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RESEARCH ARTICLE

ALGERIAN DAIRY INDUSTRY; CAN IT CONTROL BACTERIAL CONTAMINANT INDICATORS OF HYGIENIC QUALITY DEFECTS IN THE PRODUCTION CHAIN OF RAW AND PASTEURIZED MILK?

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Key words:-
Pasteurized milk, ferment, acidified milk, HACCP, hygienic quality, microbial hazard, consumer health.

Abstract

This study is a contribution to the adaptation of a quality control system of food products namely HACCP plan (*Hazard Analysis Critical Control Point*) to hazards microbiological control of pasteurized milk and acidified milk manufacturing, following an investigation to establish a HACCP plan with the determination of critical control points (CCP). Microbiological control of contaminant germs has been performed in duplicate test for pasteurized milk; acidified milk; milk powder and ferment that was used to prepare acidified milk; and finally rinse water and consumption water.

Analyzed microbiological parameters of pasteurized milk and rinse water showed that pasteurization process, quality of cleaning and disinfecting operation was effective. However, the quality of ferment and then acidified milk product were unsatisfactory. These results were attributed to indirect inoculation operation after preparing the ferment due not only to a lack of hygiene, but also to the defailance of cleaning and disinfecting operation of the fermentation tank.

A HACCP plan gathered the key information of the study which revealed seven critical points at different stages of the manufacturing process which need to be controlled through preventive and corrective measures that the industry must undertake to prevent the frequency of microbiological hazard occurrence, probably at the origin of consumers' food borne-infection.

Introduction:-

For many years, the quality control was to verify the safety of the finished product, which means their microbiological and chemical compliance with legislation. The dangers of food safety can occur at any stage of the food chain, and therefore require strict control over the entire chain (Leyral and Vierling, 2007).

Also, Food safety becomes a shared responsibility between all actors in the food chain, and food-borne diseases have direct impact not only on the consumers' health but also on the economical development. Therefore,

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intensification of building capacity in food safety is essential for most countries, particularly in developing countries.

By its biochemical composition rich on carbohydrate, fat, vitamins and minerals (Aggad *et al.*, 2009; Ahmed *et al.*, 2010), milk is considered as a favorable environment to the proliferation of microorganisms, especially pathogen germs (Ahmed *et al.*, 2010). These products have always been considered one of the main causes of food poisoning (Gran *et al.*, 2002).

For this purpose, the present study was undertaken, to establish a quality control system namely HACCP plan, with the determination of critical control points. A quality control operation of pasteurization step, cleaning and disinfecting operations was also studied.

Status of milk in Algeria; a product of mass Consumption:-
In Algeria, milk has an important place in the diet of everyone, whatever their incomes because, firstly, as a product rich in nutrients, milk can substitute for other expensive products like meat and, secondly, it's supported by the Algerian state (Amellal, 1995). The price support attributed by the state to the dairy offices was 43700 Dollar (USD) in 1982, which has grown to 2,3 million Dollar (USD) in 1992. In the space of a decade, the state has paid instead of consumers: 121 million Dollar (USD).

This high consumption is favored by the pricing policy of Algerian state, which encourages consumption compared to production status. Coupled with an extremely large population, this policy has led to an increase in demand, with more than two thirds of dairy consumption is covered by imports (Bourbouse *et al.*, 1989; Yakhlef, 1989; Mezani, 2000).

Milk intake per capita has improved during the same period as it was raised from 34 to 130 liters per year. While lower than the ration in European countries, where it's an average of 400 liters per year, it remains much higher than the average in Tunisia (87 liters) and Morocco (50 liters) (Boumghar, 2000).

Insufficient rate coverage of needs on milk and dairy products:-
The dairy industry is currently covering less than 40% of milk and dairy products requirements. Indeed, for a global demand estimated to 2,6 billion liters of milk equivalent in 1992, the production of dairy units was only 1,1 billion liters of milk equivalent.

The production deficit is compensated by importing milk. Between 1982 and 1992, the imports milk have attained 1,6 million tons and this costs the government 2,4 billion Dollars, either one-tenth the amount of the debt (Amellal, 1995).

Material and Methods:-

Sampling was performed at SUDLAIT Dairy industry in southwest of Algeria where the physicochemical and microbiological analyzes were performed in duplicate test during 2016 and involved the following samples "milk powder, pasteurized milk, acidified milk, ferment, rinse water and consumption water". Our purpose was firstly, to evaluate the hygienic quality of the analyzed products, secondly, identify the critical points and develop a plan or a standard quality manual for five Dairy industries visited in Algerian West.

Physicochemical Analysis:-
The physicochemical parameters studied were: temperature, titratable acidity, density, total dry matter, fat-free dry matter and fat content.

The titratable acidity was determined by measurement of lactic acid with sodium hydroxide in the presence of phenolphthalein at 1% as a color indicator according to (NA 678, 1994), The density of milk was measured by using a calibrated thermo-lactodensometer (AFNOR, 1993) The fat content was measured by the butyrometric of Gerber method according to (NF V 04-210, 1990).

Total dry matter is determined after drying in an oven at 103°C± 2 (Drying method) according to (NA 679, 1994) and fat-free dry matter of milk was calculated by taking the difference between total dry matter and fat content of milk.

Microbiological Analysis:-
Sampling was carried according to Algerian standard (NA 676, 1994; ISO 707, 1994). Microbiological analysis included after preparing decimal dilutions according to (ISO 8261, 2001), the detection and enumeration of bacterial indicators of fecal contamination; enumeration of total aerobic mesophilic flora incubated at 30°C for 72hours according to (NF V 04-016, 1985) on Plate Count Agar (PCA) (Fluka, Spain), detection and enumeration of total and fecal coliforms incubated at 37 and 44°C respectively for 24 to 48hours according to (ISO 4832, 1978) on the middle Violet Red Bile Lactose Agar (VRBL) (Biochem, Canada), search and enumeration in a liquid medium Rothe (Scharlau, Spain) for fecal Streptococci incubated at 37°C for 48hours following the method described by (Afif *et al.*, 2008) and finally, enumeration of fungal flora on Sabouraud 4% glucose agar (Fluka, India) according to (NA 5911, 1996).

Enumeration of Petri dishes having microorganisms was based on the standard set by legislation (AFNOR, 1980).
The criteria of microbiological quality employed were in accordance with the publication on dairy products (**OJAR** 35, 1998), which is based on a 3-class plan following the specifications; n, c, m and M.

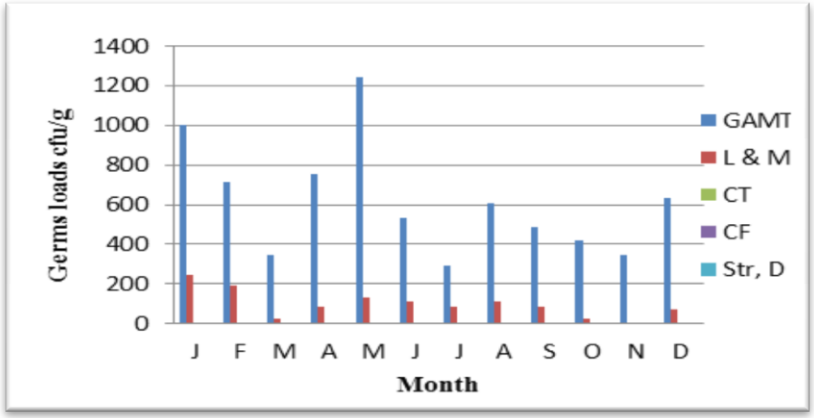
Elaboration of HACCP plan:-
Two approaches are used throughout the world to ensure food safety: mean while the USA's way principally to control the sterilization step. The European Union 'EU' emphasizes quality management and security throughout production chains. Given the situation observed in the south countries and obtained results in Europe, it seems appropriate to use this approach to ensure dairy products safety in developing countries (Faye and Loiseau, 2000).
The quality management by risks' analysis or potential hazards associated with a product or a process (HACCP approach) must be applied to the entire chain from the cow to the consumer (Leyral and Vierling, 2007). Hazard identification was based on 5M method (Medium, workforce, materials, methods and equipment) following the "cause-effect diagram" (Gouri Djaaboub, 2010; Blanc, 2007).

Results:-

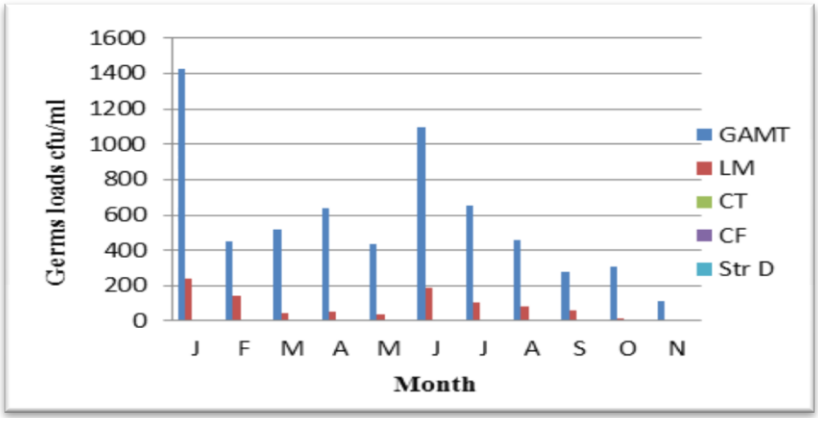
Physicochemical Analysis:-
The physicochemical analysis results of the samples do not reflect any abnormality and they were consistent to **O**fficial **J**ournal of **A**lgerian **R**epublic (**OJAR** 87, 1999; **OJAR** 80, 1999; **OJAR** 94, 1998) and to the international standard (CODEX STAND 207, 1999).

The density values obtained were between 1,030 and 1,034. The samples analyzed of pasteurized milk had a fat contents ranging from a minimum value of 1,5% and a maximum of 2%. The value of titratable acidity was between 1,5 and 1,7% for pasteurized milk. The average values of total dry matter and fat-free dry matter were 99 and 84g/l respectively. The temperature of the product at the exit of the industry does not exceed + 8,5°C.

Microbiological Analysis:-
Examined milk powders showed a variable load of aerobic germs ranging from $0,3x10^3$ to $1,2x10^3$cfu/g. The analysis also showed that the total and fecal coliforms were absent, while the average value of fungal flora was $0,3x10^3$ to $1,2x10^3$cfu/g (Figure 1).



Milk powder:-



Consumption water:-

Figure 1:- Microbiological analysis of raw materials.

GAMT:- Total aerobic mesophilic flora**, LM**: fungal flora, **CT :** Total coliforms, **CF** : Fecal coliforms, **Str. D:** fecal streptococci.

The consumption water used in reconstituted milk production has also been tested; the results found were consistent with the Algerian standard.

The average loads of different bacteriological parameters determined for partly skimmed pasteurized milk are summarized in Figure 2. The aerobic bacteria of all analyzed samples showed levels that are located in the standards and varying between $0,7x10^3$ and $1,8x10^3$cfu/ml. The origins of fecal contaminants "total and fecal coliforms" were almost negligible.

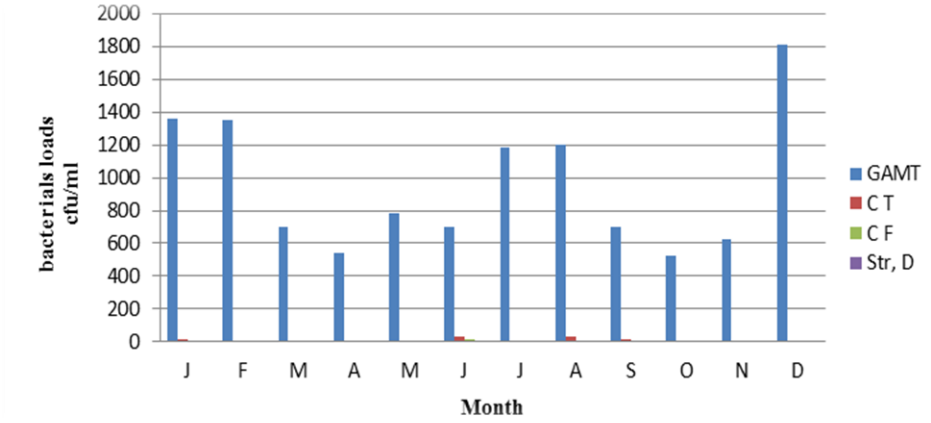


Figure 2:- Microbiological analysis of pasteurized milk packaged in bags.

GAMT:- total aerobic mesophilic flora, **LM:** fungal flora, **CT :** total coliforms, **CF** : fecal coliforms, **Str. D:** fecal streptococci.

Bacteriological analysis of acidified milk shows high contamination by a significant load of fecal coliforms, which had an average of $1,53x10^4$cfu/ml during the period when the temperature is higher from the months of May to September (Figure 3), and for the month of January, the contamination was moderate but remains above the norm and had an average of $5,6x10^2$cfu/ml fecal coliforms. While for the months from February to April, the load of total and fecal coliforms was consistent with the Algerian standard.

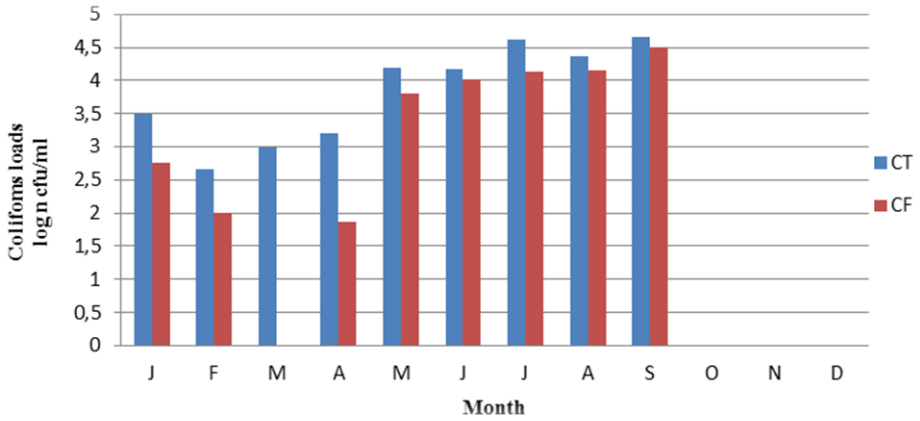


Figure 3:- Microbiological analysis of acidified milk.

CT:- total coliforms, **CF** : fecal coliforms.
In parallel, the analysis of the ferment used for the preparation of acidified milk also had a significant load of fecal coliforms in the same period of May to September (Figure 4), while for the months from February to April, the load of total and fecal coliforms was consistent with the standard's set.

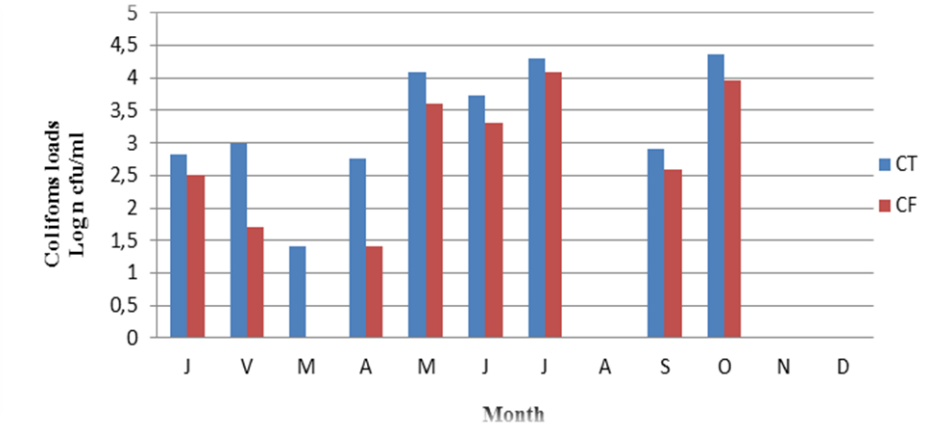


Figure 4:- Microbiological analysis of ferment.

CT:- total coliforms, **CF** : fecal coliforms.
The rinse water showed a significant load of aerobic germs with an average of $0,75x10^3$cfu/ml, a minor contamination by total and fecal coliforms was detected with an average load that is less than 0,54x10cfu/ml (Figure 5).

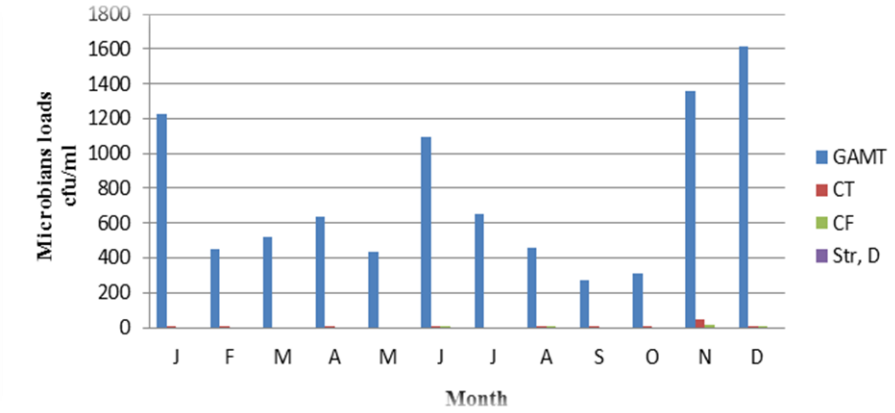


Figure 5: Microbiological analysis of rinse water.

GAMT:- total aerobic mesophilic flora, **CT :** total coliforms, **CF** : fecal coliforms, **Str. D:** fecal streptococci.

Analyzed bacteriological parameters for the reconstituted pasteurized milk and rinse water showed that the thermal treatment applied (pasteurization step) and quality of cleaning and disinfecting operation were effective, and also respected by the industry. A correlation was significant between the milk powder, pasteurized milk and the quality of cleaning and disinfecting operation for the searched microbiological parameters, because of a possible contamination of milk during manufacturing probably also present in the rinse water, and bad cleaning/ disinfecting operation of tubing 'closed circuit' may contaminate the product.

However the ferment quality and subsequently the acidified milk product were unsatisfactory. A correlation was significant for both products.

Assurance safety and hazard identification "HACCP approach"
The following table (Table 1) provides an illustration of a hazard identification approach, CCP and control measuring in the production process based on the interactive decision tree for dairy subsidiaries in west of Algeria - Raw milk, partly skimmed pasteurized milk packaged in bags and acidified milk.

Table 1:- Control measuring in the process production of reconstituted milk, pasteurized raw milk packaged in bags, and acidified milk.

Steps	Control measuring
The raw material: -Receipt of local raw milk -Milk powder	-Check and control the health program and maintenance of premises and separation zones, personal hygiene "uniform clothes + body and hand hygiene" -Managing the storage conditions of raw material, raw milk must be refrigerated no later than 2 hours after milking at 4°C maximum. -Systematical control of microbiological parameters especially physicochemical ones at the arrival of milk. -Strict compliance with hygiene "rule of 5M," sampling conditions of raw milk "healthy collection». -Respect the standards determining the initial quality of the raw material -Cleaning and disinfection of equipment -Avoid collecting milk from animals treated with antibiotics and mastitis milk.
Pasteurization step	-Check pasteurization scales (time/temperature) -Regular maintenance pasteurizer
Cleaning and disinfecting operation	-To check the status, validity and the dose of used disinfectant. -To check the correct operation of CIP

Acidified milk	**Semi-direct /direct inoculation**	-Use of selected cultures in sufficient load adapted to the production conditions (direct inoculation is recommended). -Create a sterile area during direct or semi-direct inoculation -Cleaning and disinfecting of the equipment -Respect the time of lactic fermentation, it should be sufficient -A good cleaning of tanks before and after preparation of acidified milk. - Compliance with strict hygiene rules 'GHP'. -Ensure closing of tank covert after inoculation process. - Control of titratable acidity of acidified milk, do not exceed 85°D (< 8,5g/l lactic acid). -Keep tank cover closed after cleaning step. -Walk forward.
	Thermisation/ cooling	-Check temperature of product at cooling exit before being packaged -Temperature of the product should be 4 to +6°C. - Titratable acidity should be below 85°D.
	Conditioning	-Sterile packaging; hermetic. -Keep the polystyrene packaging in a clean place
	Storage/ marketing	-Cold preservation during the storage, transport and distribution especially temperature. -Respect the consumption deadline of the product -Extended loading and unloading of dairy products should be avoided. -Separation of dairy products in the storage location.

Discussion:-

The good physicochemical quality of samples reflects mastery and continuous control for replenishment and pre-pasteurization operations, which satisfy the physicochemical standards.

Microbiological analysis results of raw materials (milk powder and water for reconstitution) indicate the excellent microbiological quality of milk powder (low level of total aerobic microflora and no coliforms). These results fully meet the recommended standards by International Dairy Federation (IDF, 1974).

Getting the good hygienic quality of reconstituted milk is firstly the result of raw material quality, the stage of pasteurization and observation of the rules and hygiene measures at the local manufacturing involving maintaining continuous optimal cleanliness conditions, respect of individual hygiene of manipulators and prevention of exogenous re-contamination, as well as the effectiveness of the cleaning and disinfecting operation through CIP "Clean in place" before and after pasteurized milk manufacturing. These results were consistent with the study of Ould Moustapha *et al.,* (2012) which present the operational and technological origins to have a good hygienic quality of milk.

The presence of coliforms is generally used as an indicator of poor hygienic practices in the handling of milk (Elzyney *et al.*, 2007; Chye *et al.*, 2004). Enumeration of this flora for samples showed that there is a significant fecal contamination of the ferment and the acidified milk during periods when the temperature is high. That results from indirect inoculation operation after preparing the ferment due to a lack of hygiene, bad cleaning and disinfecting operation of fermentation tank, knowing that the high temperature promotes the growth of contaminating microorganisms.

Rigorous respect of general hygiene at the production and processing, eliminate the massive consequences of microbial contamination and gives a finished product that meets the microbiological standards of current regulations (Hamama *et al.*, 1995), we also must educate producers by setting up a training program with good manufacturing practices (Katinan *et al.,* 2012). A HACCP plan gathered the key information of the study revealed seven critical points at different stages of the manufacturing process (Milking at the farm, collection and transportation, receipt and storage of raw materials "raw milk ", pasteurization, inoculation and maturation of acidified milk, refrigeration and storage of finished product, cleaning and disinfecting operation), that are imperative to be controlled through preventive and corrective measures that the industry must undertake to prevent the frequency of microbiological risks occurrence, probably at the origin of consumers' food borne-infection.

Conclusion:-

The physicochemical analysis of pasteurized milk taken at the state of dairy industry showed no abnormalities, and for microbiological analysis, there is a low level of total and fecal coliforms, and no other contaminants such as fecal streptococci.

The consumption of acidified milk could be a risk to public health, especially in the summer season when the warm climate promotes the microbial growth. The lack of good hygiene practices, bad cleaning and disinfecting operations of fermentation tanks, the high values of the titratable acidity recorded explain the proliferation of fecal contaminants observed in the acidified milk product.

The imperative control of raw materials, finished products and control of the manufacturing process including pasteurization step, good hygiene practices and rapid cooling of the packaged product could help to provide consumers with high microbiological quality of dairy products. Thus, we must establish a quality policy "HACCP plan" as an accurate methodological tool in the searching for relevant control means adapted to the risk, with popularization of good manufacturing and hygiene practices 'GHP, GMP'.

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