



Effects of HACCP Implementation on Quality Attributes of Fortified Bakery Products in the Food Industry of Bangladesh

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ABSTRACT

The research was conducted to find out the effect of implementation of HACCP in a baking industry. The quality attributes such as microbial count and compositional analysis were done to find out the positive effect. High energy fortified biscuits was prepared as influenced by different levels of soy flour protein and wheat flour gluten content of the biscuit recipes in a food industry before food safety implementation. Packaging study was also conducted by high density polyethylene up to 90 days of storage showing moisture content just above Bangladesh Standards and Testing Institute (BSTI) requirement at 90 days for the samples S₁, S₂ and S₃. Moisture%, Protein %, fat%, sucrose % and iron content remained acceptable considering BSTI requirements. Sample S₁ containing highest soy flour protein and wheat flour gluten estimated highest protein %, fat% and iron content compared to sample S₂ and S₃. Microbial qualities of biscuits found acceptable at initial storage regardless of microbial quality of raw materials. Sensory qualities of biscuits were also evaluated which showed the sample S₃, treated with lowest amount of soy flour protein and wheat flour gluten, was the most preferred biscuit with respect to all the quality attributes. Though the high energy fortified biscuit has compact source of energy, packaging condition was not sufficient to hold moisture content as BSTI standard level during 90 days of storage.

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Introduction

Biscuits have become one of the most desirable snacks for both young and elderly people due to their low manufacturing cost, more convenience, long shelf-life and ability to serve as a vehicle for important nutrients. Biscuits are not considered as staple food as bread likely feasible fiber carriers because of their longer shelf-life and thus enable their large scale production and widespread distribution (Vratania and Zabik, 1978; Townsend and Buchanan, 1967). The protein content of cookies may be achieved through the incorporation of protein rich ingredients (McWatters, 1978). The low calorie products may be developed by adding bulking agents possessing high moisture absorption ability resulting in the reduction of calories by one-third (Nagi *et al.*, 2012). Bakery products are considered to be the better vehicles for fortification. Therefore, keeping in view the above factors, the present study was carried out to develop the high energy fortified biscuits which would serve the functional food industry. Inappropriate planning of production and distribution causes either overproduction resulting in loss of materials or unavailability of products, which require additional production and deliveries leading to customer complaints and failure costs. To support quality and food safety European legislation requires the implementation and the application of the Hazard Analysis Critical Control Point (HACCP) principles in all units which are involved in the production, transportation, deposition of foods. HACCP is a proactive risk management system that contains all steps of

food chain, from raw material manufacturer to end product and analyzes possible dangers and guard. 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 and thereby reducing the food-borne illness (Gandhi, 2009). Oxfam recommend that a food supplement containing 500Kcal (2.09 mJ) (8% of which should be supplied by protein), should be eaten each day (Oxfam, 1980). The use of biscuits to achieve the required levels of energy and protein supplementation has been proposed by a number of authorities (Buchanan and Townsend, 1969; Chablaix, 1980). High energy biscuits (HEB) are wheatbiscuits containing high-proteincereals and vegetable fat. Because of their high energy-to-weight ratio they are procured by the World Food Programme, the food aid branch of the United Nations, for feeding disaster victims worldwide. The main objectives of this study were to implement Hazard Analysis and Critical Control Point (HACCP) in a large plant called Nabisco Biscuit & Bread Factory and to compare and assess the quality and productivity before and after implementing food safety.

Materials and Method

Preparation of fortified high energy biscuits sample:

Wheat and Soy flour was collected from ten local suppliers with coded name A to J and was analyzed for wheat flour gluten %, soy flour protein % and moisture %. Three coded samples were selected on the basis of maximum wheat

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flour gluten and soy flour protein contents. Those coded samples were used for making three sample recipes S₁, S₂ and S₃. S₁ sample of high energy fortified biscuit was prepared using the bakery recipe with G coded wheat flour and soy flour. S₂ sample of high energy fortified biscuit was prepared using the bakery recipe with E coded wheat flour and soy flour. S₃ sample of high energy fortified biscuit was prepared using the bakery recipe with H coded wheat flour and soy flour.

Table 1. Wheat flour and Soy flour quality from local suppliers.

SL No	Name of the Supplier	Sample code	Wheat flour gluten%	Soy flour Protein %	Moist ure %
1	Mat sea flour mill	A	30%	36%	10.71
2	Mamun flour mill	B	28%	35.51%	13.56
3	Diamond flour mill	C	34%	36.5%	12.33
4	Pacific flour mill	D	29%	35%	13.62
5	City flour mill	E	41%	40.09%	12.71
6	Sonali flour mill	F	28%	33.47%	13.78
7	Bashundhara flour mill	G	44%	45.66%	12.88
8	Anchor flour mill	H	38%	37%	12.47
9	Raj flour mill	I	30%	36.35%	13.63
10	Mafiz flour mill	J	32%	32.27%	11.60

Water, ammonium bicarbonate, sodium bicarbonate, salt, vitamin and nutrient premix, soy flour, dalda and hydrogenated vegetable oil mixed initially by homogenization as premix. Final dough formation was done by final mixing with premix, wheat flour and sugar. After moulding and cutting, biscuit shape was formed. Baking was done with 200 – 350 °C for 6 to 10 minutes. Cooling was done in room temperature. The biscuits were packed in high density polyethylene bags using as primary packaging and stored under ambient conditions (21-30°C and 62-85% RH) with packaging materials. Biscuit from wheat and soy flour composite will be acceptable in terms of colour, aroma and overall acceptability (Oluwamukomi et al., 2011).

Determination of different quality attributes

Wet Gluten was determined based on the Glutomatic Gluten Washer and Gluten Index Centrifuge and provides information on both quantity and quality of wet gluten. The total weight of the gluten was defined as gluten quantity. The percentage of wet gluten remaining on the sieve after centrifugation was defined as the Gluten Index. Moisture content was determined adopting AOAC (2002) by oven dry method. Protein content of samples was determined by using traditional Kjeldahl method (Rangana, 1991). The Soxhlet extraction method was used for fat determination (Meatupdate, 1998). An aliquot of the filtrate obtained in reducing sugar method was taken and inverted it with Hydrochloric acid in a water bath at 60°C by keeping for 10 minutes. It was made upto volume and determined reducing sugar by Lane and Eynon method. The iron content in biscuit was determined according to the method described by Ahmed et al. 2015 where Shimadzu (Kyoto, Japan) (Model-1800) double-beam UV-VIS spectrophotometer was used to measure the absorbance.

Microbiological analysis

Total Viable Count, Enterobacteriaceae (Total Coliform), *Escherichia coli*, *Salmonella* spp. and Yeast and mold count of wheat flour were also determined according to the “Recommended method for the Microbiological Examination of Food”, Published by American Public Health association (APHA, 1967).

HACCP implementation method

This research study did not use quantitative research. The purpose of this study was to design a HACCP model that is implementing in real situation. This study matched a qualitative approach. It gives the details of phenomena that are difficult to convey with quantitative methods. Qualitative research is exploratory and open-minded which is applicable to this study (Patton, 1987).

Statistical Analysis

All biscuit sample data were analyzed statistically. ANOVA was used for determining significance / non significance data. SPSS 11.5 version was used to analyze the data.

Results

Changes in microbial counts

Only the total viable count can be found before and after HACCP implementation in this sample of high energy fortified biscuit.

Table 2. Microbial counts of high energy fortified biscuit samples before HACCP implementation.

Days	SI No.	Test Parameters	Results of S1 (CFU/g)	Results of S2 (CFU/g)	Results of S3 (CFU/g)	Permissible Max. Level (CFU/g)
0	1	Total Viable Count (TVC)	4×10^2	3.5×10^2	5×10^2	10^4
	2	Enterobacteriaceae (Total coliform)	Nil	Nil	Nil	$<10^2$
	3	<i>Escherichia coli</i>	Nil	Nil	Nil	3/10g
	4	<i>Salmonella</i> spp.	Nil	Nil	Nil	0/25g
	5	Yeasts and molds	Nil	Nil	3	$<10^2$
45	1	Total Viable Count (TVC)	8.0×10^2	7.0×10^2	6.0×10^2	10^4
	2	Enterobacteriaceae (Total coliform)	Nil	Nil	Nil	$<10^2$
	3	<i>Escherichia coli</i>	Nil	Nil	Nil	3/10g
	4	<i>Salmonella</i> spp.	Nil	Nil	Nil	0/25g
	5	Yeasts and molds	Nil	Nil	40	$<10^2$
90	1	Total Viable Count (TVC)	15.0×10^2	8.0×10^2	9.0×10^2	10^4
	2	Enterobacteriaceae (Total coliform)	Nil	Nil	Nil	$<10^2$
	3	<i>Escherichia coli</i>	Nil	Nil	Nil	3/10g
	4	<i>Salmonella</i> spp.	Nil	Nil	Nil	0/25g
	5	Yeasts and molds	Nil	Nil	1.0×10^2	$<10^2$

Table 3. Microbial counts of high energy fortified biscuit samples after HACCP implementation.

Days	Sl. No.	Test Parameters	Results of S ₁ (CFU/g)	Results of S ₂ (CFU/g)	Results of S ₃ (CFU/g)	Permissible Max. Level (CFU/g)
0	1	Total Viable Count (TVC)	100	100	Nil	10 ⁴
	2	Enterobacteriaceae (Total coliform)	Nil	Nil	Nil	<10 ²
	3	<i>Escherichia coli</i>	Nil	Nil	Nil	3/10g
	4	<i>Salmonella</i> spp.	Nil	Nil	Nil	0/25g
	5	Yeasts and molds	Nil	Nil	Nil	<10 ²
45	1	Total Viable Count (TVC)	2.0×10 ²	2.0×10 ²	1.0×10 ²	10 ⁴
	2	Enterobacteriaceae (Total coliform)	Nil	Nil	Nil	<10 ²
	3	<i>Escherichia coli</i>	Nil	Nil	Nil	3/10g
	4	<i>Salmonella</i> spp.	Nil	Nil	Nil	0/25g
	5	Yeasts and molds	Nil	Nil	Nil	<10 ²
90	1	Total Viable Count (TVC)	4.0×10 ²	3.0×10 ²	2.0×10 ²	10 ⁴
	2	Enterobacteriaceae (Total coliform)	Nil	Nil	Nil	<10 ²
	3	<i>Escherichia coli</i>	Nil	Nil	Nil	3/10g
	4	<i>Salmonella</i> spp.	Nil	Nil	Nil	0/25g
	5	Yeasts and molds	Nil	Nil	Nil	<10 ²

Total coliform, *Escherichia coli*, *Salmonella* spp. And yeasts and molds were totally nil at different storage periods.

It can be noticed that the level of microbial count increased after 45 days and 90 days while storing the samples for both case of before and after HACCP implementation. Microbial counts were always below the maximum permissible limit (cfu/g) with the BSTI recommendation. After implementing HACCP significant difference have been found in the case of TVC. TVC was always under 400 cfu/g even after 90 days of storage period.

Comparing to S₁, S₂ sample had lower microbial count. In this case also only the total viable count can be found before and after HACCP implementation in this sample of high energy fortified biscuits. Total coliform, *Escherichia coli*, *Salmonella* spp. And yeasts and molds were totally nil at different storage periods. It can be noticed that the level of microbial count increased after 45 days and 90 days while storing the samples for both case of before and after HACCP implementation. Microbial counts were always below the maximum permissible limit (cfu/g) with the BSTI recommendation. After implementing HACCP significant difference have been found in the case of TVC. TVC was always under 300cfu/g even after 90 days of storage period which was 800cfu/g before implementation of HACCP.

Comparing to S₁ and S₂ sample, S₃ sample had higher microbial count. The total viable count and yeast and mold can be found before HACCP implementation in this sample of high energy fortified biscuits. After HACCP implementation yeast and mold count were nil. Total coliform, *Escherichia coli*, *Salmonella* spp. were totally nil at different storage periods. It can be noticed that the level of microbial count increased after 45 days and 90 days while storing the samples for both case of before and after HACCP implementation though TVC level was zero at 0 day. Microbial counts were always below the maximum permissible limit (cfu/g) with the BSTI recommendation. After implementing HACCP significant difference have been found in the case of TVC. TVC was always under 200cfu/g even after 90 days of storage period which was 900cfu/g before implementation of HACCP.

Changes in chemical composition

Moisture content of S₂ sample was lower in all the stages of storing period comparing to S₁ sample.

Moisture content was increasing day by day for this sample. As for example at 0-day moisture content was 1.33% and after 90 days of storage period it became 4.633% before implementing HACCP. But after implementing HACCP overall moisture absorption reduced significantly. Though it exceeded maximum level which is 4.5% at 90 days of storage period before HACCP implementation, after implementation it reduced to 3.62% and that is the visible advantages of HACCP implementation.

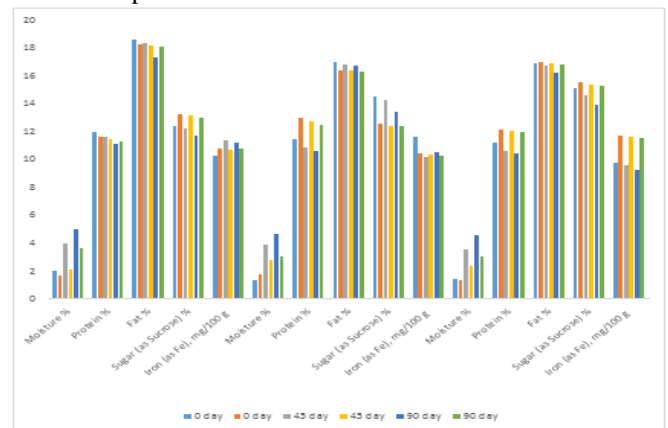


Figure 1. Chemical composition analysis of S₁, S₂ and S₃ sample at 0 day, 45th day and 90th day of storage before and after HACCP implementation.

Protein content of sample S₂ decreased moderately while comparing to 0 day, 45th day and 90th day of storage period before HACCP implementation. It can be easily noticeable that after implementing HACCP protein content of sample S₁ decreased very slightly. The recommended protein content according to BSTI is 10-15g/100g which was maintained properly all over the storage periods. The level of protein content was always higher for S₂ sample after HACCP implementation while comparing to before implementation of HACCP.

Fat content of Sample S₂ decreased very slowly while comparing to 0 day, 45th day and 90th day of storage period before HACCP implementation. The recommended fat content according to BSTI is 15-18g/100g which could be maintained properly all over the storage periods. All values were below the BSTI recommendation.

It can be easily noticeable that after implementing HACCP fat content of sample S₂ decreased very slightly though the fat content did not show any significant difference before and after HACCP implementation.

Fat content of Sample S₁ decreased rapidly while comparing to 0 day, 45th day and 90th day of storage period before HACCP implementation. The recommended fat content according to BSTI is 15-18g/100g which could not be maintained properly all over the storage periods. At 0 day and 45th day of storage period the fat content was 18.55% and 18.33% respectively which were higher than BSTI recommendation. It can be easily noticeable that after implementing HACCP fat content of sample 1 decreased very slightly though the fat content was slightly higher than BSTI recommendation at all over the storage period after HACCP implementation.

Sugar content of sample S₂ decreased moderately while comparing to 0 day, 45th day and 90th day of storage period before HACCP implementation. It can be easily noticeable that after implementing HACCP sugar content of sample S₂ decreased very slightly. The recommended fat content according to BSTI is 10-15g/100g which was maintained properly all over the storage periods. The level of sugar content was always lower for S₂ sample after HACCP implementation while comparing to before implementation of HACCP.

The BSTI recommendation for iron content in biscuit sample is 9.35-12.65 mg/100g which was properly maintained with S₁ sample in all over the storage period before and after implementation of HACCP. Iron content of sample S₁ decreased moderately while comparing to 0 day, 45th day and 90th day of storage period before HACCP implementation. It can be easily noticeable that after implementing HACCP sugar content of sample 1 decreased very slightly. The level of iron content was always higher for S₁ sample while comparing to before and after implementation of HACCP.

The chemical composition of S₃ sample was lower in all the stages of storing period comparing to S₁ and S₂ sample. Moisture content increased day by day for this sample. As for example at 0-day moisture content was 1.38% and after 90 days of storage period it became 4.533% before implementing HACCP. But after implementing HACCP overall moisture absorption reduced significantly. Though it exceeded maximum level which (4.5%) at 90 days of storage period before HACCP implementation, after implementation it reduced to 3.01% and that is the visible advantages of HACCP implementation.

Fat content of sample S₃ decreased very slowly while comparing to 0 day, 45th day and 90th day of storage period before HACCP implementation. The recommended fat content according to BSTI is 15-18g/100g which was maintained properly all over the storage periods. All values were below the BSTI recommendation. It can be easily noticeable that after implementing HACCP fat content reduced very slightly in different period of storage. So it did not show any significant difference before and after HACCP implementation.

Sugar content of sample S₃ decreased rapidly while comparing to 0 day, 45th day and 90th day of storage period before HACCP implementation. It can be easily detectable that after implementing HACCP sugar content of sample S₃ decreased very slightly. The recommended fat content according to BSTI is 10-15g/100g which was maintained

properly all over the storage periods. Sugar content was always higher after comparing to S₂ sample after HACCP implementation. The level of sugar content was always lower for S₂ sample after HACCP implementation while comparing to before implementation of HACCP.

The BSTI recommendation for iron content in biscuit sample is 9.35-12.65 mg/100g which was not properly maintained with S₃ sample in all over the storage period before implementation of HACCP. Iron content found very less comparing to S₁ and S₂ sample. Iron content of sample S₃ decreased moderately while comparing to 0 day, 45th day and 90th day of storage period before HACCP implementation. It can be easily noticeable that after implementing HACCP sugar content of sample S₃ decreased very slightly. The level of iron content was always lower for S₂ sample while comparing to before and after implementation of HACCP.

Discussion:

Gandhi (2009) included hazard description, critical limit, observation procedure, responsible person, monitoring procedure and corrective action in his HACCP Control chart for production of soy milk where as Burson (1998) reported processing step, records and verification procedure in his control chart of meat product. Zhao (2003) reported processing step in HACCP control chart for cheddar cheese which is also similar to this proposed control chart. Two CCPs i.e. frying and packaging were found in manufacturing of high energy biscuits. The moisture and ash were decreased with corresponding increase in the percentage of soy flour (Banureka and Mahendran, 2009). In a previous study, protein and fat contents of biscuits increased with increasing soy fortifications (Ugwuona, 2009). Water activity was more closely related to the physical, chemical and biological properties of foods and other natural products than the total moisture content. Specific changes in color, aroma, flavor, texture, stability and acceptability of raw and processed food products were associated with relatively narrow water activity ranges (Rockland and Nishi, 1980). The addition of hydrogenated vegetable oils in convenience foods was found to improve their storage stability (Patki and Arya, 1994). Manley (2000) stated that the low moisture content and low water activity of bakery products imparted them a long mold free shelf-life, typically many months.

Conclusion

The present study investigated the influence of HACCP implementation on fortified bakery products in food industry. Percentage of Moisture, Protein, fat, sucrose and iron content remained acceptable considering BSTI requirements. Based on the principle of the HACCP and several generic models, the HACCP model was designed to suit the real situation of the biscuit plant to produce the safe and quality end product. The finding of this re-search revealed that, biscuit produced with S₁ bakery recipe had highest chemical composition in terms of moisture(%), protein(%), fat(%) and iron content to that of the S₂ and S₃ bakery sample. Beside this, sucrose content was highest in the S₃ sample. During 90 days of storage, fat content showed non-significant difference among the samples but moisture %, protein%, sucrose% and iron content made significant difference. After HACCP implementation microbial count were done again. At 45th day, total viable counts for S₁, S₂ and S₃ samples were 200cfu/g, 200cfu/g and 100cfu/g respectively. *Enterobacteriaceae* (Total coliform), *Escherichia coli*, *Salmonella* spp. and yeast and mold count were also found zero at 45th day. After 90 day, TVC increased for all the groups. S₁, S₂ and S₃ samples

showed 400, 300 and 200cfu/g respectively. All the values were lower than permissible maximum level. *Enterobacteriaceae*(Total coliform), *Escherichia coli*, *Salmonella* spp. and yeast and mold count were also found zero at 90th day. The quality and productivity of bakery fortified biscuit is considered to be improved by a prerequisite program of HACCP implementation.

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