DRY BEAN SOAKING AND PROCESSING

Dry beans are processed using a standard soak procedure. All black or colored beans are to be segregated from white beans during soaking. Individual nylon bags **(A)** are aggregated into large nylon mesh bags and are designated into "soak lots" (approximately 25 bags in each)

Soak conditions

Initial Cold Soak: 30 minutes at 25ºC (ambient temperature) for navy, great northern, pink, and small red beans. Overnight soak (12-14 hours) at 25 ºC (ambient temperature) for kidney, cranberry and pinto beans. Use large plastic containers **(B)** for this initial soak (60 lb capacity).

Final Hot Soak: 30 minutes at 87.8 ºC for all bean market classes. Cold soaked beans are transferred to an indirect steam heated temperature controlled water bath blancher **(C)** and maintained at 87.8 ºC. Beans are maintained submerged under the surface. Temperature of this soak will be maintained by a steam controller/regulator and water temperature will be monitored.

Soak water: Calcium ion concentration directly influences textural properties of processed beans and therefore must be controlled. Use of 75-100 ppm calcium ion has been demonstrated to be optimum for quality evaluation. We use 100 ppm Calcium in both our hot and cold soak water.

Cooling and Draining Soaked Beans

Soaked beans will be cooled by submersion for 3-5 minutes in a large container of cold tap water **(D)**. Cooled beans will be removed from cooling water and drained on perforated racks. Each bag of beans is spread out flat to facilitate uniform drainage.

(A)

(B)

(C)

(D)

Can Filling and Weight Gain During Soaking

Contents of nylon bags (soaked beans) should be opened and rapidly transferred to labeled 303 x 406 cans after draining for approximately 10-15 minutes. Cans are kept covered with the mesh canning bags **(E)** until weighing to prevent moisture loss.

Tare of Balance and Cans: Determine the mean tare weight of the empty cans by weighing 5 cans (without lids). Tare balance to accommodate the median can weight. Weigh all soaked beans after filling the cans and record weights.

Brining and Exhausting

Gently boiling brine **(F)** will be used to cover the beans in the cans. This brining will be performed immediately prior to the thermal exhaust. Hand dip hot brine and fill cans after they are placed on the exhaust box conveyor **(G)**. Exhaust box temperature is maintained at 98.9 – 100ºC.

Brine Preparation: Basic formulation: 100 ppm Ca^{2+}, 5.67 g/lb H_2O of salt, and 7.09 g/lb H_2O of sugar.

Sealing and Processing

The cans of beans should be hermetically sealed immediately upon removal from the exhaust box **(H)**. We use a Dixie Canner Model UD-AL. Transfer sealed cans to the retort basket **(I)**. Stack cans uniformly in the basket.

Process Schedule: Vent – 2 minutes, hold through come-up time. Process – Heat at 115.6ºC for 45 minutes. After the 45 minutes of heating is complete a 15-minute cooling cycle begins. Cold running water (35ºC) is forced over the cans during this stage. The retort is equipped with a temperature-recording chart and is operated by qualified personnel. Processed cans are removed from the retort, and then towel dried and turned label-side up on a tabletop.

Can Storage

Dried processed cans are placed in storage at ambient temperature for a minimum of two weeks. After this two week period the cans may be opened and evaluated.

(E)

(F)

(G)

(H)

(I)

PROCESSING QUALITY TRAITS OF DRY BEANS:
THEIR DESCRIPTIONS AND CALCULATIONS.

FOOD QUALITY TRAITS:

Dry Bean Weight (g) – The fresh weight of beans equivalent to 90 grams of total solids at a given moisture content, e.g. 107.1 g of bean fresh weight @ 16% moisture is equivalent to 90 g solids.

Soaked Bean:

Soaked bean weight (g) – The weight of the bean sample after soaking in distilled water adjusted to 100 ppm Ca^{2+} for 30 minutes at ambient temperature (71 +/- 2ºF) and 30 minutes at 195ºF (beans of the Pinto, Cranberry and Kidney market classes are soaked for 12-14 h at ambient temperature followed by a 30 minute hot soak). The soaked bean weight is a measure of both the weight of water and weight of total solids in a sample.

Soaked bean water content (%) – A measure of the proportion (%) of bean weight after soaking due to water alone and is calculated as follows:

$$\frac{[\text{Soaked bean weight (g)} - \text{Fresh weight equivalent to 100 g solids}]}{\text{Soaked bean weight (g)}} \times 100$$

Hydration Coefficient – This is the ratio of two masses of hydrated beans and is another way of looking at the hydration characteristics of a sample of soaked beans. The hydration coefficient reflects the weight increase of beans after soaking relative to the initial fresh weight equivalent to 90 g solids. The hydration coefficient is a rapid indicator of how well a bean is hydrated prior to thermal processing (cooking in a retort). A hydration coefficient of **1.8** is considered optimum by the processing industry. The hydration coefficient is calculated as follows:

$$\text{Hydration Coefficient} = \frac{\text{weight of soaked bean (g)}}{\text{fresh weight (g) of beans equivalent to 90 g solids}}$$

Thermally Processed Beans

Clumps - The degree of packing of beans in the can. Clumping is manifest when individual beans adhere to one another rather than occurring as individual grains. Clumping is due to extruded protein, dietary fiber, starch, and their physical-chemical interactions. Clumps are visually rated on a 7-point rating scale**:**

1 = severe; beans are packed solidly in the can and heavy aggregation of beans is noted;
7 = no clumping; beans fall freely from can and no aggregation of beans is apparent.

Splits - Measures the extent of transverse and tangential splitting of beans. Samples are visually rated on a 7-point scale;
1=very severe splitting with most beans in the sample split;
7=most beans in sample show no splits (small transverse cracks, 2 mm, on seeds permissible).

Washed-Drained Weight - The washed-drained weight is the weight of beans after they have been rinsed and drained for two minutes. The washed-drained weight takes into account the degree of hydration that occurred during soaking, blanching, and cooking in the retort. Cooked beans are rinsed and drained in a sieve **(J)**, **(K)** to wash away any macromolecules extruded from the bean. A washed-drained weight of **240-280 grams** for a sample of beans equivalent to 90 grams of initial solids is considered typical.

Washed-drained weight coefficient – This is another ratio of the mass of hydrated beans and is a quick way to evaluate the water entrainment of a cooked sample of beans. A typical value for the washed-drained weight coefficient should fall between 1.4 to 1.6. Values < 1.4 are atypical and low and indicate that the bean sample has low water entrainment; values > 1.6 indicate that the bean sample has an atypical washed-drained weight on the high side and has high water entrainment. The washed-drained weight coefficient is calculated as follows:

(J) **Washed-drained weight coefficient** = $\frac{\text{Washed-drained weight (g)}}{\text{Soaked bean weight (g)}}$ **(K)**

Percent Solids - The percent of total soluble solids remaining in the sample after thermal processing. This trait is determined by oven drying 100 grams from each texture evaluation at 80.6°C until weight remains constant. This takes approximately 24 hours.

Water Content of processed beans (%) =

$$\frac{\text{weight of texture sample} - \text{weight of sample after oven drying}}{\text{weight of texture sample}} \times 100$$

Texture – Determined by placing 100 g of washed, processed beans into a standard shear-compression cell **(L)**, **(M)** of a Kramer Shear Press and applying force with a dynamic hydraulic system. Values reported indicate the **kilograms** force Required to bring beans to a point of catastrophic failure (total loss of bean integrity) of the sample. Texture affects the Perceived stimulus for chewing and is an index of the firmness and softness of a food and, thus, serves as an index for Consumer acceptance for cooked bean seeds. Bean seeds may be unacceptable if they are perceived as too firm ("tough beans") or too soft ("mushy beans") after cooking.

The textural standards established for several market classes of processed beans are:

	Maximum Force Resistance (kg) Descriptor		
Market Class	Highly Desirable (Ideal)	Desirable (Satisfactory)	Undesirable [a] (Unsatisfactory)
Navy	50-60	40-70	< 40, > 70
Black Turtle	55-65	45-75	< 45, > 75
Dark Red Kidney	65-75	55-85	< 55, > 85
Light Red Kidney	60-70	50-80	< 50, > 80
Great Northern	40-50	30-60	< 30, > 60
Pinto	60-70	50-80	< 50, > 80
Small-red	65-75	55-85	< 55, > 85

[a] Too soft or too firm.

Peak height – The maximum height of the peak generated and displayed on the recorder chart paper **(N)** of an Allo-Kramer Shear Press **(O)**. Peak height is converted into forces as follows:

1. Kilograms force = peak height x 1.36
2. Newtons = kg force x 9.80

Processing Quality Index - The processing quality index (PQI) is a summarization of various subjective processing quality descriptors to arrive at a single value (index) for describing dry bean processing quality and which is useful to plant breeders as a selection index. The PQI is constructed as a linear function of the following descriptors: the amount of clumping, splitting, and overall appearance of a canned bean sample; cooking broth characteristics of viscosity, color, and amount of starch extruding into the liquid; and cooked seed characteristics of color, size, and shape for the market class.

The seven descriptors mentioned above of which the PQI comprises is each rated by several judges on a 7 point Hedonic Scale and are weighted as such:

Full descriptor set	Score weights	Abbreviated descriptor set	Score weights
Clumps	[1 x]	1. Clumps	[1 x]
Splits	[1 x]	2. Splits	[1 x]
Appearance	[2 x]	3. Appearance	[2 x]
Viscosity	[1 x]		
Color	[1 x]		
Free starch	[1.5 x]		
Seed Characteristics[b]	[1.5 x]		

[b] Seed characteristics include color, size and shape of the seed.

(L)

(M)

(N)

(O)

COLOR (both dry and processed):

The surface color of dry or thermally processed beans, an important consumer and processor quality characteristic, is measured with a Hunter Lab Color and Color Difference meter. The Hunter Lab instrument has three scales on which all the primary colors of the color spectrum are considered.

L scale – Measures whiteness or blackness of an object on a scale from 0 (pure black) to 100 (pure white)

aL scale – Measures the redness or greenness of a sample on a 100-point scale where 0 to + 50 = redness and 0 to – 50 = greenness

bL scale – Measures the yellowness or blueness of a sample on a 100-point scale where 0 to + 50 = yellowness and 0 to – 50 = blueness

Hue Angle (°) – Hue angle converts the surface color values of an object on the aL and bL scales to an expression of human perception for the primary colors (using a Hunter LabScan instrument).
Hue angle is calculated as the Arc tan (b*/a*) when both **a* and b* are positive**.
Hue angle is calculated as Arc tan (b*/a*) **+ 180** when **a* is negative and b* is positive**.
Hue angle is calculated as Arc tan (b*/a*) **+ 180** when both **a* and b* are negative.**
Hue angle is calculated as Arc tan (b*/a*) **+360** when **a* is positive and b* is negative.**
Hue angles are interpreted as follows:

0° = Red
45° = Orange
90° = Yellow
135° = Yellow-green
180° = Green
225° = Blue-green
270° = Blue
315° = Purple


L,a,b Color Solid
L = 100
-a
+b
+a
-b
L = 0
HunterLab Reston, VA

Hue angles for dry bean market classes:

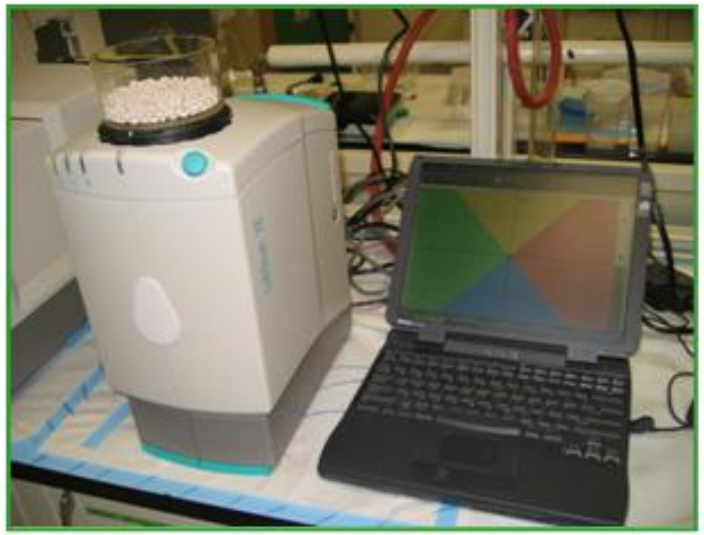
Thermally Processed (cooked) Beans	
Market Class	Hue Angle Range
Dark red kidney	10° to 25°
Light red kidney	35° to 50°
Small-red	35° to 45°
Pink	40° to 50°
Navy	70° to 80°
Great Northern	70° to 80°
Small white	70° to 80°
White kidney	70° to 85°
Pinto	50° to 60°
Black	20° to 40°

where:

$a^* = 500 \times [(x \text{ value}/98.041)^{1/3} - (y \text{ value}/100)^{1/3}]$

$b^* = 200 \times [(y \text{ value}/100)^{1/3} - (z \text{ value}/118.103)^{1/3}]$

(P)



Lightness – A measure of lightness or darkness where 100 = maximum lightness and 0 = maximum darkness of an object. Lightness is measured using the L-scale of the Hunter instrument.

Chroma – A value calculated from the aL and bL scales of the Hunter Lab LabScan instrument **(P).** The higher the chroma value, the brighter the color. As chroma values approach zero, colors approach gray. Chroma values close to zero can make an accurate hue angle difficult to calculate, and is often a consideration when evaluating black beans.

$\text{Chroma} = [(a^*)2 + (b^*)2]^{1/2}$