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Hazard Analysis and Critical Control Points (HACCP) in pasteurization department for a Dairy Factory in Damietta Governorate

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ABSTRACT

This study aimed to apply Hazard Analysis and Critical Control Points (HACCP) in dairy industry for one of the dairy factories in Damietta governorate in pasteurization department. this study focused on microbiological hazards in addition to displaying physical and chemical hazards in the factory which appeared during the visit of National Food Safety Authority (NFSA) in the factory under study. the highest mean value of Total Bacterial Count (TBC)of pasteurization division for the first-time being milk exit hatch from the car (S1) (47×10^3) cfu/ml, skimmed device exits to cream tank (S4) (27.6×10^3), respectively. Results of the total fungi and yeasts were higher than, (0.9×10^3cfu/ml). the highest contaminated swabs were milk exit hatch from the car (S1) having (6.4×10^3) followed by cream tank (S5) which giving (6.1×10^3 cfu/ml), respectively. the results of *Esherichia coli* were two swabs gave positive results. Those swabs were (S1) and (S2), and other swabs showed negative results. the maximum value of TBC in pasteurization division for the second time was pasteurization device entrance (S6) (7.1×10^3) cfu/ml as pasteurization is the first control point in the pasteurization process. the minimum value was homogenizer exit (S5) (0.3×10^3 cfu/ml), TBC decreases in (S7) comparing with (S6) this mean that pasteurization eliminate contamination with TBC in manufacturing process pasteurization was (CCPs). the highest contaminated swab of total count of Fungi and Yeasts was Tetra Pack machine A1'buoy (S9) showed (10.6×10^3 cfu/ml). Nine of swabs were tested for *E. coli*. It was found that all samples were negative. All chemical tests were identical with the Egyptian standard specifications NO.1616/2005. Milk and its products (UHT milk-yoghurt-cheese- cream-butter-dried milk) are food allergens. According to HACCP plan the factory must put Control program in food allergens. the factory under study was unconformity to NFSA requirements in physical hazards.

INTRODUCTION

Dairy products have an ultra-protection because of well controlled processing conditions such as heating, drying, chilling, curing, freezing, and fermenting. Hazard Analysis and Critical Control Points (HACCP) studies related to four types of hazards in the field of food industry. Microbiological hazards (contamination) include bacterial contamination. Bacterial contamination is the most common cause of food poisoning worldwide. Microorganism's hazard such as *Salmonella*, *Shigella*, *Staphylococcus*, *Clostridium*, *Escherichia coli* and *Aspergillus flavus*. Chemical hazards which included toxic substances like Pb, Zn, pesticide, bacterial toxins, and other toxins. Physical and industry process hazards, each step of manufacturing food steps beginning of raw materials receiving to the final product distribution. Common sources of physical contaminations are hair, glass or metal, pests, jewelry, dirt, and fingernails. Food allergy is an allergic emergency that typically occurs within the first few minutes to two hours and can produce the sudden onset of itching, hives (urticaria), swelling of the face, tongue or back of the throat that may be accompanied by difficulty breathing and/or light headedness and hypotension. Allergy to milk other than other food is more common in children than in adults **(El-Ghoneim *et al*., 2019)**. And food allergens hazard **(Khoa and Jeongb, 2020 and Kohilavani *et al*., 2021).** ISO 22000 refers to the combination of HACCP principles and Prerequisite Programs (PRPs)1 on the basis of ISO 9000 standard system structure. Most food safety management systems normally establish PRPs as the basis of hygiene protocols, suggesting that there is only a minor difference between HACCP and ISO 22000. So far, however, there has still been very limited discussion about the financial impact of HACCP certification, despite it being widely adopted in the food industry and being directly related to the health and safety of consumers **(Feng Liu *et al*., 2021).** The initial implementation of this system requires additional resources for staff training equipment and extra supplies purchase, as well as technical support. In the long term, the return of the investment is verified by the reduction of contaminated food, improvement on quality and safety of the food, increase in reliability and fewer complaints from consumers. If correctly developed, the pre-requisite programs can provide good control for the basic principles of food handling and can also be used to support implementation of an HACCP plan. As a result, the plan becomes more efficient, easier to manage and less expensive **(Roberto *et al*., 2006).** The basic principles behind the HACCP concept have been in use for many years in the dairy industry under the rubric of common sense. Because the dairy industry has a very good overall safety record, there has been no need to adopt the HACCP system with all its ramifications. This will change now in the European Union, and several publications gave HACCP plans for the dairy industry. These generic or model plans are useful to give guidance, and furnish ideas or reference values, but they cannot substitute for a HACCP study which should establish a line- and product-specific HACCP plan **(Schothorst and Kleiss, 1994).** Most dairy products have an excellent safety record, due to well-controlled processing conditions. The main potential hazards are microbiological. Pasteurization, however, has proved to be successful as a CCPs to control classical zoonoses as well as newer foodborne pathogens. Chemical hazards are less important and have in most cases been taken care of by the suppliers of raw materials. Physical hazards are related mainly to packaging. The dairy industry uses a variety of technologies (e.g. heating, drying, chilling, freezing, curing, fermenting), but the HACCP concept can be successfully applied in all types of production lines. The WHO text is used as background document for some comments specific to the dairy industry **(Schothorst and Kleiss, 1994).** The dairy industry has many years' experiences with the basic principles of HACCP. The fact that brucellosis, tuberculosis and some other zoonoses can be milk borne was already known in the last century, and the boiling of milk before consumption was recognized as an effective preventive measure. Pasteurization was introduced in the dairy industry partly to combat these diseases, and heating requirements considered the heat resistance for these zoonotic agents. In HACCP terminology, *Mycobacterium bovis* was identified as a potential hazard, pasteurization as a critical control point (CCPs) and critical limits were established to ensure reduction to acceptable levels. Later *Salmonella*, *Campylobacter* and *Listeria monocytogenes* were added to the list of potential hazards in raw milk, and mandatory pasteurization has been proven to be an essential preventive measure **(Sharp, 1986 and Ramos *et al*., 2021).** This article aimed to detect hazards and critical control points for pasteurized milk in all manufacturing steps, these hazards including microbiological, physical, chemical and food allergens hazards.

MATERIAL AND METHODS

Microbiological analysis was done using Pour Plate Method **(Benson, 2001)**. Total Bacterial was incubated at 30°C for three days **(El-Kadi *et al*., 2018)** using Nutrient agar medium (N.A) **(Ronald, 2010)**. Fungi and yeasts Count **(Anon, 1992)** was in Potato dextrose agar medium (PDA) and it incubated at 30°C for five days **(Hamad *et al*., 2020)**. The most probable number (MPN) technique **(APHA, 2005)** was used for counting Coliform. Tubes of MacConkey broth medium were used for Coliform count (*Escherichia coli*) **(El-Dengawy *et al*., 2012)**. All tubes were incubated at 37°C for one days. The number of positive tubes were recorded. The most probable number of microbes per ml of sample was calculated from standard Tables **(Sutton, 2010)**. Samples (swabs) were taken starting from receiving raw milk to the final product passing by all manufacturing steps in order to recognize all hazards surrounding with food **(Oranusi *et al*., 2003)**. All practical work completed in Microbiology Laboratory, Faculty of Agriculture, Damietta University.

Tubes with 10 ml of sterile tap water were used for each swab. The swabs were shacked well for 1 min. The solution was transferred into 90 ml sterilized tap water and the dilutions was from 10^{-1} to 10^{-3} were done. One ml of dilution (10^{-1} - 10^{-2} -10^{-3}) was inoculated into sterile Petri dish, and then melted suitable medium was poured and mixed well then left to solidifying. These Petri dishes were then incubated at the suitable temperature for appropriate period **(El-Fadaly *et al*., 2016)**. Obtained single developed microbial colonies of different morphologies in all used cultivation media were picked-up (**Spencer and Spencer, 2001)**. Chemical analysis was done using **Fat content (F%):** Fat Content was determined using Gerber tube for milk samples according to **BSI (1955). Titratable acidity (TA):** Titratable acidity for milk samples was determined as given by **Ling (1963). To estimate lactometer using** by hydrometer, **Calculate Solid Not Fat (SNF)= (**fat×0.2) + (lactometer÷4) +0.14 Samples collection was done twice from some of critical points, in the first department which was pasteurization department. Ten samples were collected in the processes of the first time which began with Preparing pasteurized milk for manufacturing yoghurt product (Table 1). Nine samples were collected in the second time which began with Preparing pasteurized milk for manufacturing UHT Milk (**Table 1**).

RESULTS AND DISCUSSION

Description of Processing operation in production hall. In the morning milk supplier arrived at the company hence the production engineers its work begins in partnership with the quality engineer who measure the temperature (check cleaning of the milk car and take sample milk to make the chemical examination which only put the limits between acceptable and rejected milk by group of chemical tests (PH, acidity, fat, protein, SNF, antibiotic test and boiling test)

Microbiological hazards

Results presented in **Table (2)** showed that, microbiological hazards in the first time. The highest mean value of TBC of pasteurization division being Milk exit hatch from the car (S1) (47×10^3) cfu/ml, skimmed device exit to cream tank (S4) (27.6×10^3), respectively. (S1) was high because the supplier wasn't follows Pre-Requisite Programs (PRP) especially (GMP) as mentioned earlier. (S4) came as the second highest step because of the skimmed device exit to cream tank was opened on cream tank without any protective method. But it was the lowest mean value being pasteurization device exit to yoghurt tank (S10) (0.85×10^3) cfu/ml as the milk pasteurized at 85^0C for 15 seconds, the total bacterial count decreases in (S10) comparing with (S9) this mean that pasteurization eliminate contamination in manufacturing operation this step was (CCPs). These results are in line with those obtained by **(Giacometti *et al*., 2015)** who reported that, *Salmonella* spp. and *L. monocytogenes* found in raw milk, but pasteurization treatment decreased the count. Results of the total fungi and yeasts count of Pasteurized Milk samples were higher than, 0.9×103cfu/ml as clearly shown in Table (2). The highest contaminated sample was Milk exit hatch from the car (S1) having (6.4×103) followed by Cream tank (S5) which giving 6.1×103 cfu/ml swabs, respectively. The count of Fungi and Yeast decreases in (S10) comparing with (S9) this mean that pasteurization eliminate contamination in manufacturing process as pasteurization was critical control point **(CCP)**.

When applying examination on the line of producing Pasteurized Milk on MacConkey broth medium, two samples gave positive results. Those swabs were (S1) and (S2), and other swabs showed negative results (Table 2). The received milk contaminated with *E. coli* in Milk exit hatch from the car (S1) as the supplier wasn't care about good manufacture practice (GMP) especially follow up cleaning and disinfection for the milk car subsequently Milk receiving hose end (S2) also contaminated with *E. coli*, they were (OPRP) this mean it is possible elimination of *E. coli* in the second step as the Table 1 showed. These results were in line with **(McAloon *et al*., 2015)** who reported that hygiene scoring of animals presents a useful tool for monitoring the hygiene of the dairy cow and by association, the cow's environment. Several systems have been developed for assessing dairy cow hygiene. Results presented in Table (3) showed that, microbiological hazards in the second time. The maximum value was Pasteurization device entrance (S6) (7.1×103) cfu/ml as pasteurization is the first control point in the pasteurization process. In this step the milk entered to Pasteurization device at 85^0C for 15 seconds to get rid of the bacteria, the second point had high value was Tetra Pack machine A1'buoy (S9) (5.1×103 cfu/ml) in this step a defect happened in the machine sterilization lead to increase the number of (TBC). The minimum value was Homogenizer exit (S5) (0.3×103 cfu/ml), Total Bacterial Count decreases in (S7) comparing with (S6) this mean that pasteurization eliminate contamination with TBC in manufacturing process pasteurization was (CCP). These results were like Filippis et al. (2021) who taken samples from pasteurization milk division (Silos, pasteurizers, concentrators, Tanker trucks and they tested the presence of Lactococcus, Acinetobacter, Streptococcus, Staphylococcus, Bacillus, Pseudomonas, and Listeria monocytogenes in the milk. They reported that, the presence of potential pathogens (Listeria monocytogenes, Staphylococcus spp.) on food processing surfaces, which may contaminate the food.

Results of the total count of Fungi and Yeasts (Table 3) exhibited that the highest contaminated swab was Tetra Pack machine A1'buoy (S9) showed (10.6×103 cfu/ml) followed by Preparing and keeping the pasteurized milk cooling (S8) which gave (8.5×103 cfu/ml) the last point had high value was Tetra Pack machine A1'buoy (S9) in this step a defect happened in the machine sterilization lead to increase the count of Fungi and Yeasts before packaging in packs.

Nine of swabs were tested for E. coli and the obtained results is recorded in Table (3). It was found that all samples were negative. The main reason for these negative results comparing with the former swabs in Table (2) that here not received a raw milk from the same former supplier.

Physical hazards

In the factory under study physical hazards represented in Hard materials such as showed in Table (4). Small metals pieces resulting from instruments, equipment and metal too Results presented in Table (3) using in production. Glass such as glass in windows and doors which exposed to break with high rate so every specifications relating with safety food factories prevented using glass in windows and doors and submitted solution replacement by using plastic or alimental in the structure of the windows and doors, in the factory under study the factory windows made of wood in the external frame and internal part made of glass which cause a lot of problems in production halls so National Food Safety Authority recommended in all visitation with change the structure of windows as glass and wood together represented critical point in production process and prevented applying HACCP plan, also glass found in thermometer which used in all production processes starting with receiving milk even packing the final product to measure temperature, for this reason NFSA prevented using glass thermometer in production halls and its presence considered case of incompatible and recommended with using digital thermometer. Stones, wood pieces which appeared clearly in wooden pallets in production halls using in raise products after ending production, so NFSA obligated the factories to use plastic pallets instead of wooden pallets which represented physical hazards.

Chemical and food allergens hazards.

Chemical analysis and food allergens in pasteurization department were showed in Tables 5, 6 and 7. These results compared with Egyptian standard specifications NO. 1616/2005 for pasteurized milk which texted that: the ratio of fat must not decrease than 3% and the ratio of solid not fat must not increase than 8.25% in natural milk and 8.50% in modified milk. Hence the product was identical to the specification NO. 1616/2005.

CONCLUSION

This study aimed to knowing Hazards in pasteurization department for one of the dairy factories in Damietta governorate This study focused on realizing microbiological physical, chemical hazards and allergy foods in the department under study, evaluation, and control on it to reduce it to acceptable limits even not to effect on consumer health.

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CONFLICT OF INTEREST:

The authors declare that they have no conflict of interest.

AUTHORS CONTRIBUTION

Hamad, M. N. F.; El-Kadi, Sh. M. L.; and Abo-Zaid, Hoda G. developed the concept of the manuscript. Abo-Zaid wrote the manuscript. All authors checked and confirmed the final revised manuscript.

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Table (1). Samples collection (swabs and its number) in pasteurization division and its time.

Critical Points (Hazards)	Pasteurization department	
	First time	Second time
Milk exit hatch from the car.	▲S1 (Time 09:20)	
Milk receiving hose end.	▲S2 (Time 09:28)	
Skimmed milk exit for buoy balance device.	▲S3 (Time 09:35)	
Skimmed device exit to cream tank.	▲S4 (Time 09:40)	
Cream tank.	▲S5 (Time 09:41)	
Shorting solution tank.	▲S6 (Time 09:50)	▲S1 (Time 10:05)
Funnel for dissolving milk powder.	▲S7 (Time 09:51)	▲S2 (Time 10:05)
Knife used to open packages of milk powder and stabilizer.	▲S8 (Time 09:52).	
Pasteurization device entrance.	▲S9 (Time 10:05)	▲S6 (Time 10:30)
Pasteurization device exit to tank.	▲S10 (Time 10:10)	▲S7 (Time 10:50)
Lacor solution tank.		▲S3 (Time 10:10)
Homogenizer entrance.		▲S4 (Time 10:25)
Homogenizer exit.		▲S5 (Time 10:26)
Preparing and keeping the pasteurized milk cooling.		▲S8 (Time 11:10)
Tetra Pack machine A1'buoy.		▲S9 (Time 03:30)

Table (2). Microbiological examination of pasteurization division for the first time.

Critical Points (Hazards)	Microbial counts (cfu/ml)		
	Total bacteria	Fungi and yeasts	*E. coli*
Milk exit hatch from the car (S1)	47×10^3	6.4×10^3	0.9×10^3
Milk receiving hose end (S2)	4.5×10^3	2.8×10^3	0.2×10^3
Skimmed milk exit for buoy balance device (S3)	2.2×10^3	4.4×10^3	Negative
Skimmed device exit to cream tank (S4)	27.6×10^3	4.0×10^3	Negative
Cream tank (S5)	0.7×10^3	6.1×10^3	Negative
shorting solution tank (S6)	3.6×10^3	2.0×10^3	Negative
Funnel for dissolving milk powder (S7)	0.2×10^3	2.0×10^3	Negative
Knife used to open packages of milk powder and stabilizer exit (S8)	4.1×10^3	0.9×10^3	Negative
Pasteurization device entrance (S9)	2.4×10^3	2.7×10^3	Negative
Pasteurization device to yoghurt tank (S10)	0.85×10^3	2.5×10^3	Negative

Table (3). Microbiological examination of pasteurization division for the second time.

Critical Points (Hazards)	Microbial counts (cfu/ml)		
	Total bacteria	Fungi and yeasts	*E. coli*
Shorting solution Tank (S1)	4.9×10^3	2.1×10^3	Negative
Funnel for dissolving milk powder (S2)	4.1×10^3	4×10^3	Negative
Lacor solution tank (S3)	4.9×10^3	2×10^3	Negative
Homogenizer entrance (S4)	0.6×10^3	2.5×10^3	Negative
Homogenizer exit (S5)	0.3×10^3	2.8×10^3	Negative
Pasteurization device entrance (S6)	7.1×10^3	0.4×10^3	Negative
Pasteurization device entrance (S7)	1.6×10^3	1.3×10^3	Negative
Preparing and keeping the pasteurized milk cooling (S8)	1.5×10^3	8.5×10^3	Negative
Tetra Pack machine A1'buoy (S9)	5.1×10^3	10.6×10^3	Negative

Table(4). Physical hazards of pasteurization division.

Hall production	Physical Hazards			According to NFSA*
	Small metals pieces	Glass	Stones, Wood pieces	
Pasteurization milk hall	√	X	X	Non confirmatory

*NFSA: Means National Food Safety Authority.

Table (5). Chemical analysis in pasteurization department for producing UHT milk date of 8/11/2020.

Name of sample	Time	Fat	(L)	PH	(T)℃	Boling	Detection			Alcohol test	SNF	S.NO* 1616/2005
							H_2O_2	formalin	Bicarbonate			
Received milk	8:30	3.7	30.5	6.85	4℃	N.	N.	N.	N.	N.	8.50	Identical
Pasteurized milk	11:50	3.2	33	6.80	15℃	N.	N.	N.	N.	N.	9.0	Identical

Total solid 8.25%for received milk and 8.50% for modified milk; (T): Temperature /(L): Lactometer/ (N): Negative.; ESS (Egyptian standard specifications) (2005)

Table (6). Chemical analysis in pasteurization department for producing natural yoghurt date of 17/10/2020.

Name of sample	Time	Fat%	(L)	pH	Acidity	(T)℃	SNF	TS%	S.NO* 1616/2005
Received milk	8:20	3.4	32.0	6.80	0.15	4℃	8.82	12.22	Identical
Pasteurized milk	10:15	3.9	12.5	6.79	0.16	23℃	8.60	12.5	Identical

تحليل المخاطر ونقاط التحكم الحرجة (HACCP) في قسم البسترة لمصنع ألبان بمحافظة دمياط.

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تهدف هذه الدراسة إلي تطبيق تحليل المخاطر ونقاط التحكم الحرجة (الهاسب) في صناعة الألبان بقسم البسترة لأحد مصانع الألبان بمحافظة دمياط ، حيث تركز هذه الدراسة علي المخاطر الميكروبيولوجية بالإضافة إلي عرض المخاطر الفيزيائية والكيميائية في المصنع والتي ظهرت أثناء زيارات الهيئة القومية لسلامة الغذاء في المصنع تحت الدراسة، **<u>ووجدت النتائج التالية:</u>**

أعلي قيمة للعد البكتيري الكلي بقسم البسترة لأول مرة كانت المأخوذة من خرطوم خروج اللبن من السيارة (S1) ومخرج جهاز الفراز في تنك القشدة (S4) بقيمة (47×10^3 cfu/ml) (27.6×10^3 cfu/ml) علي التوالي، وسجلت قيم العد الكلي للفطريات والخمائر في المسحة (S4) بقيمة (6.4×10^3cfu/ml) وهي أعلي من المسحة (S1) والتي سجلت (6.1×10^3 cfu/ml)، أما عن نتيجة بكتيريا القولون فقد أعطت مسحتين موجبتين وكانتا المسحة الأولي (S1) والثانية (S2) أما عن المسحات الباقية فكانت سالبة.

أعلي قيمة للعد البكتيري الكلي بقسم البسترة للمرة الثانية كانت مدخل جهاز البسترة (S6) بقيمة (7.1×10^3) حيث أن البسترة أول نقطة تحكم في عملية البسترة، وأقل قيمة كانت مخرج جهاز المجنس (S5) بقيمة (0.3×10^3 cfu/ml) وانخفض العد البكتيري الكلي في المسحة (S7) مقارنة بالمسخة (S7) هذا يعني أن البسترة تقضي علي التلوث بالبكتيريا في العملية التصنيعية وتمثل البسترة نقطة تحكم حرجة.

أعلي مسحة ملوثة بالعد الكلي للفطريات والخمائر كانت من عوامة ماكينة التتراباك وهي المسحة (S9) والتي سجلت (10.6×10^3 cfu/ml)، وجد أن ثمانية من المسحات اختبروا لبكتيريا القولون ووجد أن كل المسحات سالبة.

كل التحاليل الكيميائية متطابقة مع المواصفة القياسية المصرية رقم ٢٠٠٥/١٦١٦.

يعتبر اللبن وجميع منتجاته من اللبن المعقم، الزبادي، الجبن، القشدة، الزبدة، اللبن المجفف من الأغذية مسببات الحساسية، طبقا لخطة الهاسب المصنع يجب أن يضع برنامج تحكم بشأن الأغذية المسببة للحساسية، وعليه خلص البحث إلي أن المصنع تحت الدراسة غير متوافق مع متطلبات الهيئة القومية لسلامة الغذاء بشأن الأخطار الفيزيائية.


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