International Food Research Journal 16: 11-19 (2009)

Review Article
Quality of soybean and its food products

Gandhi, A. P.

Central Institute of Agricultural Engineering, Bhopal-462038(MP), India

Abstract: Specific standards used for both soybeans and soy based foods available internationally were exhaustively reviewed. Besides the author proposed specific protocols for different soy products developed at Soybean Processing and Utilization Center. These standards will be guiding principles for both the producer and consumer of soybeans globally.

Keywords: Quality factors, soybean, food products

Introduction

The use of soybean products in the feed and food industry has increased steadily. The world soybean production is currently 219.8 million metric tons out of which India produced 9.3 million metric tons constituting about 4% of the total world production. Out of this production, less than 10% is directly used for human consumption (Gandhi, 2006). The dominant position of soybeans and their products is primarily associated with their high nutritional quality especially with respect to protein and amino acids. While basic standards specifications for soybeans/soy meals have been established (NOPA, 1997), no official specifications exist for other soy products that are used now a days. Further more NOPA specifications only refer to four chemical constituents. Current evaluations of soy products are based on a much larger array of tests allowing a more accurate evaluation of the nutritive value of the different products. Developments in the technological modifications of soybean products, along with a better understanding of the effects on performance and health of relatively unknown compounds, such as isoflavones, will add value to soy products. Accurate analysis of these new compounds will be of greater importance. Hence the quality analysis of soy products is needed at all stages of the protein supply chain in the food and feed industry and quantified with the maximum and minimum limits of each desirable component.

Quality characteristics can be classified into three general categories: defects, shipment and storage factors and end use related factors. End use quality factors are classified as either physical properties or chemical composition characteristics. The physical properties include germination, hilum color, seed count, seed size, hardness, seed coat cracking, and purity. Chemical composition include moisture, protein, Nitrogen Solubility Index(NSI), 7S/11S proteins,Protein Dispersbility Index(PDI), amino acids, lipoxygenase, Trypsin Inhibitor(TI), oil, fatty acids, fiber, sugars and isoflavones. The level, plus presence or absence of these characteristics is generally referred to as Quality. High quality soybeans have desirable levels of certain characteristics or combination of characteristics. The physical and chemical characteristics are usually measurable by some means (AACC, 2004; AOAC, 2004; AOCS, 2004&AOSA, 2003). Other practices such as organic production practices are very difficult, if not impossible, to measure in the soybeans themselves and require a system of traceability or verification. Most of the countries are adopting the National Oilseed Processor Association(NOPA) specifications for their domestic soybeans. The most accepted standards or specifications for the specific soybean products are illustrated in this paper. Table 1 gives the classification of quality factors.

Corresponding author.
Email: *apg@ciae.res.in*
Fax: +91-755-2730416

Table 1. Classification of soybean quality factors (Hurburgh and Brumm, 2004)

Classification	Examples	Comment
Defects	• Foreign material • Damage • Splits • Heat damage • Toxic substances	Defects reduce the value of grain for all users.
Shipment and storage factors	• Moisture variation • Insect infestation • Sour, heating	Unstable grain quickly becomes high in defects
End use related factors	• Composition (e.g. protein, oil sugars etc) • Composition quality (NSI,7S/11S proteins) • Seed coat damage	Different users will have different needs and desires.

Table 2. Official US grades for soybean (FGIS, 1994)

	Grade US Nos.			
Grading factors	**1**	**2**	**3**	**4**
Minimum test weight (lbs/bushel)	**56.0**	**54.0**	**52.0**	**49.0**
	Maximum Percent limits of			
Damaged kernels				
Heat (part of total)	0.2	0.5	1.0	3.0
Total	2.0	3.0	5.0	8.0
Foreign Material	1.0	2.0	3.0	5.0
Splits	10.0	20.0	30.0	40.0
Soybeans of other colors	1.0	2.0	5.0	10.0
	Maximum count limits of			
Other materials	9	9	9	9
Animal filth	1	1	1	1
Castor beans	2	2	2	2
Crotalaria seeds	0	0	0	0
Glass	3	3	3	3
Stones	3	3	3	3
Unknown foreign substances	10	10	10	10

Table 3. Quality factors in the US soybean grades (FGIS, 2004)

Factor	Description	Unit of measure	Methods of measure
Moisture (MC)	Fraction of water on a total weight basis	Percent, wet basis.	Hot Air Oven or other moisture meters.(Standard temperature and measurement period as per approved methods)
Test weight (TW)	Bulk density of whole kernels.	Pounds per bushel (1Bushel=1.245 ft3)	One quart (800 g) filled from a height of two inches.
Foreign material (FM)	Fraction of fine particles and non grain material	Percent, total weight basis	Carter dockage tester with 8/64 inch round hole screen plus hand picking of large non-bean material
Heat Damage (HDK)	Soybeans and pieces of soybeans that are materially discolored and damaged by heat	Percent, total weight basis	Visual judgment of grader, hand picking
Total damage (DKT)	Fraction of beans with mold, insect or frost damage.	Percent, total weight basis.	Visual judgment of grader, hand picking
Splits	Soybeans with more than one fourth of the bean that is removed and not damaged	Percent, total weight basis	Visual judgment of grader, hand picking, with assistance of a 10/64 inch by ¾ inch slotted screen
Musty, sour, heating	Presence of mold odors or heating grain	Yes or no judgment	Judgment of grader

Soybean grading

The classification of grain and oil seeds according to quality characteristics or factors is called grading. The process of grading is called inspection. The US Grades and Standards for grain were first established in 1916. The Federal Grain Inspection Service, a division of USDA determines the procedures and equipment used for official inspections. The grain standards act defines soybeans as grain that consists of 50% or more of whole or broken soybeans that will not pass through an 8/64-inch round hole sieve and not more than 10% of other grains for which standards have been established. There are two classes of soybeans: yellow and mixed soybeans. Yellow soybeans have yellow or green seed coats, which in cross section are yellow or have yellow tinge and may include not more than 10% of soybeans of other colors. Mixed soybeans are those that do not meet requirement of the class Yellow soybeans. Table 2 shows the official US grades for soybean. They may be adopted for Indian soybeans also.

Similarly, all of these quality parameters may be adopted for Indian soybean since the same quality attributes are expected.

Soybean seed type and applications

Large seeded soybeans for tofu, soymilk, Edamam and soy nuts

Large seeded soybeans are mainly bred for tofu and soymilk production. They are moderately high in protein content with improved ratio of 7S/11S or lack of lipoxygenase and lower oil content. Tofu beans also have a high NSI or PDI, high water up take, low calcium and high germination rate. The yield and quality of tofu and soymilk are influenced by protein and oil content. A high protein/oil ratio provides a higher tofu yield and firmer texture. The taste of tofu and soymilk is closely related to soluble sugars in seeds. High total carbohydrates, high sucrose, low raffinose and low stachyose are highly desirable. Most tofu beans have large seeds (larger than 20 g/100 g) with yellow seed coat, yellow cotyledons, clear hilum and thin but strong seed coat that is free from cracking and discoloration.

Table 4. Other quality parameters (FGIS, 2004)

Character	Description	Method of measure
Protein and oil	Soybean protein and oil content	Standard chemical methods
Cracked seed coats	Sound soybeans that have readily discernible cracked seed coats, sound soybeans that have all or a part of the seed coat removed or sound soybeans that are ¾ or more of a whole soybean.	Visual inspection of approximately 125 grams after the removal of foreign material and damaged kernels.
Seed count	Number of seeds per unit weight.	Number of seeds per gram of approximately 25 grams after the removal of foreign material and non-whole soybeans.
Seed sizing	Percentage of soybean seeds passing through or remaining on top of a sieve size specified by the applicant for service,	Approximately 125 grams of soybeans, after the removal of foreign material, are sieved.
White (clear) hilum	Percent of whole soybeans with a clear white hilum. Up on request, tests for other hilum colors (buff, brown etc) can be provided.	Visual inspection of approximately 125 grams after the removal of foreign material and damaged kernels

Medium sized soybeans for bean sprouts, meal and oil

Soybeans with medium seed size (10 to 12 g/100 g) and a high germination rate are preferred for bean sprouts. High protein, high isoflavone, high sugar and lipoxygenase free soybeans are desirable for bean sprouts. For quality determination of soybean meal and soybean oil, National Oilseed Processors Association (NOPA) has developed standards for trading (Table 5).

Table 5. NOPA specifications for soy meal

Character	Maximum	Minimum
Protein		44%-49%
Fat		0.5%
Fiber	3.3%-7.0%	
Moisture	12%	
Urease activity	pH raises in between 0.12and 2.0 units.	
Lysine	2.85%	
Ash	<7.5%	
PDI	73-85%	

For crude de gummed soybean oil, the specific standards are (Table 6).

Table 6. Specifications for soybean oil

Analytical requirements	Maximum	Minimum
Un saponifiable Matter	1.5%	
FFA, as oleic	0.75%	
Moisture and volatile matter and insoluble impurities.	0.3%	
Flash point		250°F
Phosphorus	0.02%	
Iodine value	130-136 meq	
Peroxide value	2	

Besides the above soy products a number of other soy based foods are prepared for which the standards are proposed. The details are enumerated as under.

Other soybean products

Defatted soy flour

Table 7 shows the ASA recommended standards for defatted soy flour. It is made entirely from defatted soy meal and is currently used worldwide by commercial processors. Soy flour is also a common ingredient in blended food aid products and can also be fortified with various micronutrients (Table 7).

Table 7. Chemical and physical requirements

Character	Minimum	Maximum
Protein (Nx6.25), % As is	50	
Moisture, %		9.0
Fat, %		1.5
Crude Fiber, %		3.5
Ash, %		7.0
PDCASS	0.90	
Carbohydrates, %	20	
Standard Plate Count		50000/g
Salmonella	Negative	
E .coli	Negative	

Soy protein concentrate.

It is made wholly from defatted soy meal. Soy protein is flour like product consisting of about 70% protein and is being used in a variety of meat systems, baked foods and dairy applications. ASA has prescribed the following specifications (Table 8).

Table 8. Chemical and physical requirements

Character	Minimum	Maximum
Protein (Nx6.25), % As is	65	
Moisture, %		6
Fat, %		1.0
Crude Fiber, %		4.0
Ash, %		6.0
PDCASS	0.95	
Carbohydrates, %	20	
Material through a US standard sieve 100 screen	95	
Standard Plate Count		10000/g
Salmonella	Negative	
E. coli	Negative	

Soy protein isolates

It is made wholly from defatted soy meal and is used as an ingredient in high protein foods including dairy foods, nutritional supplements, meat systems, infant formulas, nutritional beverages, cream soups, sauces and snacks. It is also a good source of protein in milk replacers. Due to high protein content, it is highly suited for those people who have high protein needs due to growth (children), famine (acute needs) and chronic diseases (HIV/AIDS/tuberculosis). ASA has prescribed the following requirements (Table 9).

Table 9. Chemical and physical requirements

Character	Minimum	Maximum
Protein (Nx6.25)% As is	90	
Moisture, %		6
Fat, %		1
Crude Fiber, %		0.2
Ash, %		4.5
PDCASS	0.90	
Carbohydrates, %	4	
Material through a US standard 100 screen	95	
Standard Plate Count		10000/g
Salmonella	Negative	
E .coli	Negative	

Texturised soy protein

It is made wholly from either defatted soy meal flakes or soy protein concentrates. It is widely used as ingredient in ground meat for patties, sausages, and meal loaf, and in vegetarian foods and stews. ASA also prescribed the following standard (Table 10):

Table 10. Chemical and physical requirements

Character	Minimum	Maximum
Protein (Nx6.25), % As is	50	
Moisture, %		10.0
Fat, %		3.0
Crude Fiber, %		4.0
Ash, %		6.5
PDCASS	0.90	
Carbohydrates, %	20.0	
Standard Plate Count		50000/g
Salmonella	Negative	
E. coli	Negative	
Granule size	May vary from 1/16 inch to ¼ inch.	

Full fat soy flour

Full Fat Soy flour is used for fortifying the other cereals/millets/pulses at 10-15% level in the preparation of traditional recipes. It is available in sealed polythene bags and hermetically sealed metal containers. The shelf life is about one month at normal retail shelf temperatures. It is essential to ensure product safety. Gandhi (2008[a]) developed HACCP protocols for the production of better quality full fat soy flour with product safety. The suggested quality specifications are presented in Table 11.

Table 11. Quality Standard for Full Fat Soy Flour

Composition	Minimum	Maximum
Protein(Nx6.25)% as is	35	
Fat,%	18	
Crude Fiber,%		4.0
Ash,%		6.5
Moisture%		10.0
Physical parameters		
Granulation:	90% pass thru US sieve 200(0.074 mm)	
Microbiology:		
Total plate count, no/g		20000
Total coli forms,no/10g		10
*Salmonella,*no/100g	Negative	
E.coli,no/100g	Negative	
Staphylococcus,no/10g		100
Yeast,no/10g		100
Mold,no/10g		100
Other chemical characters		
Protein solubility,%	20	80
TIA	Less than 75% of the original	
Urease activity:	Nil	
Available lysine,g/6.gN	5.5	
Sensory parameters:		
Color:	Creamy to yellow	
Odor:	Less beany	
Taste:	Nutty	
Defects:		
Insect parts:	Total absence.	
Foreign material:	Total absence.	

Medium fat soy flour

Medium Fat Soy flour is used for fortification with other cereals/millets/pulses at 10-15% level in the preparation of traditional recipes. In chickpea flour and papad, it can be added up to 20 and 40%, respectively. It is available in sealed polythene bags (HDPE 400 microns) and hermetically sealed metal containers. The keeping quality is about six months at normal retail shelf temperatures and has to be used within a month after opening the packet. It is essential to ensure product safety. The package should give all the nutritional information and instructions to use. The suggested quality specifications are presented in Table 12 (Gandhi, 2008[b]).

Table 12. Quality Standard for Medium Fat Soy Flour

Composition	Minimum	Maximum
Protein(Nx6.25)% as is	45.0	
Fat,%		7.0
Crude Fiber,%		5.0
Ash,%		8.0
Moisture%		10.0
Physical parameters		
Granulation:	90% pass thru US sieve 200(0.074 mm)	
Microbiology:		
Total plate count, no/g		20000
Total coli forms,no/10g		10
*Salmonella,*no/100g	Negative	
*E.coli,*no/100g	Negative	
*Staphylococcus,*no/10g		100
Yeast,no/10g		100
Mold,no/10g		100
Other chemical characters		
Protein solubility,%	20	80
TIA	Less than 75% of the original	
Urease activity:	Nil	
Available lysine,g/6.gN	5.5	
Sensory parameters:		
Color:	Light brownish	
Odor:	Less beany	
Taste:	Nutty	
Defects:		
Insect parts:	Total absence.	
Foreign material:	Total absence.	
Black specks:	Total absence.	

Soy biscuits

Soy biscuits are consumed directly at any time either with tea or alone. They are available in sealed polythene bags (HDPE 400 microns)/laminated packages/ hermetically sealed metal containers. The shelf life is about six months at normal retail shelf temperatures, however, should be used within a month after opening the packet. It is essential to ensure product safety. The package should provide all the nutritional information. The suggested quality specifications are presented in Table 13 (Gandhi, 2008[b]).

Table 13. Quality standard for soy biscuits

Composition	Minimum	Maximum
Protein(Nx6.25)% as is	12.0	
Fat,%	5.0	
Crude Fiber,%		4.0
Ash,%		6.5
Moisture%		10.0
Microbiology:		
Total plate count, no/g		20000
Total coli forms,no/10g		10
*Salmonella,*no/100g	Negative	
E.coli,no/100g	Negative	
Staphylococcus,no/10g		100
Yeast,no/10g		100
Mold,no/10g		100
Other chemical characters		
Protein solubility,%	20	80
TIA	Less than 75% of the original	
Urease activity:	Nil	
Available lysine,g/6.gN	5.5	
Sensory parameters:		
Color:	Creamy to yellow	
Odor:	Less beany	
Taste& texture	Nutty& crunchy	
Defects:		
Insect parts:	Total absence.	
Foreign material:	Total absence.	
Black specks:	Total absence.	

Soy bread

Soy bread is consumed directly at any time either with tea or alone. It is available in sealed polythene bags (HDPE 400 microns)/laminated packages. It will be fresh for 6 day's at normal retail shelf temperatures. It is essential to ensure product safety. The package should give all the nutritional information. The suggested quality specifications are presented in Table 14 (Gandhi, 2008[b]).

Table 14. Quality standard for soy bread

Composition	Minimum	Maximum
Protein(Nx6.25)% as is	30.0	
Fat,%	1.5	
Crude Fiber,%		4.0
Carbohydrates,%		40.0
Ash,%		6.5
Moisture%		40.0
Microbiology:		
Total plate count, no/g		20000
Total coli forms,no/10g		10
Salmonella,no/100g	Negative	
E.coli,no/100g	Negative	
Staphylococcus,no/10g		100
Yeast,no/10g		100
Mold,no/10g		100
Other chemical characters		
Protein solubility,%	20	80
TIA	Less than 75% of the original	
Urease activity:	Nil	
Available lysine,g/6.gN	5.5	
Sensory parameters:		
Color:	Creamy to yellow	
Odor:	Less beany	
Taste& texture	Nutty & soft	
Defects:		
Insect parts:	Total absence.	
Foreign material:	Total absence.	
Black specks:	Total absence.	

Table 15. Quality standard for soy milk

Composition	Minimum	Maximum
Protein(Nx6.25)% as is		4.0
Fat,%		2.0
Crude Fiber,%		4.0
Carbohydrates,%		3.0
Ash,%		6.5
Moisture%		80.0
Microbiology:		
Total plate count, no/g		20000
Total coli forms,no/10g		10
Salmonella,no/100g	Negative	
E.coli,no/100g	Negative	
Staphylococcus,no/10g		100
Yeast,no/10g		100
Mold,no/10g		100
Other chemical characters		
Protein solubility,%	20	80
TIA	Less than 75% of the original	
Urease activity:	Nil	
Available lysine,g/6.gN		
Cholesterol	5.5	
Lactose	Nil	
SF,%	Nil	15.0
USF,%		65.0
Sensory parameters:		
Color:	Creamy to yellow	
Odor:	Less beany	
Taste:	Nutty	
Defects:		
Insect parts:	Total absence.	
Foreign material:	Total absence.	
Black specks:	Total absence.	

Table 16. Quality standard for soy paneer

Composition	Minimum	Maximum
Protein(Nx6.25)% as is	5.0	
Fat,%	3.0	
Crude Fiber,%		1.0
Carbohydrates,%	2.0	
Ash,%		6.5
Moisture%		90.0
Microbiology:		
Total plate count, no/g		20000
Total coli forms,no/10g		10
Salmonella,no/100g	Negative	
*E.coli,*no/100g	Negative	
Staphylococcus,no/10g		100
Yeast,no/10g		100
Mold,no/10g		100
Other chemical characters		
Protein solubility,%	20	80
TIA	Less than 75% of the original	
Urease activity:	Nil	
Available lysine,g/6.gN	5.5	
Iron, mg	1.8	
Calcium, mg	1.0	
Phosphorus, mg	0.95	
Vitamin,B_1,mg	0.05	
Vitamin B_2,,mg	0.04	
Nicotinic acid, g	0.5	
Sensory parameters:		
Color:	Creamy to yellow	
Odor:	Less beany	
Taste:	Nutty	
Defects:		
Insect parts:	Total absence.	
Foreign material:	Total absence.	
Black specks:	Total absence.	

Soy milk

Soy milk (plain/flavored) is ready to drink and applicable to all sections of people suffering from lactose intolerance (Infants/youth/old/pregnant etc). The soymilk may consist of pure water, soybean extract, sugar and salt. It has 3-4% protein, 1.5-2.0% fat and 8-10% carbohydrates. Flavored soymilk may consist of pure water, soybean extract, sugar, salt, flavors and permitted food colors. Plain soy milk is packed in 200/500 ml polythene bags/ glass bottles/ tetra packs. The soy milk has shelf life of six months when packed in tetra packs or else for few weeks under refrigerated conditions. It has to be stored and distributed at ambient temperature. It is essential to ensure product safety. The suggested quality specifications are presented in Table 15 (Gandhi, 2008[b]).

Soy paneer (Tofu)

It is also known as soybean curd and is a good source of protein and isoflavones. It is made by adding calcium or magnesium salts to soy milk, which enables the soy protein to coagulate to form curd. A simple and low cost technology for making tofu was developed at domestic level. When the tofu is made with calcium, calcium becomes an essential component. The texture of tofu can vary from extra firm, firm, soft and silken, can be used in almost any culinary capacity. Extra firm tofu is best used for marinating and cutting in to cubes for a stir-fry. The softer one is used for desserts or other foods those require wetter consistency. Again it is essential to ensure product safety. The suggested quality specifications are presented in Table 16 (Gandhi, 2008[b]).

Conclusion

High quality soybeans and soy based foods are generally preferred and the standards available will assist the producer and consumers in the selection of the best based on various physical and chemical characteristics and end-use. These standards will be useful for all the people concerned with the soybean industry globally.

References

AACC. 2004. Approved Methods of AACC, American Association of Cereal Chemists: St. Paul, Minnesota.

AOAC. 2004. Official Methods of Analysis of AOAC, International. Association of Analytical Chemists international, Gaithersburg, Maryland.

AOCS. 2004. Official Methods and Recommended Practices of the AOCS, The American Oil Chemists Society, Champaign, Illinois.

AOSA. 2003. Rules for testing Seeds, 2003. The Association of Official Seed Analysts, Las Cruses, New Mexico.

Dudley-Cash, W.A. 2003 Soybean meal quality, ASA, Brussels, Belgium.

FGIS. 2004. Federal Grain Inspection Service Reference Methods and Laboratories/Optional Quality assessment Services.

Gandhi, A. P. 2006**.** Soybean-the greater bean, World Grain (USA), February issue, p 59-62.

Gandhi, A. P. 2008 Development of HACCP Procedure for the production of full fat soy flour. International Food Research Journal 15(2): 141-154.

Gandhi, A. P. 2008 Development of HACCP procedures for the production of soy based food and their evaluation, un published Project Report.

Hurburgh, C. R. and TJ Brumm, T. J. 2004. Grain Quality in Managing Grain after Harvest, Bern, C. J. and Bern, T. J. B. Ed, ISU, Ames.

NOPA. 1997-1999. National Oilseeds Processors Association, Year Book and Trading Rules, Washington, DC.