

For this test, a sample of soybeans is ground, mixed in a specific ratio with water, and blended at a set speed (7500 rpm) for a specific time (10 minutes). The nitrogen content of the ground soybeans and of the extract are determined using the combustion method. The PDI value is the quotient of the nitrogen content of the extract divided by the nitrogen content of the original bean.

Possible Values 50-95 Typical Results 70-90