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RESEARCH ARTICLE

IMPLEMENTATION OF HAZARD ANALYSIS AND CRITICAL CONTROL POINT (HACCP) SYSTEM IN DAIRY PROCESSING.

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Abstract

To guarantee the safety of yoghurt, fermented cream and kariesh cheese production, the Hazard Analysis Critical Control Points (HACCP) system was applied to the production process. The biological, chemical, and physical hazards that may exist in every step of yoghurt, fermented cream and kariesh cheese production were identified. In addition, the critical control points were selected and the critical limits, monitoring, corrective measures, records, and verifications were established. The critical control point, which includes pasteurization, was identified. Implementing the HACCP system in food manufacturing can effectively ensure food safety and quality. The HACCP plan tasks positively influenced the microbiological quality in the assessment of the final products.

Introduction:-

Control Dairy products are essential components of the human diet, but various contaminants, e.g. microorganisms from personnel, equipment and water, or even veterinary drugs, chemical pollutants and toxins can act as causative agents for many food-borne diseases **(WHO, 1999-2000 and Demirbas *et al.*, 2006)** . The systematic approach to minimize economic losses and food poisoning outbreaks from all steps in the dairy production process has been positively affected by the development of the Hazard Analysis and Critical Point (HACCP) system. HACCP has been standardized by the (**Codex Alimentarius Commission**, **1996)** and generally is a preventive approach which identifies, maintains, evaluates, controls and monitors each production point that is significant for food safety (**Mortimore and Wallace, 2013**).

HACCP was originally developed as a "zero defects" program and considered to be synonymous with food safety. HACCP is a science-based system used to ensure that food safety hazards are controlled to prevent unsafe food from reaching the consume (**Bardic, 2001; Morris, 1997; Smukowski, 1996).**

In contrast to the classical approach, HACCP establishes control systems that focus mainly on preventative measures rather than relying on end product testing **(Dobson, 1995).** It targets the identification of specific hazards (microbiological, chemical and physical) and suggests the adoption of preventative measures for their control. The main benefits and barriers after the application of the HACCP system in the above industry are also identified and discussed **(Peristeropoulou *et al.*, 2015; Pierson and Corlett, 1992)**.

HACCP is a world-recognized, effective, and preventive food hygiene management system. At present, the HACCP system has been widely adopted by many countries such as the United States, Japan, the United Kingdom, and member states of the European Union, as well as international organizations such as the World Health Organization, Food and Agriculture Organization, and Codex Alimentarius Commission **(Meng *et al.*, 2011).**

Milk and milk products such as cheese are historically among the safest foods **(Kosikowski and Mistry, 1997).** However, the recent (80Õs) high number of separate outbreaks involving *Listeria monocytogenes, Salmonella spp., Escherichia coli* and *Streptococcus spp*.**(Johnson *et al.*, 1990)** made HACCP also essential for the dairy industry. During the latest years several applications of HACCP in milk and milk products, including cheese, have been reported **(Dijkers *et al.*, 1995; Jervis, 1992; Varnam and Sutherland, 1994; Lecocq *et al.*, 1996).**

In this study, we focused on the identification and analysis of hazards (microbiological, chemical and physical), evaluation and installation of preventive measures that include controlled operational prerequisite programs (OPRP) and critical control points (CCP), and that at the production line yoghurt, fermented cream and kariesh cheese in Food Technology Research Institute, Agricultural Research Center, and Giza, Egypt.

In this study HACCP plan was established through the following tasks:
- Assembly of HACCP team.
- Description of the products and its intended use.
- Construction of flow diagram and on-site verification.
- Hazard analysis.
- Identification of the critical control points (CCPs).
- Establishment of critical limits for each CCP.
- Establishment of monitoring procedures.
- Establishment of corrective actions.
- Establishment of verification procedures.
- Establishment of documentation and records.

Materials and methods:-

Materials:-

Fresh buffalo milk& Fresh skim milk were obtained from the Agricultural Research Center, Giza, Egypt, and used for milk or cream standardization. Fresh cream with 25% fat was prepared.

Pure culture of S*treptococcus thermophilus* and *Lactobacillus delbrueckii subsp. bulgaricus* 1:1 were obtained from Chr. Hansen Laboratories, Denmark.

Hand sanitizers: Soft care Plus (H400) (Professional product for care "Bacteriostatic hand wash") and Soft care Alco Plus(H500) (Hand disinfectant) as well as chlorine solution and salt were purchased from local market.

Manufacture of set yoghurt, fermented cream and kariesh cheese:-

Flow diagrams for manufacture are shown in **Figurs (1, 2 and 3).**

Methods of analysis:-

Chemical analysis: The total solids, protein and ash content of milk and milk products were determined according to procedures described by the **A.O.A.C. (2000)**. The fat content, acidity and pH value were determined according to **Ling (1963).** Lactose content of milk was determined according to **(Barentt and Abdel-Tawab, 1957**).

Chemical hazards: Presence of formalin, starch and bicarbonate in received milk was determined according to **Kotterer and Muench (1978**) and detection of H_2O_2 was carried out according to **Pien *et al.* (1953)**. Clot on boiling: Clot on boiling test was carried out as described by **Ling (1963).**

Physical hazards: Presence of strange odor or metal in received milk was determined

Microbiological analysis:-

Ten g sample was taken from raw milk , yoghurt , fermented cream and kareish cheeses then homogenized in sterile 90 ml of 0.1% peptone water. Serial 8 fold dilutions in sterile 0.1% peptone water were prepared for bacterial analysis. MRS agar was used for the enumeration of Lactobacilli. Plates were incubated at 30°C for 24 h. Potato Dextrose Agar was used for yeast and mould enumeration. Plates were incubated at 25°C for 5 days, according to **(APHA ,1994).** Violet Red Bile Agar was used for the enumeration of *coliforms*. Plates were incubated at 37°C for 24 h, according to (**APHA,1994*).*** *Staphylococcus aureus and Salmonella spp* were detected according to methods recommended by the **(ICMSF, 1996).**

Table (1):	Physicochemical properties of yoghurt, fermented cream and kariesh cheese at 4°C during storage.					
Samples	Physicochemical properties					
	Total Solids	Fat	Protein	Ash	Lactose	pH
Yoghurt						
Zero Time	12.13	3.5	4.1	0.69	3.85	4.66
After 7 days	12.15	3.5	4.2	0.71	3.77	4.61
After 14 days	12.18	3.5	4.4	0.72	3.69	4.51
Fermented Cream						
Zero Time	31.81	25.1	2.21	0.69	3.97	4.61
After 14 days	31.88	25.1	2.25	0.69	3.71	4.59
After 21 days	31.89	25.0	2.27	0.71	3.65	4.51
Kariesh Cheese						
Zero Time	30.13	0.50	24.22	1.77	3.77	4.51
After 14 days	30.89	0.50	25.31	1.81	3.31	4.27
After 21 days	31.12	0.50	25.93	1.85	3.11	4.12

Results and discussion:-

The overall flow diagram of the Yoghurt , Fermented Cream& Kariesh Cheese technical were summarized in **Figurs (1, 2 and 3)** including receiving of raw materials, clarification , standardization, heat treatment, cooling**,** starter inoculation , filling and cold storage.

Hazard analysis and prevention measures establishment:-

From the receipt of materials to the delivery of the final products to every retailer, hazard analysis was performed at every technical procedure to define any biological, chemical, and physical factors that may affect food safety. The severity and risk will determine the significance of each hazard.

In this study the hazard analysis associated with the production process of yoghurt, fermented cream and kariesh cheese were determined **(Table 2, 3, 4&5 and Form 1).**

a- Physical hazards:-

The high quality raw milk is the basis for production of high quality milk and other dairy products. The milk should have good flavor, free from off-odor and any visible contamination of forage materials. The physical hazards associated with the raw milk were identified and shown in **Table (2).**

b- Chemical hazards:-

Table (3) shows that the milk delivered by suppliers was free from formalin. Starch, and bicarbonate were no detected of the raw milk samples. 2% of samples of the raw milk from suppliers clotted by boiling. With respect to H_2O_2, as seen from the same Table, 66% of milk samples contained H_2O_2. H_2O_2 is usually added in summer time in order to improve milk keeping quality. Presence of H_2O_2 indicated the improper production and handling.

c- Biological hazards:-

Biological hazards of milk and milk products were evaluated microbiologically before and after HACCP pre-requisite programmer application. Data obtained are shown in **Tables (4 and 5)** of reflected the powerful effect of HACCP pre-requisite programs application as all samples were free from pathogenic microorganisms at zero time and during the storage period the same results according to **Kassem *et al.* (2002)** studied the hygiene quality of some packaged milk (pasteurized or sterilized) and dairy products before and after application of HACCP system at a milk and dairy products company in Cairo, Egypt. They mentioned that the assessment of hygiene quality of the milk and dairy products before and after HACCP system showed an improvement in quality and overall

improvement in the condition at the company. Also, **Hoolasi (2005)** investigation of many milk and milk product samples microbiologically and chemically before and after HACCP system implementation the tighter controls that were implemented impacted positively on the microbiological quality of the product.

Table (2):	**Physical hazards including forage, insect fragments and impurities for raw milk and plastic cups.**		
Raw Materials	**Forage g/100g**	***Insect fragments* g/100g**	**Impurities g/100g**
Raw Milk	1.21	0.038	1.062
Plastic cups	-	-	+

The corrective action taken was: a) Clarification of milk b) using plastic cups sanitizer as well as washing with hot water.

Table (3):	**Detection of starch, formalin, bicarbonate, H_2O_2 presence and clot on boiling of raw milk.**
Test	**% of positive samples**
H_2O_2	66
Formalin	-
Starch	-
Bicarbonate	-
Clot on boiling	2

The corrective action taken was rejection of the up normal milk samples.

Table (4):	**Microbiological analysis of milk and milk product samples before HACCP pre-requisite programmer application.**					
Samples	**Microorganisms**					
	Total counts	**Mold& yeast**	***Staphylococcus aureus***	**Coliform group**	***Salmonalla spp.***	**Sporfoming**
Raw milk	Over	$20x10^3$	$42x10^3$	$160x10^3$	$16x10^3$	$85x10^3$
Heat treated milk	$10x10^1$	ND	ND	ND	ND	ND
Yoghurt						
Zero Time	$150x10^5$	$25x10^3$	$20x10^3$	$60x10^5$	ND	$15x10^2$
After 7 days	Over	$40x10^4$	$15x10^4$	$150x10^5$	ND	$6x10^2$
After 14 days	Over	$52x10^3$	$30x10^4$	$155x10^4$	ND	$14x10^2$
Fermented Cream						
Zero Time	$20x10^5$	$75x10^4$	$77x10^4$	ND	ND	$10x10^3$
After 14 days	revO	$75x10^4$	$45x10^4$	ND	$120x10^4$	$10x10^3$
After 21 days	revO	$26x10^4$	$140x10^4$	ND	$152x10^4$	$6x10^2$
Kariesh Cheese						
Zero Time	Over	$14x10^3$	$102x10^5$	ND	$98x10^5$	$30x10^5$
After 14 days	Over	$40x10^5$	$15x10^4$	ND	$98x10^5$	$14x10^4$
After 21 days	Over	$85x10^4$	$95x10^4$	ND	$63x10^4$	$6x10^2$

ND Not Detected

Table (5):	**Microbiological analysis of milk and milk product samples after HACCP pre-requisite programmer application.**					
Samples	**Microorganisms**					
	Total counts	**Mold& yeast**	***Staphylococcus aureus***	**Coliform group**	***Salmonalla spp*.**	**Sporfoming**
Heat treated milk	ND	ND	ND	ND	ND	ND
Yoghurt						
Zero Time	$6x10^3$	ND	ND	ND	ND	ND
After 7 days	$3.2x10^9$	ND	ND	ND	ND	ND
After 14 days	$1.7x10^6$	ND	ND	ND	ND	ND
Fermented Cream						
Zero Time	$13x10^3$	ND	ND	ND	ND	ND
After 14 days	revO	ND	ND	ND	ND	ND
After 21 days	revO	ND	ND	ND	ND	ND
Kariesh Cheese						
Zero Time	$.5x10^9$	ND	ND	ND	ND	ND
After 14 days	$9.4x10^9$	ND	ND	ND	ND	ND
After 21 days	$7.4x10^9$	ND	ND	ND	ND	ND

ND not detected

The engagement of the entire HACCP team in the identification and analysis of each steps of the production process separately from the raw materials until the storage of final product resulted in only one CCP while the other steps were identified as an operating pre-requisite programmer.

Acceptance of raw material:-

Milk and other dairy products can provide yoghurt, fermented cream, kareish cheese with fat content and nonfat solids, giving yoghurt, fermented cream, kareish cheese, its distinctive starter and rich nutritional materials. Additionally, fermented cream offers various kinds of fine lipid, which enhances the smooth mouth feel of the final product **(Li, 2005).**

The microbiological quality of yoghurt, fermented cream & kareish cheese should be low, as it is a rich growth medium for microbes. There are numerous reports on the incidence of human pathogens in yoghurt, fermented cream, kareish cheese such as *Salmonella species, Staphylococcus aureus, and Sporforming* **(Vought and Tatini, 1998; Massa *et al*., 1989; Torkar and Mozina, 2000)**. Raw material suppliers are required to submit quality inspection reports. Every batch of material should be sampled and inspected.

Identification of critical control points (CCPs) during the entire production process and drafting of programmes for monitoring were carried out by experts of each field (HACCP team).

In the team were engaged, food and technology consultants, quality control manager, quality control engineer, microbiologist, chemist, production manager, production engineer, maintenance engineer and research and development engineer.

The team made the full description of the products with necessary data on the manners of use, composition, conditions of processing, packaging, storage, distribution and time limit for their use **(Form 2).**

Establishing CCPs and critical limits:-

Critical control point in the production process of the products was identified through the use of decision tree **(Fig. 4)** and illustrated in **form (3).**

CCP pasteurization:-
The one CCP suggested in this study was the pasteurization process. Pasteurization temperature should be maintained at 80-85°C, and the temperature needs to be maintained for 15 minutes **(Zhong, 2012).** Inadequate pasteurization may allow the pathogens to remain and grow, whereas extra-high temperature or extra-long pasteurization may negatively affect product quality.

Establishing monitoring procedure:-
To guarantee that the critical limit established at every CCP can be continuously fulfilled, monitoring procedure must be established in the HACCP system. The monitoring procedure contains the following factors: object, such as additive quantity; method, such as demanding for inspection report; frequency, such as every batch; personnel, such as operators **(Form 4).** In this respect , (**Ali and Fischer, 2000)** showed that the implementation of HACCP programmer play a lead role in developing monitoring strategies and generating validation data to help the HACCP team assesses the effectiveness of the processing control being used. Monitoring procedure conclusion for CCP through products manufacture was evaluated and illustrated in **(Form 4).**

Establishing corrective measures, verification, record, and documentation:-
In order to prevent unsafe products from reaching consumers, a corrective action is carried out when there is a deviation from any established CCP. During this procedure, problems will be corrected and production will be put back in control. Any unqualified product will be further tested to determine its safety. A complete HACCP plan also requires a verification procedure, such as random sampling and testing, to examine whether HACCP can effectively control food safety. Additionally, the implementation of the HACCP system should be well documented. Documentation usually includes the content of hazard analysis and CCP determination, and recordkeeping includes CCP monitoring activities, deviation and associated corrective actions, and verifications. These procedures help to verify that HACCP controls are in place and are being appropriately maintained.

Regarding the corrective actions taken by the work team, (Form 5) shows:
-Rejection of received milk if the contamination is evident through receiving raw milk.
-Re-heat treatment (time & temperature) if the monitoring results were corrected.
-Sanitizer and washing with hot water for plastic cups.

Verification procedures were established (Form 6) to verify that the HACCP system is working correctly through processing.
HACCP team is responsible for verification of HACCP system and that will achieve through:
-Ensure that the HACCP plan is functioning effectively.
-Review of records for complains accuracy, and identification of non-compliance and corrective action taken.
-Equipment function checks e.g temperature and time.
-Microbiological end products testing.
- Chemical end products testing

Documentation and record keeping of HACCP system for products processing (Form 7) included:
- Listing of the HACCP team and assigned responsibility.
- Description of the product and its intend use.
- Flow diagram for the products process steps.
- Hazards associated with each CCP and preventing measures.
- CCP determination
- Critical limits for each CCP.
- Monitoring procedures for every process step and CCP.
- Corrective action for deviation from critical limits.
- HACCP plan.
- Record keeping.
- Procedures for verification of HACCP system.

Form (1): Hazard analysis for yoghurt, fermented cream and kariesh cheese

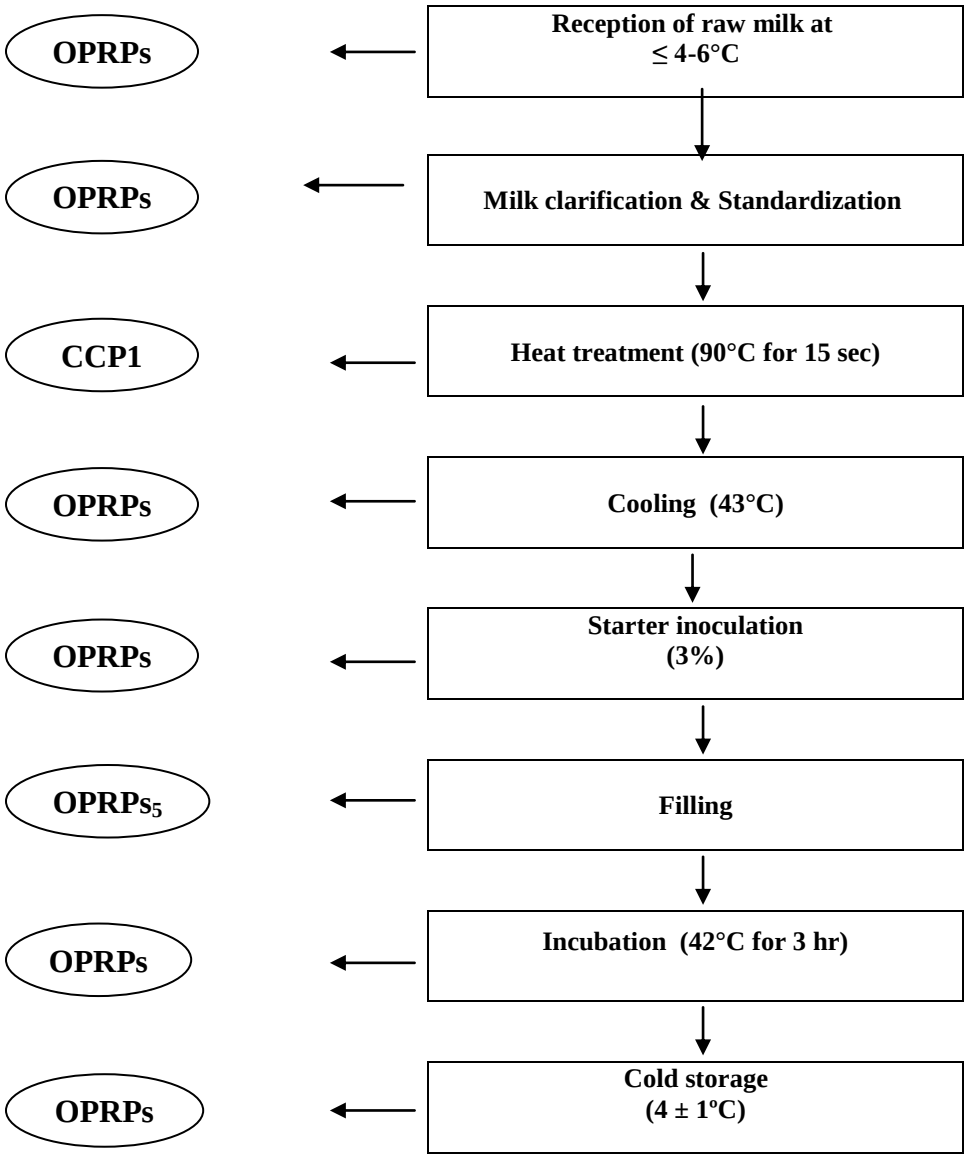
#	Process steps	Hazards	Preventive Measures
1	**Receiving raw milk.**	- High microbial load - Cross Contamination - High acidity - Environmental contamination	- Receive at < 4-6˚C
2	**Clarification of milk**	- Cross Contamination	- R-Clarification
3	**Separation of milk**	- Cross Contamination	
4	**Heat treatment**	- Microbial survival	Time and temperature control
5	**Processing**		
	a: Yoghurt (Fig.1)	- Microbial growth - Cross contamination	- Time temperature control - GMP
	b: Fermented Cream (Fig.2)		
	c: Kariesh Cheese (Fig.3)		
6	**Packaging**	- Cross contamination	- GMP
7	**Storage**	- Microbial growth	- Lab Test

GMPs: Good Manufacturing Practices.

Form (2): Description of yoghurt, fermented cream and kariesh cheese and its intended use.

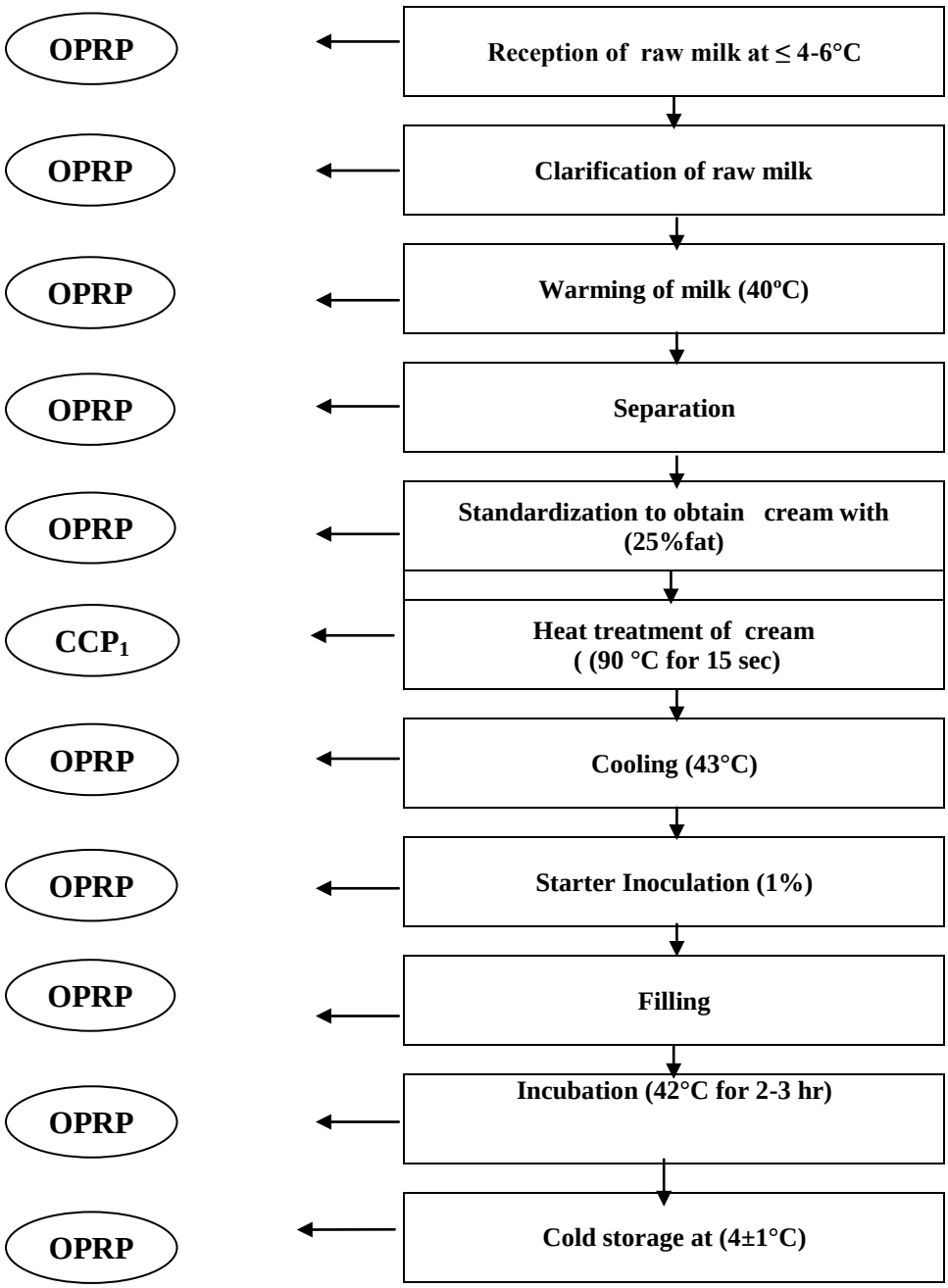
	Common Name Description	Yoghurt	Fermented Cream	Kariesh Cheese
	Process description	Reception of natural raw milk at ≤4-6°c, milk clarification, milk standardization, heat treatment, cooling, starter inoculation, filling, incubation, cold storage	Reception of natural raw milk at ≤4-6°C, milk clarification, warming of milk 40±2°C , separation, standardization to obtain cream with 25 % fat, heat treatment of cream, cooling, starter inoculation, filling, incubation, cold storage	Reception of natural raw milk at ≤4-6°C, milk clarification, warming of milk 40±2°c , separation, heat treatment of skim milk, cooling, starter inoculation, incubation, whey drainage, filling, cold storage
	Composition	Buffalo milk, bacterial cultures	Cream made from pasteurized cream and starter culture.	Skim milk , bacterial cultures
	Consumer/Customer intended use	The product is used as fermented milk (yoghurt), all age groups (kids ,young and old)	The cream is used as fermented product	The product is used as soft fresh cheese (Kariesh cheese)
	How it is to be used?	Direct consumption	Direct consumption	Direct consumption
	Important properties	pH=4.6	pH = 4.5	pH = 4.5
	Packaging	Plastic cups	Plastic cups	Plastic cups
	Shelf life	14 days	14 days	21 days
	Labeling instructions	Within legal limits	Within legal limits	Within legal limits
	Special Storage and distribution control	Refrigeration at 4±1˚C	Refrigeration at 4±1˚C	Refrigeration at 4±1˚C

Based on the technical data the HACCP team confirmed the following figures for the production process. The following figures of the production process were very important for risk analysis determination.



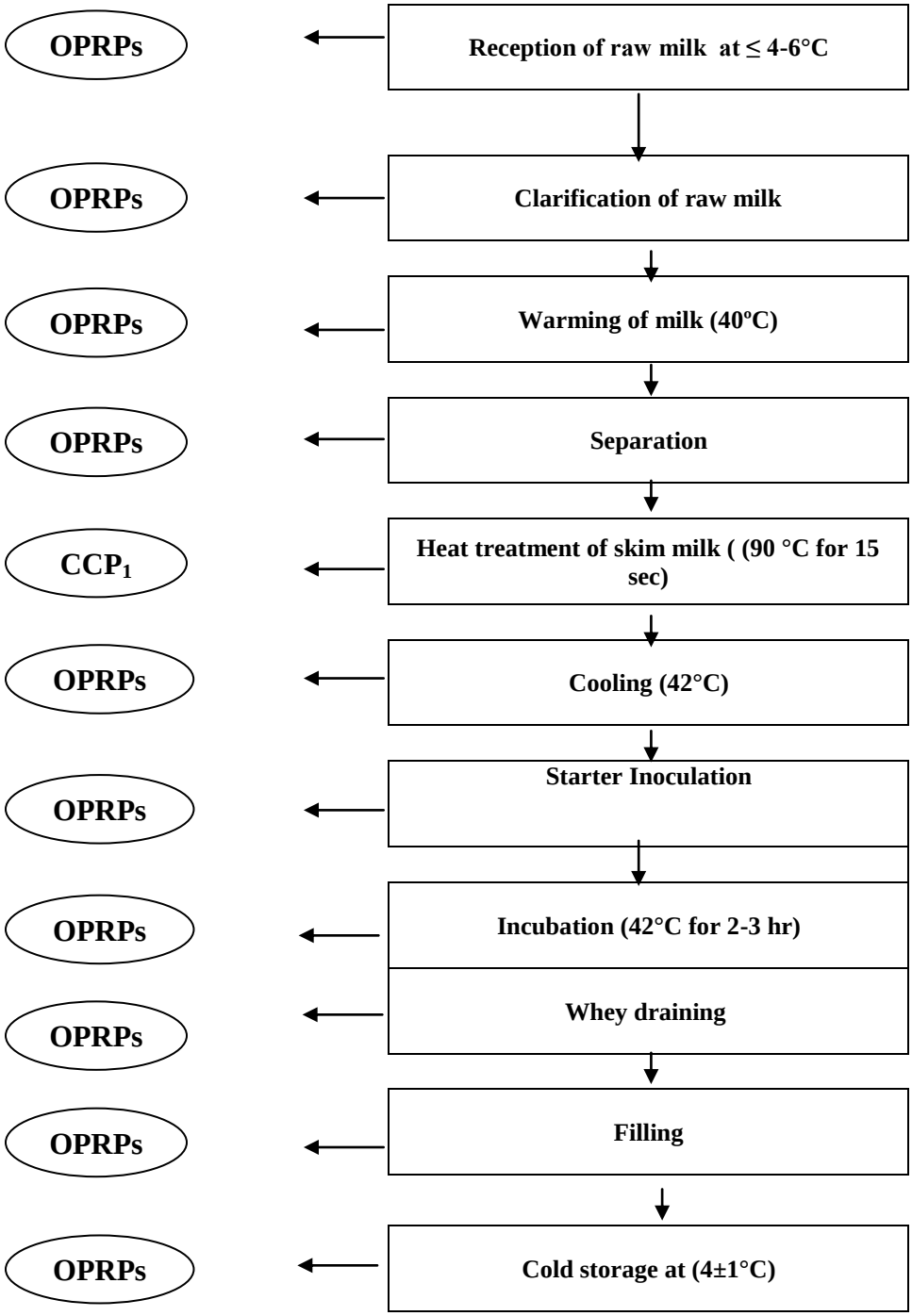
OPRPs: Operating pre-requisite programmer

Figure (1): Flow diagram of Yoghurt process



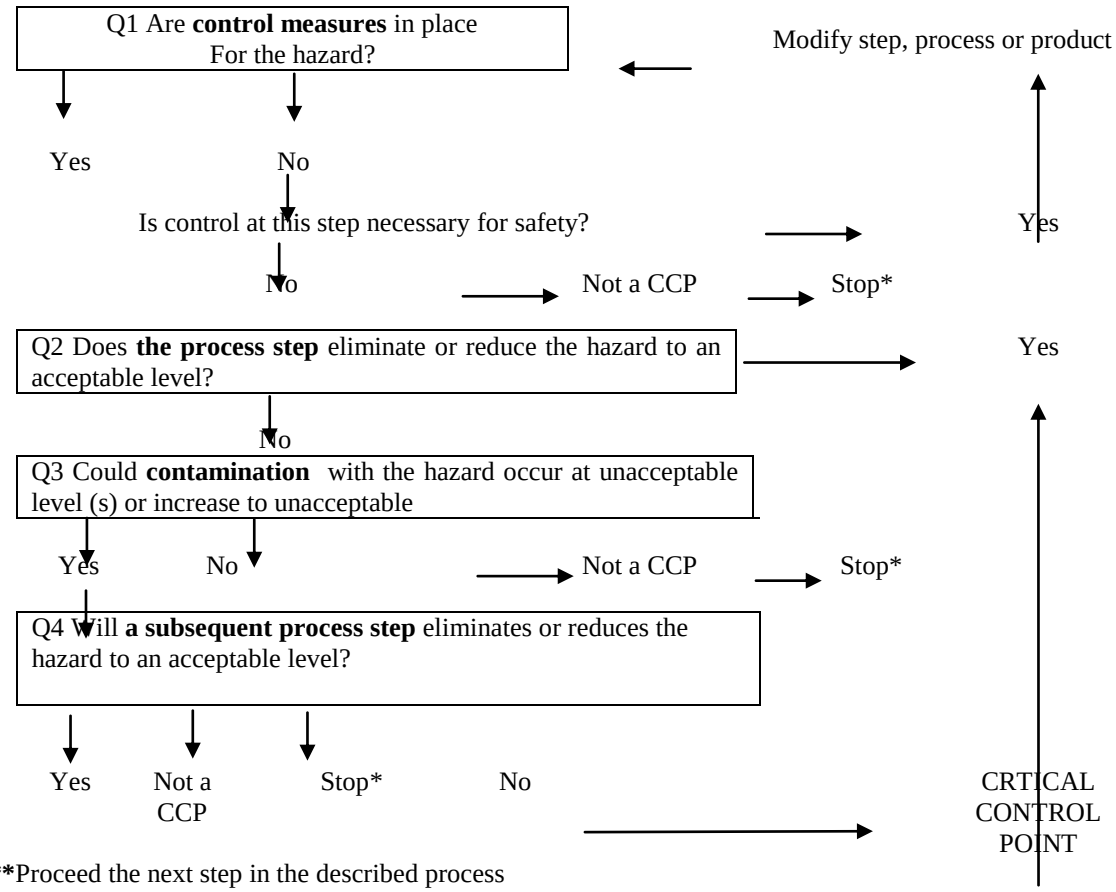
OPRPs: Operating pre-requisite programmer

Figure (2): Flow diagram of fermented cream process



OPRPs: Operating pre-requisite programmer

Figure (3): Flow diagram of kariesh cheese process



**Proceed the next step in the described process

Figure (4): HACCP decision tree for the determination of critical points in HACCP plans (Jervis, 2002).

Form (3):	**Critical limits for yoghurt, fermented cream and kariesh cheese (each identified CCP process).**			
#	Process steps	Hazards	Preventive Measures	Critical Limits
1	**Receiving raw milk.**			Receive milk at < 4-6˚C and pH 6.6 check (change) supplier
2	**Clarification of milk**			
3	**Separation of milk**			
4	**Heat treatment**			Heat treatment at 90-95˚C for 15 seconds
5	**Processing**			Time and temperature control mentioned in the flow diagrams of the products
	a: Yoghurt (Fig.1)			
	b: Fermented Cream (Fig.2)			
	c: Kariesh Cheese (Fig.3)			
6	**Packaging**			Manual packages
7	**Storage**			Storage at 4±1˚C

Form (4): Monitoring system for each CCP or OPRPs through product processing.

Process steps		Hazards	Preventive measures	Critical limits	Monitoring			
					Procedure		Frequency	Responsible
1-	Receiving raw milk				-	Temperature and pH measurements –time and temperature measurements	-at every receiving time -at every heat treatment	-Quality control and production supervisors
2-	Clarification of milk & separation				-	Visual inspection	- at every clarification	
3-	Heat treatment					- Time and temperature measurements.	- at every heat treatment	
4-	Processing				-	Time and temperature measurement	- at every handling	
	A:yoghurt (Fig.1)							
	B:Fermented cream (Fig.2)							
	C:Kariesh Cheese (Fig.3)							
5-	Packaging				-	Visual inspection	- at every packaging	
6-	Storage					Visual inspection	-at every storage period	

Form (5): Corrective actions in the process.

Process steps		Hazards	Preventives measures	Critical limits	Monitoring			Corrective actions
					Procedure	Frequency	Responsible	
1.	Receiving raw milk							- Reject received milk if contamination is evident
2.	Clarification of milk & separation							- Re- clarification
3.	Heat treatment							- Re- Heat treatment milk
4.	Processing:-							- Correct time and temperature
	a:yoghurt (Fig.1)							
	b:Fermented cream (Fig.2)							
	c:Kariesh Cheese (Fig.3)							
5.	Packaging							- Visual display reject for damaged - Sanitizer and washing with hot water plastic cups
6.	Storage							- Testing of the product

Form (6):	**Verification procedures for products processing.**								
Process steps		**Hazards**	**Preventive measures**	**Critical limits**	**Monitoring**			**Corrective actions**	**Verification procedures**
					Procedures	Frequency	Responsibility		
1.	Receiving raw milk.								
2.	Clarification of milk & Separation								
3.	Heat treatment								Check Heat treatment records-Testing of the product- check calibration of monitoring devices
4.	Processing:								
	A: Yoghurt								
	B: Fermented Cream								
	C:Kariesh Cheese								
5.	Packaging								
6.	Storage								- Check storage temp. records- testing of the product- check calibration of monitoring devices.

Form (7): HACCP plan products processing.

Processing steps		Hazards	Preventive measures	Critical limits	Monitoring			Corrective actions	Verification	Record
					Procedures	**Frequency**	**Responsibility**			
1.	Receiving raw milk.									
2.	Clarification of milk & separation									
3.	Heat treatment									Heat treatment (CCP1) Monitoring work sheet Tabs testing report Calibration Certificate Monitoring devices
4.	. Processing:									
	a: Yoghurt (Fig.1)									
	b:fermented cream (Fig.2)									
	c: Kariesh Cheese (Fig.3)									
5.	Packaging									
6.	Storage									-Storage monitoring sheet-lab testing report-calibration certificate monitoring, devices

Conclusions:-

The application of the HACCP system provides food manufacturers with effective preventive methods to guarantee food safety and improve management. Additionally, the documentation and records generated in the HACCP system can easily help in tracing the origin of contamination, thus preventing further production of substandard products and lower the consumption of manpower, material, and financial resources.

The HACCP system in this study for yoghurt, fermented cream and kareish cheese line manufacture is developed in the same literature review. The prerequisite program was provided to deal with some hazards before the production; therefore, to simplify the HACCP plan. The product description was used to alert the consumer to the potential hazards in the final products. By answering the questions in the decision trees, the critical control point was determined. Finally, the HACCP system form was developed to include components of several HACCP principles which are critical limits, monitoring, corrective action and responsibility.

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