Application of hazard analysis and critical control point system in the dairy industry

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تطبيق تحليل المخاطر ونظام نقاط التحكم الحرجة في صناعة الألبان

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الخلاصة: هدفت هذه الدراسة لتقييم جودة الالتزام بالإصحاح في المنتجات من الألبان المعلبة (المبسترة أو المعقمة) ومنتجات أخرى قبل وبعد تطبيق تحليل المخاطر ونظام نقاط التحكم الحرجة على الشركات المنتجة للّبن ومنتجات الألبان في مدينة القاهرة في مصر. وقد وصفت الدراسة خطوات تطبيق تحليل المخاطر ونظام نقاط التحكم الحرجة ورصدت العملية لتقييم تأثيرها. وقد أظهر تقييم جودة الإصحاح في منتجات الألبان قبل وبعد تطبيق تحليل المخاطر ونظام نقاط التحكم الحرجة تحسُّناً ملحوظاً في الجودة وتحسُّناً عاماً في شروط الشركة المنتجة.

ABSTRACT This study aimed to assess the hygiene quality of some packaged milk (pasteurized or sterilized) and dairy products before and after application of a hazard analysis and critical control point (HACCP) system at a milk and dairy products company in Cairo, Egypt. The steps taken to put HACCP in place are described and the process was monitored to assess its impact. Assessment of the hygiene quality of the milk and dairy products before and after HACCP showed an improvement in quality and an overall improvement in the conditions at the company.

Application du système des points de contrôle critiques dans l'analyse des risques dans l'industrie laitière

RESUME L'objectif de cette étude était d'évaluer la qualité hygiénique de certains laits conditionnés (pasteurisés ou stérilisés) et produits laitiers avant et après l'application du système des points de contrôle critiques dans l'analyse des risques (HACCP) dans une entreprise laitière et de produits laitiers au Caire (Egypte). Les mesures prises pour mettre en place le système HACCP sont décrites et le processus a fait l'objet d'un suivi pour en évaluer l'impact. L'évaluation de la qualité hygiénique du lait et des produits laitiers avant et après l'application du HACCP a montré une amélioration de la qualité ainsi qu'une amélioration globale des conditions dans l'entreprise.

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Introduction

The hazard analysis and critical control point (HACCP) system is a preventative measure that assesses hazards, estimates risks and establishes specific control measures that emphasize prevention rather than reliance on end-product testing [*1*]. The main potential hazards in most dairy products are microbiological [*2*], and the dairy industry has increased its efforts for quality and safety assurance through the development and implementation of proactive programmes such as HACCP [*3*]. This study was carried out to assess the effect of applying HACCP on the hygiene quality of dairy products produced at one plant in Egypt.

Methods

Application of HACCP system [*4*]

The steps used to apply the HACCP system in one dairy plant were as follows.

- The support of senior management of the company for food safety and HACCP application was sought and obtained.
- A team was formed which included : production manager, production engineer, consultant of food hygiene and sanitation, consultant of food microbiology and a technician from the laboratory.
- Products were described in terms of ingredients, processing, packaging, storage and distribution.
- Each step in the process was outlined in sequence in the flow diagram from raw materials through processing, packaging and storage.
- In order to identify the hazards the following actions were undertaken:
  - Observing operations. Each product preparation process was observed for:
    - Receipt of raw materials, storage, heat treatment, cooling and packaging (production of packaged milk)
    - Fermentation, concentration, homogenization, additives, temperature, packaging and storage (production of dairy products).
    - Personal hygiene, education, health, cleanliness, habits, premises, equipment, floors, walls and ventilation (working conditions).
  - Measuring operations. Time and temperature applied during the production and storage of milk and dairy products were measured and recorded on the flow diagrams.
  - Testing operations. Three kilograms of homogenized products were taken from each step during milk and dairy product production. They were aseptically collected, transferred to the laboratory under cooling conditions and examined for the presence of wood, stone, bone, metals, dust and straw (physical hazards), and for the presence formalin and hydrogen peroxide and the measuring of acidity and pH (chemical hazards) [*5*].
- The critical control points (CCP) decision tree was used to determine whether a step was a CCP for the identified hazard. The critical limits used included temperature, time and pH. The rapid physical and chemical measurements were used as monitoring procedures. Procedures for corrective action were established to ensure that the CCP was brought under control. Verification pro-

cedures included time, temperature, pH and acidity measurements and were used to determine if CCPs were under control. As validation, 30 samples were collected from the end-products of the different milk and dairy products (5 samples from each product) and were tested microbiologically. Records included the measurement of time and temperature as well as the visual observation of the CCPs so that they do not exceed the critical limits. Documentation included HACCP plan, CCP, monitoring records, corrective action and verification data as well as information on cleaning and disinfection.

Evaluation of the microbiological quality before HACCP

First, 60 samples [10 samples from each milk and dairy product (packaged pasteurized milk, packaged sterilized milk, packaged white cheese, ice cream, yoghurt and processed cheese)] were analysed microbiologically before HACCP application. Second, another 60 samples (of the same products) were examined 2 months after HACCP application.

The microbiological procedures were those recommended in the International Commission on Microbiological Specification for Foods [*6*]. Culture media were those of Oxoid, Biolife and Difco.

For each sample, 25 g were weighed out and transferred to a sterile blender with 225 mL of 0.1% peptone and mixed thoroughly for 2 minutes to prepare the milk or dairy product homogenate. These were then analysed as follows.

Aerobic and anaerobic total bacterial, psychrotrophic and spore formers counts

Appropriate dilutions of the food homogenate were prepared and inoculated onto sterile Petri dishes. Plate count agar (Oxoid) media were then poured. Plates were incubated at 35–37 °C for 48 hours and colonies were then counted and reported as total colony count/mL or gram of milk or dairy product. A second set of plates was incubated at 35–37 °C for 48 hours in a carbon dioxide incubator or under anaerobic conditions using a gas pack anaerobic jar. Colonies were then counted and reported as anaerobic total bacterial count. A third set of plates was incubated at 2–8 °C for 7–10 days and then colonies counted and reported as psychrotrophic count/mL or g of milk or dairy product. In case of spore formers count, the food homogenate was boiled first at 75–80 °C and then rapidly cooled. Appropriate serial dilutions were prepared and inoculated onto the surface of sterile and dried plate count agar media. These were incubated finally at 35–37 °C for 48 hours.

Detection of coliforms [most probable number (MPN)] and fecal coliforms

One mL of each of the decimal dilutions of the milk or dairy product homogenate was inoculated into each of three separate tubes of MacConkey broth (Oxoid) and then incubated at 35–37 °C for 48 hours. Counts were calculated from the number of posi-tive tubes showing both gas and yellow colour production using the MPN tables.

The positive MacConkey tubes were then subcultured in brilliant green lactose bile broth (Oxoid) tubes, then incubated at 44 °C. Tubes of peptone water were also incubated at 44 °C. Cultures showing gas production in brilliant green broth and indole formation in peptone water were presumed positive for fecal coliform organisms.

Detection of Staphylococcus aureus

A sample of 0.1 mL of the milk or dairy products homogenate and dilutions was inoculated on the surface of previously

dried Baird-Parker (Difco) agar plates and incubated at 35–37 °C for 48 hours. Colonies appearing to be black and shiny with narrow white margins and surrounded by clear zones were identified by coagulase test reactions. The coagulase test was carried out by first inoculating typical colonies in brain heart infusion broth (Difco) and incubating at 37 °C for 24 hours. From the resulting cultures, 0.1 mL was then added to 0.3 mL of rabbit plasma in sterile tubes and incubated at 37 °C for 4 hours. The formation of a distinct clot was evidence of coagulase activity.

Detection of Bacillus cereus

A sample of 0.1 mL of the milk or dairy product homogenate was streaked over the dried surface of *B. cereus* agar plates and then incubated at 37 °C for 48 hours. Typical colonies of *B. cereus* had a distinctive turquoise blue colour and were surrounded by an egg yolk precipitate of the same colour

Enumeration of mould and yeast

Appropriate dilutions of Sabouraud dextrose agar plates (Oxoid) were poured over 1 mL of the milk or dairy product homogenate and dilutions. Plates were incubated at 22–25 °C for 3 days and then colonies were counted and reported as mould and yeast count/mL or gram of the milk or dairy product.

Detection of Salmonella *spp.*

Samples of milk or dairy products were first inoculated in lactose broth (Oxoid) and incubated at 37 °C for 24 hours. Then 1 mL of the pre-enriched milk or dairy product homogenate was transferred to both 10 mL of selenite cystine broth and 10 ml of tetrathionate brilliant green broth and incubated at 44 °C for 24 hours. Then 0.1 mL of the resulting growth was streaked over the surface of the previously dried brilliant green agar and bismuth sulfite agar plates, which were then incubated at 35 37 °C for 24 hours. For identification, 2–3 suspected colonies were inoculated into tryptone broth for indole test, triple sugar iron agar slant (Oxoid), urea broth and lysine iron agar. These were incubated at 37 °C for 24 hours. *Salmonella* species is indole negative, on triple sugar iron it produces acid (yellow) and alkaline (red) with or without gas and hydrogen sulfide, is urea negative, and on lysine iron agar shows an alkaline (purple) reaction throughout the medium. Serological tests were then carried out.

Evaluation of the degree of hazard observed in the milk and dairy product plant before and after HACCP application

This part aimed to evaluate the hygiene and the sanitary layout and practices during the processing of packaged milk and other dairy products as this affects the quality and safety during production. This was assessed twice, once before and once after HACCP application, using a detailed checklist, which included the measurements and items previously mentioned. Depending on the score given to the observed plant, it was categorized as medium hazard (> 78%) or low hazard (78%–59%) or no hazard (< 59%) plant [7,8].

Results

Figure 1 shows the process flow diagrams of pasteurized or sterilized milk, white cheese and yoghurt. Figure 2 shows the process for ice cream and processed cheese.

Table 1 shows a summary of the HACCP control charts for milk and dairy products production. It can be seen from

the table that receipt of raw milk was a critical control point (CCP) because high acidity (chemical hazard) cannot be eliminated by any subsequent processing steps. Heat treatment, pasteurized and sterilized milk storage, processing and packaging were also CCPs because the subsequent steps mentioned in the flow diagrams (Figures 1 and 2) cannot eliminate any existing hazards mentioned in the table. To prevent these hazards, the control of time and temperature and the application of the rules of good manufacture practices (GMP) are needed. Time, temperature and GMP limits that should be followed at each process step are mentioned under critical limits (Table 1). These should be followed accurately to avoid hazards occurring. Continuous time, temperature and pH measurements, in addition to visual inspection, are the monitoring procedures that will prevent any deviation in the critical limits. The corrective actions mentioned Table 1 are those to be used if a product was made while there was a deviation in the critical limits.

Table 2 shows the low microbial count in the samples examined during the validation step. The highest aerobic count [2.9 × 104 colony forming units/g (CFU/g)] was detected in white cheese. The only pathogen detected was Stapylococcus aureus, which was detected in white cheese. Table 3 shows a significant mould and yeast decrease after applying HACCP to packaged white cheese (t-value = 4.781) and a significant S. aureus decrease in packaged ice cream (t-value = 9.775). Figure 3 shows a decrease in the hazard percentage detected at the plant after applying HACCP, and the plant was then classified as a no hazard (safe) plant (42.4%).

Discussion

The plant in this study was not applying the rules of GMP, which explains the presence of many critical control points. The application of GMP would limit the CCPs to those monitored by time, temperature and pH measurements. Before the HACCP system, raw milk was received from different sources (Cairo, Giza, Fayoum and Zagazig). Chemical hazards in the raw milk were not assessed at this point nor in the following steps, while physical hazards (dust and straw) were screened for at the point of receipt. Uncovered or inadequately covered vehicle tanks were used for milk transportation, which took more than 1–2 hours at temperatures sometimes exceeding 10 °C. In addition, utensils used during receipt were unclean and unsafe. Poorly cleaned utensils and equipment surfaces are known to harbour and promote the spread of microorganisms [*9*]. The cleaning and disinfecting procedures of the cooler tanks at the plant during cooling were difficult to carry out as the construction of the tanks did not comply with Egyptian standards.

Although microbial survival was the potential microbiological hazard during heat treatment (Table 1), the aerobic count of packaged pasteurized milk before HACCP was 4.0 × 104 CFU/g and the other tested microorganism ranged from < 10 to none (Table 3). The potential for contamination at this stage makes it a CCP [*10*]. As regards packaged sterilized milk, the microbial counts were < 10 CFU/mL and no pathogens were detected (Table 3). These results concur with those of El-Sherbeeny et al [*11*]. For the packaged white cheese, the mould and yeast measurement was 5.7 × 102 CFU/g and the

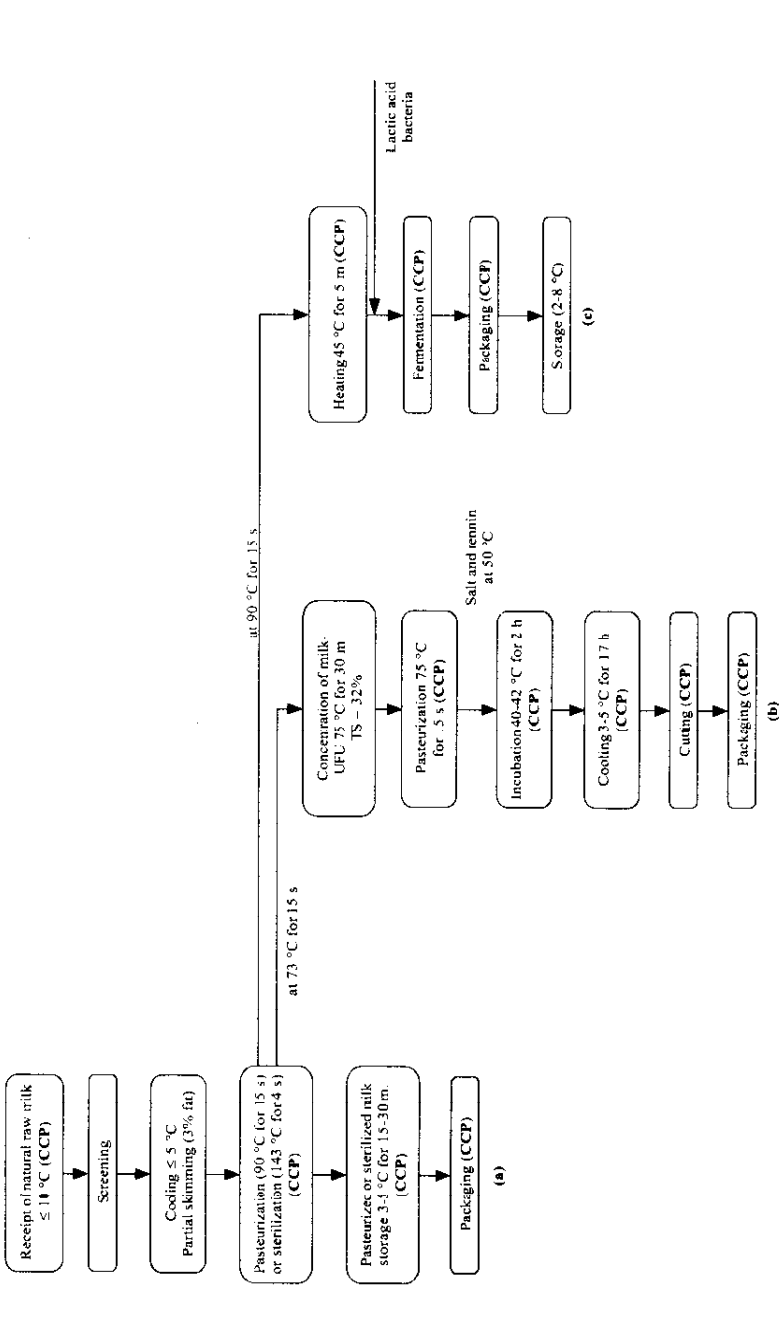

Figure 1 **Process flow diagrams of (a) pasteurized or sterilized milk, (b) white cheese and (c) yoghurt**
UFU = ultra filtration unit; TS = total solid; CCP = critical control point

Table 1 **Summary of the HACCP control charts of milk and dairy products production**

Process step	CCP	Hazard	Preventive measure
1. Receiving raw milk	1.1	High microbial load	Receive at < 10 °C
	1.2	Cross contamination	GMP
	1.3	High acidity	
	1.4	Dust and straw	
	1.5	Environmental contamination	
4. Heat treatment (pasteurization, sterilization and cooking)	4.1	Microbial survival	Time and temperature control
			Sterilization at 143 °C for 4 seconds
			Cooking at 90 °C (processed cheese)
5. Pasteurized and sterilized milk storage	5.1	Spores germination in pasteurized milk	Time temperature control
	5.2	Cross contamination	GMP
6. Processing: incubation and cutting (white cheese), holding, ageing and freezing (ice cream), heating and fermentation (yoghurt), transportation (processed cheese)	6.1	Microbial growth	Time temperature control
	6.2	Cross contamination	GMP
7. Packaging	7.1	Cross contamination	GMP

CCP = critical control point.
GMP = good manufacturing practice.

Critical limits	Monitoring procedure	Frequency	Corrective action
Receive milk at < 10 °C and pH > 6.10	Temperature and pH measurements	At every receiving	Reject received milk if contamination is evident
Check (change) supplier			
Pasteurization at 90–95 °C for 15 seconds and at 65–80 °C for 10 minutes (ice cream)	Time and temperature measurements	At every heat treatment	Correct time and temperature
			Repasteurize or resterilize milk
Storage at 3–5 °C	Time and temperature measurements	At every storage	Correct time and temperature
Cleaned and sanitized pipes and tanks	Visual inspection		Repasteurize or resterilize milk
Adjust at time and temperature mentioned in the flow diagrams of each product	Time and temperature measurements	At every handling	Discard if contamination is evident
Cleaned and sanitized environment, utensils and tanks (GMP)	Visual inspection		
Sealed packages	Visual inspection	At every packaging	Discard if contamination is evident

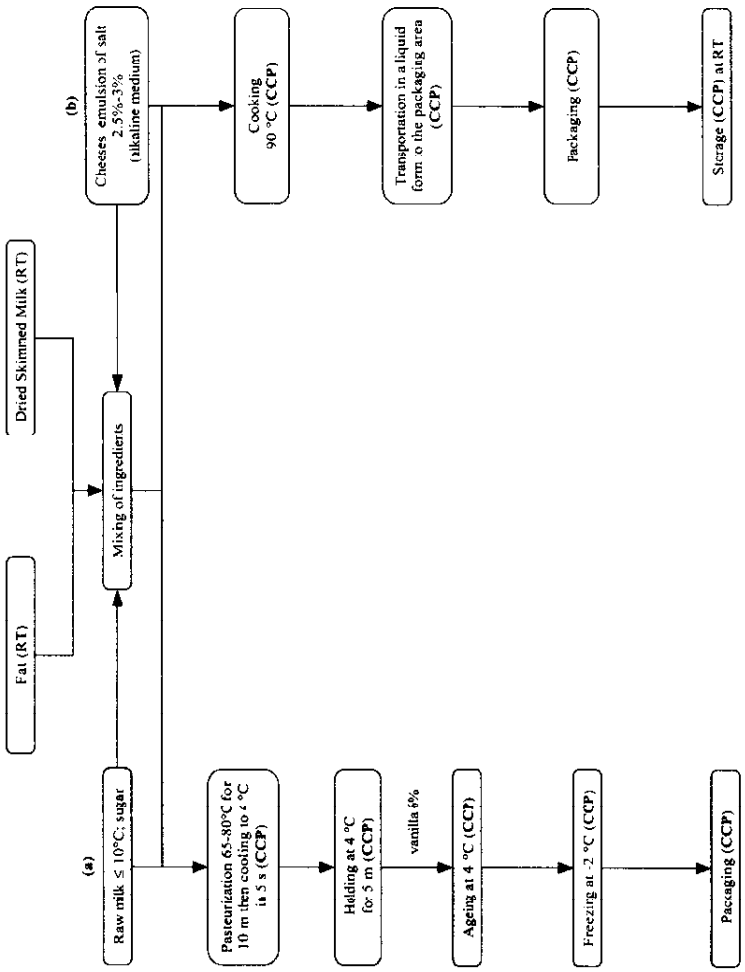

Figure 2 **Process flow diagrams of (a) ice cream and (b) processed cheese**
RT = room temperature; CCP = critical control point

Table 2 **Mean microbial counts of random samples of packaged milk and dairy products taken as a part of the validation procedure**

Microbial test	Pasteurized milk	Sterilized milk	White cheese	Ice cream	Yoghurt	Processed cheese
Aerobic count[a]	7.6×10^2	< 10	2.9×10^4	2.8×10^3	4.0×10^3	4.0×10^3
Anaerobic count[a]	< 10	< 10	< 10	< 10	< 10	< 10
Psychrotrophic count[a]	< 10	< 10	< 10	< 10	< 10	< 10
Mould and yeast[a]	< 10	< 10	2.6×10^3	4.0×10^3	3.0×10^3	2.0×10^2
Coliforms[b]	–ve	–ve	4.0×10^1	–ve	2.5×10^2	2.0×10^1
Fecal coliforms[b]	–ve	–ve	–ve	–ve	–ve	–ve
Bacillus cereus[a]	–ve	–ve	–ve	–ve	–ve	–ve
Staphylococcus aureus[a]	–ve	–ve	2.0×10^2	–ve	–ve	–ve
Salmonella spp.[a]	–ve	–ve	–ve	–ve	–ve	–ve
Spore formers [a]	< 10	< 10	< 10	< 10	< 10	< 10

Number of samples = 5 from each product.
[a]Colony forming units/g.
[b]Most probable number/ng.

coliform measurement was 2.7×101 most probable number/g (MPN/g) of (Table 3). Houlidou et al. found that coliform bacteria and *Escherichia coli* in soft cheese were < 10 MPN/g in 50 samples, >103 MPN/g in 5 samples, >104 MPN/g in 13 samples and >105 MPN/g in 2 samples [*12*]. Salmonella and mould and yeast were not detected [*12*]. Both *B. cereus* and *S. aureus* were detected in the packaged ice cream (Table 3). *Salmonella* spp. was not detected, a finding also reported by others [*13*]. B. cereus was not detected in packaged yoghurt (Table 3). It has been reported that lactic acid bacteria inhibit the growth of the vegetative cells of *B. cereus* [*14*]. Cross-contamination during processing of processed cheese is known to provide opportunities for microbial growth. Contamination might occur from workers touching foods and from the cloths and sponges used to wipe surfaces in areas where both raw and final products are found [*15*].

Following the decision tree matrix, CCPs identified in this study included pasteurization, sterilization, heat treatment (yoghurt) and cooking (processed cheese) as these steps should eliminate or greatly reduce the hazards [*4*]. CCPs also included storage and packaging steps and other steps following heat treatment as these are not followed by any subsequent step to eliminate any added hazard. Critical limits used were time–temperature control, in addition to cleaning and sterilizing of equipment, utensils and hands. Limits also included the application of sanitary measures by food handlers (Table 1). Corrective actions given in Table 1 were taken immediately when there was a deviation at the CCP.

Verification activities included; checks on the proper functioning and accuracy of CCP monitoring equipment and checks of

Table 3 **Microbial counts of packaged dairy products before and after hazard analysis and critical controlpoint (HACCP) application**

Microbial test	Pasteurized milk			Sterilized milk		
	Before HACCP	After HACCP	t	Before HACCP	After HACCP	t
Aerobic count[a]	$4.0 \times 10^4 \pm 1.5 \times 10^4$	$4.5 \times 10^2 \pm 4.5 \times 10^2$	1.138	< 10	< 10	–
Anaerobic count[a]	< 10	<10	–	< 10	< 10	–
Psychrotrophic count[a]	< 10	<10	–	< 10	< 10	–
Mould and yeast[a]	< 10	<10	–	–ve	–ve	–
Colform[b]	–ve	–ve	–	–ve	–ve	–
Fecal coliforms[b]	–ve	–ve	–	–ve	–ve	–
Bacillus cereus[a]	–ve	–ve	–	–ve	–ve	–
Staphylococcus aureus[a]	–ve	–ve	–	–ve	–ve	–
Salmonella spp[a].	–ve	–ve	–	–ve	–ve	–
Spore forms[a]	< 10	<10	–	< 10	< 10	–

Values are given as mean ± standard deviation.
Number of samples = 10 from each product before HACCP and 10 from each product after HACCP.
Significant at P < 0.05. [a]Colony forming units/g. [b]Most probable numbering.

CCP records to verify the adequacy of monitoring and to verify HACCP performance. Records of time and temperature were also checked. Thirty end-product samples were also analysed microbiologically as a validation procedure. Microbial counts were found to have decreased considerably after application of HACCP (Table 2). It should be noted however that it is impossible to determine safety by sampling the output for hazardous contamination. The only way to have reasonable confidence that the output is safe is to verify that there is a control process at each step [*16*]. All information related to the steps and principles of HACCP were examined and kept at the plant.

There were two benefits from applying HACCP. First, there was a decrease in the microbial count of the milk and dairy products produced after HACCP application (Table 3). This indicated the successful application of the HACCP system at the plant. This has also been shown in other studies [*7,8*]. Second, the conditions at the plant have also improved after HAACP and the plant has been evaluated as a safe (no hazard), plant. The score percentage of some of the hazardous practices observed decreased from 100% before HACCP to 66.7% after HACCP for handling of raw milk, from 66.7% to 33.3% for packaging and cleaning and sanitary maintenance, and from 92.9% to

Table 3 **Microbial counts of packaged dairy products before and after hazard analysis and critical control point (HACCP) application (continued)**

Microbial test	White cheese			Ice cream		
	Before HACCP	After HACCP	*t*	Before HACCP	After HACCP	*t*
Aerobic count[a]	$2.4 \times 10^4 \pm 1.3 \times 10^4$	$1.9 \times 10^4 \pm 0.9 \times 10^4$	1.173	$1.2 \times 10^6 \pm 1.1 \times 10^6$	$1.8 \times 10^3 \pm 1.1 \times 10^3$	1.837
Anaerobic count[a]	< 10	< 10	–	< 10	< 10	–
Psychrotrophic count[a]	< 10	< 10	–	< 10	< 10	–
Moud and yeast[a]	$5.7 \times 10^2 \pm 0.6 \times 10^2$	$5.0 \times 10^2 \pm 0.4 \times 10^2$	4.781*	$2.4 \times 10^5 \pm 1.1 \times 10^5$	$2.3 \times 10^3 \pm 0.7 \times 10^3$	0.125
Coliform[b]	$2.7 \times 10^1 \pm 2.2 \times 10^1$	$2.4 \times 10^1 \pm 0.3 \times 10^1$	0.305	$8.0 \times 10^1 \pm 0.3 \times 10^1$	–ve	0.100
Fecal coliforms[b]	–ve	–ve	–	–ve	–ve	0.850
Bacillus cereus[a]	–ve	–ve	–	$1.2 \times 10^2 \pm 0.7 \times 10^2$	–ve	–
Staphylococcus aureus[a]	$2.3 \times 10^2 \pm 0.5 \times 10^2$	$2.0 \times 10^2 \pm 2.3 \times 10^2$	0.239	$7.0 \times 10^2 \pm 0.5 \times 10^2$	$1.5 \times 102 \pm 1.1 \times 102$	9.775*
Salmonella spp[a].	–ve	–ve	–	–ve	–ve	–
Spore forms[a]	$5.9 \times 10^2 \pm 1.1 \times 10^2$	$5.8 \times 10^2 \pm 1.3 \times 10^2$	0.248	< 10	< 10	–

Values are given as mean ± standaid deviation.
Number of samples = 10 from each product before HACCP and 10 from each product after HACCP.
**Significant at $P < 0.05$.*
[a]Colony forming unitsig.
[b]Most probable numbering.

Table 3 **Microbial counts of packaged dairy products before and after hazard analysis and critical control point (HACCP) application (concluded)**

Microbial test	Yoghurt			Processed cheese		
	Before HACCP	After HACCP	*t*	Before HACCP	After HACCP	*t*
Aerobic count[a]	$1.6 \times 10^3 \pm 0.7 \times 10^3$	$1.5 \times 10^3 \pm 0.4 \times 10^3$	0.937	$1.5 \times 10^3 \pm 0.3 \times 10^2$	$1.4 \times 10^3 \pm 0.2 \times 10^3$	1.033
Anaerobic count[a]	< 10	< 10	–	< 10	< 10	–
Psychrotrophic count[a]	< 10	< 10	–	< 10	< 10	–
Mould and yeast[a]	$2.5 \times 10^3 \pm 0.7 \times 10^3$	$2.0 \times 10^3 \pm 1.2 \times 10^3$	0.917	$1.5 \times 10^2 \pm 0.4 \times 10^2$	$1.5 \times 10^2 \pm 0.2 \times 10^2$	0.649
Coliform[b]	$5.0 \times 10^1 \pm 0.2 \times 10^1$	$5.0 \times 10^1 \pm 1.1 \times 10^1$	0.590	$2.9 \times 10^1 \pm 0.1 \times 10^1$	$2.5 \times 10^1 \pm 2.2 \times 10^1$	0.076
Fecal coliforms[b]	–ve	–ve	–	–ve	–ve	–
Bacillus cereus[a]	–ve	–ve	–	–ve	–ve	–
Staphylococcus aureus[a]	–ve	–ve	–	–ve	–ve	–
Salmonella spp[a].	–ve	–ve	–	–ve	–ve	–
Spore forms[a]	< 10	< 10	–	< 10	< 10	–

Values are given as mean ± standard deviation.
Number of samples = 10 from each product before HACCP and 10 from each product after HACCP.
**Significant at P < 0.05.*
[a]Colony forming units/g.
[b]Most probable numbering.

71.4% for the hygiene of workers (Figure 3).

Education and training of food service workers in the use of sanitary techniques (which is an integral part of HACCP application) is an accepted strategy to achieve production and service of safe food [*17*]. It is recommended that the HACCP system be implemented in all food establishments. Food safety authorities and the food industry, as appropriate, should verify that systems are properly designed and that CCPs are effectively monitored.

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HACCP: introducing the hazard analysis critical control point system

The HACCP system was conceived over 30 years ago and since then has become the internationally recognized and accepted method for food safety assurance. While originally developed to ensure microbiological safety of food stuffs, it has been broadened to include chemical and physical hazards in food. WHO played an important role in the development and implementation of the HACCP system. HACCP: introducing the hazard analysis critical control point system discusses the benefits of HACCP and provides a guide for government and industry for the implementation of HACCP. The document can be accessed free online at: http://whqlibdoc.who.int/hq/1997/WHO_FSF_FOS_97.2.pdf