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Application of HACCP Protocols for the Production of Soy milk

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Abstract : The Hazard Analysis Critical Control Point (HACCP) system aims at ensuring the safety of food products. Such a procedure has been developed for the production of soy milk. The hazards, critical control limits, observation practices and corrective actions have been summarized in comprehensive tables. Further more, the production process was meticulously analyzed for drafting such HACCP protocol for the production process.

Key words: Soybean, soy milk, hazard, HACCP, critical limits, critical controls.

Introduction

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About 840 million people were undernourished and 799 millions were from the developing countries. In India 233.3 millions were under nourished comprising about 24% of the total population (FAO, 2002). Hence there is every need to save millions of lives every year. This can be combated through dietary diversity and food fortification along with supplements. In this context soybean (*Glycine max* M) with 40% protein and 20% fat assumes the most predominant position in solving the nutritional imbalances prevailing. It not only provides the quality macronutrients but also various other micronutrients, which are otherwise required to fight against the hidden hunger. Efforts are being made to popularize various soy-based foods besides the oil, which is very popular in India. In India about 9.3 million tones of soybeans are produced annually and 80% is utilized for oil extraction. Only 10% is available for direct food uses. The extruded soy chunks are very popular but too expensive and beyond the reach of a common man. Among various foods soy milk is having a great potential, as it can be prepared at domestic level using the assets available. People are more health conscious now. Lactose intolerance is on the increase. Soy drinks are much more palatable than in the past. A simple method was developed and scaled up for the production of soy milk. (Gandhi,1983&Gandhi *et al 1987).*

HACCP has become synonymous with food safety. (FAO 1995). It is a world wide recognized systematic and preventive approach that addresses biological, chemical and physical hazards through anticipation and prevention rather than through end-product inspection and testing. Prior to application of HACCP the production of soy milk should be according to Codex General Principles of Food Hygiene, the appropriate Codex Codes of practice and appropriate food safety legislation. Management commitment is necessary for implementation of an effective HACCP system. In the present investigation efforts were made to develop

HACCP protocols for producing soy milk of superior quality with utmost safety.

Materials and Methods

The soybean variety JS 335 was obtained from the Institute Farm. It was cleaned thoroughly and made free from all the dirt, stubbles and other foreign matter. It was stored in air tight containers till further use. The soy milk was produced using the process developed by Gandhi *et al* (1984). AOAC (1990) methods were used for analyzing various chemical constituents and APHA (1984) recommended methods were used for microbiological examination of the products. All the chemicals used were of the analytical grade and the experiments were conducted in triplicate and the mean values were computed for assessment. FAO/WHO (2006) guidelines were used for the preparation of HACCP plans.

Results

Soymilk (plain)/flavored milk

Strictly speaking soy milk is a water extract of whole soy beans. It is an off white emulsion/suspension containing the water soluble proteins and carbohydrates and most of the oil of the soybeans. Plain: Bean to water ratio 1:5 contains 4% protein. Dairy type soymilk: Bean to water ratio 1:7 and contains 3.5% protein. Slightly sweetened and contains oil, salt and imitation flavors. Soy beverages: Bean to water ratio 1:20 and contains 1% protein. Cultured products: Any of the above after lactic acid fermentation or acidification with lactic acid. Blends: Mixtures of soy milk and other vegetable or dairy milks.

Soybean types required for making soy milk

Large seeded soybeans. (larger than 20 g/100) with a yellow seed coat, yellow cotyledons, clear hilum and thin but strong seed coat. The beans should have moderately high in protein content and lower oil content with improved ratio of 7S/11S and lack of lipoxygenase High NSI, high water uptake, low calcium and high germination rate are essential. A high protein/ oil ratio provides a higher tofu yield and firmer texture. Taste is closely related to soluble carbohydrates content in seeds. High total carbohydrates, high sucrose, low raffinose and low stachyose, are highly desirable.

Preparation of soymilk

The soy milk was prepared with and without HACCP procedure for comparison. The detailed protocols were prepared and presented. The product description which should be after final preparation is given in table1

Table 1 Product description

1. Product name	Soy milk(plain/flavored)
2. Important product characteristics of end product	A_w < 0.5; FFA < 1%; Total microbial counts < 50000/g. 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.
3. How the product is to be used	Plain/flavored milk is ready to drink and applicable to all sections of people suffering from lactose intolerance. (Infants/youth/old/pregnant etc).
4. Packaging	Plain soy milk is packed in 200/500 ml polythene bags/ glass bottles/tetra packs,
5. Shelf-life	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.
6. Where the product will be sold	Retail, institutions and food service. Could be consumed as a health food.
7. Labeling instructions	Required to ensure product safety.
8. Special distribution control	No physical damage, excess humidity or temperature extremes.

The identified biological, chemical and physical hazards related to the production of soy milk are given in Table 2.

Table 2 Product ingredients and incoming material

Raw material	Packaging material	Dry ingredients
Soybeans B, C, P	Polythene bags B, C, P	Sodium bicarbonate B, C, P
Other		
Water (municipal) B, C		

Flow diagram

Soybeans	**Packaging material**	**Dry ingredients**	**Water**
1. Receiving P	2.Receiving P	3. Receiving P	4. In taking
5.Storing B P	6.Storing B C P	7. Storing B C P	
8. Cleaning P	9.Inspecting B P	10. Dumping	
11. De hulling P			
12. Soaking B C			13. Chlorinating
14. Wet grinding B C			
15.Filteration/coagulation B P C			
16. Homogenization B P C	17.Filling C P		
	18.Weighing B		
	19.Closing/sealing B		
	20.Inspecting B P		
	21. Labeling B		
	22. Storing B		
	23.TransportB		

B= biological;C=chemical;P=physical

The details of all identified hazards are enumerated in Table 3.

Table 3 Identified Hazards

	Biological Hazards	**Chemical Hazards**	**Physical Hazard**
Ingredients / Materials			
Soybeans	could contain soil borne/ air borne pathogenic organisms, yeasts or moulds	could contain pesticide residues could contain mycotoxins.	could be contaminated with harmful extraneous materials namely glass, metal, plastic, wool etc.
Dry ingredients	could contain microbial contaminants. could contain rodent excrements		could be contaminated with harmful extraneous materials
Soybeans Receiving			inadequate protection against harmful extraneous material could result in contamination
Dry Ingredient Storage		could be contaminated with non food chemicals as a result of improper storage	
Dry Ingredient Receiving			in adequate protection against harmful extraneous material could result in contamination
Water	could contain microorganisms	could be contaminated with toxic substances	
Packaging Material	could contain defects which could result in leakage		
Processing Steps			
Dehulling	could be contaminated with microorganisms		
Soaking	could contain microorganisms		

Grinding	could contain heat resistant spores	cleaning chemical residues could contaminate the beans. if live steam is used, boiled water additives could carry over and contaminate the product	
Filtration	could be contaminated with microorganisms		
Weighing	overfilling may lead to leakage and prone to contamination		
Transport	physical damage to packages results in leakage and contamination of product		

The next step is identification of Critical Control Points (CCPs). The CCP determination is shown in Table 4.

Table 4 CCP determination

Process step/incoming materials	**Category and identified hazard**	**Q_1**	**Q_2**	**Q_3**	**Q_4**
Soybeans	B=Pathogens	Yes	Yes	Yes	Yes, therma processing
	C=Pesticides	No(farmers/growers level-GPP)			
	C= heat stable toxins	No(farmers/growers level-GPP)			
	P= harmful extraneous material(HEM)	Yes(visual inspection and foreign object removal)	Yes	Yes	No
Packaging materials	B=pathogens	Yes	Yes	Yes	Yes, sterilization
Dry ingredients as delivered	B= bacterial spores B=rodent excretes(GMP) P=HEM(GMP)	Yes	N/a	Yes	Yes, therma processing
Water at intake	B= GMP C= heavy metals & other toxins(GMP)				
Cleaning and grading of soybeans	P=GMP				
Dehulling of soybeans	B	Yes	Yes	Yes	No
Soaking of soy splits	Water(GMP) Sodium bi carbonates (0.5%)				
Grinding/cooking in water	B C	Yes	Yes	Yes	No
Filtration	B C	Yes	Yes	Yes	No
Filling	P(GMP)				
Weighing	P(GMP)				
Packaging and sealing	B	Yes	Yes	Yes	No

Instructions

- Category and identified hazard: Controlled by Codex General Principles of Food Hygiene, if yes indicate GMP and proceed to next hazard. If no proceed to question 1.
- Q_1: Do control preventive measures exist, if no, not CCP; if yes proceed to next.
- Q_2: Is this operation specifically designed to eliminate, if no proceed to Q3. if yes CCP and identify it in the last column.
- Q_3: Could contamination with identified hazards occur in excess of acceptable levels, if no, not CCP. If yes Proceed to Q4.
- Q_4: Will subsequent operation controls the contamination levels, if no CCP; if yes not CCP.

Some of the unaddressed hazards connected to this process are presented in Table 5.
The detailed HACCP plans are given in Table 6.

Table 5 Unaddressed Hazards

Unaddressed hazard from previous list	Identified methods of addressing the hazard
Soybeans could contain pesticide residues	Up stream(farm level) programs such as A: Training persons who apply pesticides. B: Purchasing registered pesticides for growers. C: Auditing growers application of pesticides and records there of. D: Requiring periodic pesticide residual analysis reports.

Table 6 HACCP Plan

Process step	CCP No	Hazard description	Critical limits	Monitoring procedure	Deviation procedures	HACCP records
De hulling	1	Inefficient de hulling may cause the contamination of the product with the micro organisms.	Less than 0.1%	On line check of the sample.	Line operator to adjust the clearance of the de huller drums.	Operator log book
Blanching /cooking	2	In adequate heat treatment	Cook the splits as specified in the scheduled process(under pressure/open vessel boiling)	Check the quality of splits for urease test	Operator should adjust the time and temperature as per the authorized contingency plan and to inform the QC.	Operator log book.
Drying(Sun/mechanical)	3	Improper drying	The moisture content should be less than 8%-10%.	Check the moisture content as per the guide lines.	If moisture content is greater the splits may be dried again and inform QC	Operators log book.
Packaging and sealing	4	Over filling, improper gauge polythene and improper sealing	Max fill weight as specified in the scheduled process. Proper sealing leaving recommended space.	On line check to reject over and under filled bags and improperly sealed bags.	Line operator to adjust the settings.	Operators log book and quality control report.

The HACCP for general activities are also enumerated in Table 7.

Table 7HACCP for general activities:

Stage	Activity	Control activity
Raw material harvest	Liaison with the farmers for unit operations like harvesting, threshing and winnowing.	Specifications of grain quality are required. Rejection of under sized seeds.
Raw material transport	Transport in sacks to drying area.	Correct sacking and handling.
Raw material inspection	Sampling and routine inspection.	Correct sampling methods, training and inspection methods.
Preparation of seeds	Cleaning, grading, dehulling, conditioning and blending.	Training operators for equipment, preventing insect infestations, check for moisture content.
Packaging	Filling in to containers and sealing.	Establish specifications for labels and fill weights.

Description of soy milk manufacturing process: Implementation of HACCP.

Receiving soybeans (CCP-1): Soybeans must come from approved dealers. At the time of its receipt it must be accompanied with its complete quality certificate and microbiological assessment reports. The certificates should indicate the moisture content of the beans, degree of foreign materials and the micro organisms present (number of colonies), insects etc as compared to the upper approved standards of BIS/ISO. At the time of receipt, visual control of soybeans must be carried out to find out the contaminants if any. Further more the proximate composition of the beans must be established with reference to its macro and micro nutrients. Defective beans mean that the soy flour will be most likely unsafe for the consumption. Soybean variety may play an important role. Bold seeded varieties are preferred.

Storage of soybeans in silos (CCP-4): The temperature (<20^{o}C) and the relative humidity (<65%) during the storage must be low. They should be recorded at regular intervals. If any deviation from the safer limits, must be immediately rectified. When soybean is stored for a long period, microbiological analysis should be carried out.

Receiving secondary materials (greasing, detergents, insecticides, pesticides and sacs) (CCP-2): These materials must be procured from the approved suppliers with quality certificates. These materials must be suitable for using them with food items. No contamination must come from the packaging materials. If these materials do not comply with the standard specifications, must be returned to the suppliers and a new order should be placed with other suppliers.

Storage of secondary materials: The temperature and relative humidity during storage must be below 20^{o}C and 65% respectively. The place should be air conditioned. The temperature and RH should be continuously recorded and corrective actions must be undertaken whenever any deviation occurs.

Application of anti insect methods (CCP-5): Any chemicals used during storage along with the soybeans should comply with the safety legislations. The quantity should be with in the prescribed concentrations.

Cleaning & grading of soybeans (CCP-6): All the physical contaminants should be removed. They should be graded. Only sound soybeans should be taken for processing.

Removal of stones: The stones, metals and dust must be removed from the soybeans so that the final product will comply the quality standards as prescribed by BIS/ISO.

Storage of soybeans in silos: The temperature and relative humidity must remain low i.e. <20^{o}C and <65% temperature and relative humidity respectively. They should be recorded regularly and corrective actions should take place when deviated from the routine. When it is stored for a long time. Microbiological analyses should be done.

Weighing: the soybeans are weighed and passed through a magnetic system so that the magnetic materials are removed.

Steeping: As per the quality standards of water prescribed by the GFHP and food grade chemicals. The duration of soaking depends on the season. In winter long durations are required as compared with summer. In general 4-8 hours soaking may be opted .The moisture content of the soaked beans may be about 45%(wb).

Grinding: Type of grinders used is very critical. In general burr/colloidal/hammer mills are in vogue. The grinding may be done in two stages. Hot water may be used while grinding for inactivation of lipoxygenase which may improve the flavor. The bean to water ratio depends on the type of milk to be prepared. In general 1:8 (w/v) is preferred for plain milks and for beverages still higher dilution factor may be considered.

Cooking: Pressure cooking at 1.2kg.cm^2& temperature 121^{o}C for 40 minutes is preferred to inactivate all the anti nutritional factors.

Filtration: Use decanter centrifuge/rotating drum filter/batch type filters. Speed of the centrifuge or drums should be adjusted to get maximum residue separated.

Homogenization: Thorough mixing of the oil/emulsifier as per the required quantity before homogenization. Homogenize at 3500 psi for 30 minutes. Standardization of soymilk base by adding ingredients like sugar syrup, water, flavors (flavored milk) may also be done during this process.

UHT/pasteurization: Treatment of soy milk in UHT plant or direct pasteurization.

Packaging (CCP-10): During packaging the milk can possibly be contaminated with the micro organisms causing quality deterioration. This can be avoided by hermetic sealing and upright position of the packaging material. There should not be any migration of the low molecular weight substances from the packages. Further more contamination can take place from foreign materials like insects and rodents that accidentally happen to be packed with the flour. The personnel should comply with the (Good Manufacturing Process).

The pasteurized product(75^{o}C for 15 sec) can be filled in cartons, plastic bags, glass or plastic bottles. The product should be stored under refrigeration and has then a shelf life of approximately one week. The UHT treated product(140^{o}C for 4 sec) should be aseptically packed in cartons, plastic bags or plastic bottle. The shelf life is up to several months in ambient temperature. No preservatives are involved. It provides adequate shelf life and a product with good flavour and nutritional value. In bottle/can, sterilized soy milk(120^{o}C for 20 min) has the longest shelf life but is also a less nutritious product. Taste and appearance are also affected. Crate/outer box/transport container: The outer container in which the individual packages or bottles are stored and transported should be considered early on in the planning of a suitable packaging system.

Metal detector (CCP-7): The packed product passes through a metal detector. The product is then checked for its weight and placed in boxes (secondary packaging). The boxes are placed on the pallets and the packets are wrapped with film.

Storage: The storage temperature and relative humidity must be below 20^{o}C and 65% respectively. The place should be air conditioned. Both the temperature and relative humidity must be recorded regularly and corrective actions must be undertaken whenever deviation occur

Product quality

The product quality was tested with and with out HACCP and the results are shown in Table 8.

Table 8 Quality assessment of the Soy milk

Quality standard expected	With out HACCP	With HACCP
Composition:		
Protein:		
a maximum of 4%	3.2%	4.3%
Fat:		
a maximum of 2%	1.6%	2.0%
Carbohydrates		
A maximum of 3%	2.2%	3.0%
Crude Fiber:		
a maximum of 4%	5.0%	3.7%
Ash:		
a maximum of 6.5%	4.4%	3.3%
Moisture:		
a maximum of 80%	80%	80%
Microbiology:		
Total plate count:		
20,000/g max	30,000/g	6,000/g
Total coli forms:		
100/10g max	130/10g	Nil
Salmonella:		
Negative/100g	20/100g	Negative
E.coli:		
Negative/100g	15/100g	Negative
Staphylococcus:		
100/10g maximum	135/10g	Nil
Yeast:		
100/10g maximum	100/10g	Nil
Mold:		
100/10g max.	112/10g	Nil
TI:		
less than 75% of original.	<50%	<80%
Urease activity:		
Nil	Nil	Nil
Available lysine:		
Min 5.5g/6g N	5.2g/6gN	g/6gN
Sensory parameters:		
Color:		
Creamy to yellow	Yellow	Creamy
Odor:		
Less beany	Beany	Less beany
Taste:		
Nutty	Nutty	Nutty
Defects:		
Insect parts:		
Total absence.	Absent	Absent
Foreign material:		
Total absence.	Absent	Absent

Table 9 Synoptical presentation of hazards, CC limits, observation procedures, monitoring and corrective measures for production of soymilk.

Process step	Hazard description	Critical limit	Observation procedures		Responsible	Monitoring procedures	Corrective actions
			Control CCP	Frequency			
Receiving of soybeans(CCP-1)	Presence of foreign matter in soybean(P) Growth of micro organisms(B) Insects Fungi	5% Absence Out of five samples two of them 10^2-10^4 cfu/g, Humidity <13% Protein: 38-40% Other quality parameters as per standards.	Visual control of sample/control of the certification per lot. Control of the certification.	Per lot	QAM	Control of specifications and provide quality certificates from suppliers.	Rejection of lot and or change the suppliers**.**
Receiving of secondary materials(greasing agent, detergents, insecticides, pesticides, sacks etc(CCP-2)	Chemical substances migrating from secondary materials.	Materials suitable for food contact.	Control of the certification.	Per lot	QAM	Control of specifications and provide quality certificates from suppliers.	Rejection of lot and or change the suppliers**.**
Receiving of packaging materials(CCP-3)	Low molecular weight compounds migrating from packaging materials.	No migration.	Control of specifications.	Per lot.	QAM	Observations of the specifications and supply quality certifications from the suppliers. Evaluation of the suppliers.	Rejection of the lot and/or change of the supplier.

Water(CCP-4)	Total coli forms(B) Faeces Coli forms(B) Faeces Streptococcus(B) Sulphur reducing Clostridium(B) Presence of undesirable and toxic substances in water(eg. Heavy metals, ammonia, hydrocarbons, parasites, nitrates). Excessive quantity of residual chlorine© . Presence of foreign materials (P).	In agreement with the community legislation 80/778 for potable water. “ “ “ “	Lab control of water quality. “ “ “ “	Monthly. “ “ “ “	QAM “ “ “ “	“ “ “ “ “	“ “ “ “ “
Storage of soybeans in silos(CCP)	Growth of micro organisms (B) & insects. Fungi(B)	Absence In five sample two of them 10^2-10^4 cfu/g. Humidity < 13% Temp: < 25°C Air Conditioning.	Quality control Monitoring and recording the humidity and temperature.	Per lot Daily	QAM QAM	Control of specifications. “	Rejection of lot unsuitable. “
Steeping	Quality of water & chemicals used.	As per the quality standards of water prescribed by the	Inspection of the quality certifications	Per lot	Production Manager	Control of specifications.	Rejection of lot unsuitable.

	Steeping time and temperature of the water	GFHP and food grade chemicals. Set them as described in the process.	Recording of temperature and timings.	Per lot	Production Manager	Control of conditions as per the season.	Repair and maintenance of the equipment and rejection of lot if not properly steeped.
Grinding	Type of grinder: burr/colloidal/ hammer mills Addition of hot water if required.	Highly efficient grinding systems and in two stages.	Inspection of the quality of the mash and determine the TSS.	Per lot	Quality Testing personnel	As per the prescribed standards.	Adjustments of the grinding systems to get the desired particle size prior to operation, otherwise replace the units.
Cooking	Pressure cooking at 1.2kg.cm^2& temperature 121^{o}C for 40 minutes	Precise control of pressure, temperature and holding time.	Inspection of the cooking systems and recording the parameters.	Per batch	Production Manager	Control of conditions.	Maintenance of the systems prior to use and repair in case required, otherwise replace them.
Filtration and deodorization	Use decanter centrifuge/rotating drum filter/batch type filters.	Speed of the centrifuge or drums should be adjusted to get maximum residue separated. Monitoring the	Inspection of the units.	Every run	Production Manager	Control of conditions.	Maintenance of the systems prior to use and repair in case required, otherwise replace them.

	Deodorization under vacuum	vacuum and inspection of the quality of the extract.	Control the vacuum and recording the data.	Per lot	Production Manager	Control of conditions	
Addition of additives	Standardization of soymilk base by adding ingredients like sugar syrup, water, flavors (flavored milk).	All the dry ingredients must be of food grade.	Control of quality specifications of the ingredients and concentrations to be used for standardization. The exact composition of the product must be controlled.	Per batch	QAM	Observations of the specifications and supply quality certifications from the suppliers. Evaluation of the suppliers	Rejection of lot and or change the suppliers**.**
Homogenization	Use of good quality vegetable oil/emulsifier.	Thorough mixing of the oil/emulsifier as per the required quantity before homogenization. Homogenize at 3500 psi for 30 minutes.	Control of specifications.	Per lot	Production Manager	Observations of the specifications and supply quality certifications from the suppliers. Evaluation of the suppliers. Recording the pressure of the homogenizer and time of holding.	Prior maintenance of the system
UHT/Pasteurization	Treatment of soy milk in UHT plant or direct pasteurization.	Control of steam and temperature.	Good quality instruments fitted with the systems for recording	Per lot	Production Manager	Evaluation of the units regularly.	Maintenance of the units.
Weighing	Correct weighing measures as required	Control of weights.	Weighing scales or automatic weighing and filling units must be inspected for their accurate weights.	Per batch	Production Manager	Evaluation of the units regularly.	Maintenance of the units.

Discussion

The results clearly indicated that the soy milk produced was of better quality as compared to the traditionally prepared one. This is mainly due to the adoption of good manufacturing practices, good food hygiene practices and standard operating procedures. The HACCP protocols thus control every stage of processing and yields a better quality and safe product which was missing in the traditional processing where the end product testing exit. Thus results indicate the importance of the HACCP for producing safe and quality Soy milk.

CONCLUSION

HACCP procedures were developed for making Soy milk with utmost quality and safe for use. It will have great export potential as per the International standards.

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