УДК 637.03:637.05

Application of HACCP System and Quality of Yoghurt Production in a Small and Medium Enterprise (SME) of Dairy Products in Benin Republic

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In order to provide technical support to Benin and West African sub region in agribusiness, prospective studies audit and analysis were laid on the production of three brands of yoghurt in a small and medium enterprise (SME), producer of dairy products in Benin. The HACCP (Hazard Analysis and Critical Control Points) was used to assess the degree of integration of quality processes in SMEs. The results of the diagnostic audit focused on the production chain of 3 categories of yoghurt reveal that the company is not 100% compliant with the 12 steps (E) of HACCP. Only stages E1, E3, E4, E5 and E10 are to the norm, followed bystages E9, E8, E7, E6 and E2, whose compliance is respectively 87.2; 85.85; 70.7 and 66%.For microbiological analyzes (lactic flora, coliforms, Escherichiacoli and Staphylococcusaureus), compliance is 96.29% with the criteria of the AFNOR-2009 and CODEX STAN 243–2003, for the samples (27) collected and analyzed. The yoghurt acidity value varies from0.60 to 0.88% respectively. The contents lipids showed important variation from 4.00 to 6.00g/100g. The total sugars contents vary from 9.30 to 11.60 g/100g and its calcium is from 0.11 to 0.18 g/100g of yoghurt. The control chart indicates that the total coli forms are hazards which are to be controlled.

Key words: SMEs, HACCP, Yoghurt, Microbiological and nutritional Analysis-Control chart.

Информация о статье
Поступила в редакцию 08.08.2016, принята к печати 24.10.2016
doi: 10.21047/1606-4313-2016-15-4-3-10
Ссылка для цитирования
Agassounon Djikpo Tchibozo M., Anago D. G., Guidi T. C., Chegnimonhan V., Galimova L. V., Savadogo A., Alladagniwèkè M., Ameyapoh B. Application of HACCP System and Quality of Yoghurt Production in a Small and Medium Enterprise (SME) of Dairy Products in Benin Republic // Вестник Международной академии холода. 2016. № 4. С. 3–10.

Применение системы HACCP и оценка качества йогурта на предприятиях малого и среднего размера молочной промышленности Бенина

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В целях обеспечения технической поддержки агробизнеса в Бенине и субрегионе Западной Африки, был проведен аудит производства трех марок йогурта на предприятиях малого и среднего бизнеса по производству молочных продуктов в Бенине. Инструмент HACCP (анализ рисков и критических контрольных точек) был использован для оценки степени интеграции процессов качества на малых и средних предприятиях. Результаты диагностического аудита на производственной цепочке 3-х категорий йогурта показывают, что предприятия не на 100% соответствуют 12 шагам (E) HACCP. Только шаги E1, E3, E4, E5 и E10 находятся в соответствии со стандартом, за которыми следуют шаги E9, E8, E7, E6 и E2 с уровнями соответствия 87,2; 85; 85; 70,7 и 66%.. Что касается микробиологического анализа (молочнокислая флора, бактерии группы кишечной палочки, Escherichiacoli

и Staphylococcusaureus), уровень соответствия для анализируемых образцов по критериям AFNOR-2009 и CODEX STAN 243–2003 составляет 96,29%. Уровень кислотности йогурта изменяется в диапазоне от 0,60 до 0,88% соответственно. Уровни содержания жиров изменяются от 4,00 до 6,00 г/100 г. Общее содержание сахара изменяется в диапазоне от 9,30 до 11,60 г/100 г йогурта; содержание кальция — от 0,11 до 0,18 мг/100 г. Контрольная диаграмма указывает на то, что общее количество опасных загрязняющих веществ бактерий группы кишечной палочки должно контролироваться.

Ключевые слова: малый и средний бизнес, HACCP, йогурт, анализ питательной ценности, микробиологический анализ, анализы, контрольная диаграмма.

Introduction

The adoption of a qualitative y approach is essential for entrepreneurs to face foreign and local competition. In the current context of heightened global competition, quality in food companies is an imperative for development. In addition, a leader of a small or medium enterprise (SME) who wants to set up within its unity, concepts and tools complex international benchmark of quality management is fraught with difficulties of all kinds. These difficulties arise both in the institutional, economic and industrial environment as well as the socio-educational context. The majority of foods SMEs also face problems of quality and hygiene that come from ignorance of the principles of quality management. In general, efforts are being made within a framework of well — established procedures and they prove costly from the standpoint of human and financial resources [1].The agribusiness sector is being reformed in many countries to promote investment, to expand and diversify marketing and processing activities [2]. In 2002, while the export sector of Benin shrimp was booming, a control carried out by inspectors of Food and Veterinary Office (FVO) of European Union has identified numerous of shortcomings in relation with Community regulations [3]. The short comings identified by FVO experts on health plan are lack of evidence of official controls and noncompliance with health standards of exporting companies. These remarks of FVO prompted the Beninese public authorities to decree a «self-suspension» of exports [3] due to «precautionary principle» for a period which help to overcome the deficiencies. There are actually a vacuum of information in formal legal structures of control over the practices and the quality of productions. In Benin, there are hordes of companies including those of yoghurt production, where a range of yoghurt products marketing in supermarket on shelves, in streets, placed in refrigerated coolers. Milk products are perishable, but high nutritional with an organoleptic quality that varies with the aromas and activity of enzymes used [4, 5, 6]. However, cases of poisoning linked to contamination of milk and derivatives have been reported worldwide (Also, diseases linked to food contamination causes more morbidity and mortality in developing countries [7, 8]. Also, diseases related to the contamination of food are sources of mortality in developing countries [9]. Faced with this situation, whatever measures adopted by Manager of SME for their services, the regulation must be respected to ensure the quality of products and the safety of consumers. One of the qualitative management system recommended to professionals of production is the «Hazard Analysis Critical Control Points (HACCP)» [10, 11]. Thus, in order to support food companies, external controls are needed. This study was conducted through the auditing of systems based on the concept of «HACCP» and microbiological and nutritional quality control of yoghurt of a company in Benin Republic. In this study, to evaluate the effectiveness of the system HACCP, only microbiological analysis of productions were considered; this is because when this parameter fails, the consequences are reflected later on other parameters [12]. This control is necessary to check if the qualitative efforts emitted by the company, allows the achievement of qualitative goals.

Materials

The study focused on 3 samples selected from 3 yoghurt brands (difference between flavors) from different productions. Samples were taken on the amendment of the responsible of company H in Porto-Novo, the political capital of Benin Republic, located about 51 km from Cotonou. The choice of company coded H is linked to information collected in previous investigation performed for identification of food SMEs engaged in Benin.

Methods

The work includes three steps: first, a meeting with the head of the company H was held to take his permission and agreement so to meet his staff, especially the manager in charge of quality; then an audit was planned and conducted in the organization on the professional practice using a check list based on HACCP system. Finally, diagnostic microbiological and nutritional analyzes were conducted.

Meetings and productions followed: Audit

A survey form was developed related to 12 steps (S1 to S12) of HACCP. A literature survey supported by direct observations and a face-to-face interview [13] with all stakeholders of the company. This was recorded taking into account the degree of integration of quality processes in SMEs. An evaluation rubric was used as the support of information collection. It was developed in accordance with 12 steps and criteria in a form of open and closed questions, with balance, coupled with evaluation and observation.

Product sampling

Yoghurt samples (27) were taken and analyzed at a rate of 3 samples of each production (lot a, b, c). Sampling was made after production according to the procedure described

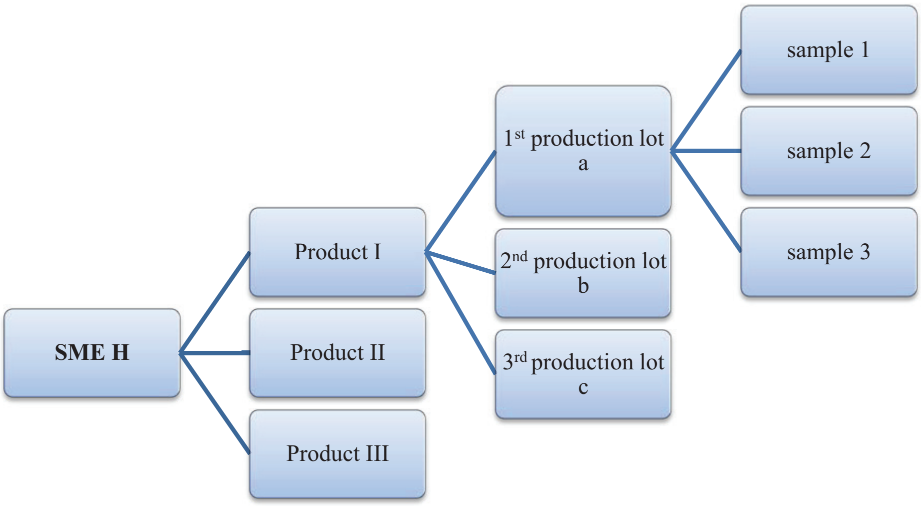


Figure 1: Sampling plan of each production

in the standard NFV04–501 [14]. Figure 1 summarizes sampling plan.

Microbiological quality control of yoghurt samples

10 g of each sample were transferred to a stomacher bag and then suspended in 90 ml of sterile buffered peptone water. All substances were mixed together; then revivification took 45 minutes at the laboratory temperature (26 ± 1°C). Decimal dilutions (10^0 to 10^6) with 9 ml of buffered peptone water were made from each stock solution [15].

Standardized methods of analysis adopted by the Economic and Monetary Union of West Africa (UEMOA) were used. Lactic acid bacteria were cultivated on Man Rogosa and Sharpe Agar (MRS, Merck 10660, Merck, Darmstadt, Germany) incubated in an anaerobic jar at 37°C, for 2–3 days and counted according to ISO standards [16]; Coliforms [17] at 30°C, for 2 days; Coliforms thermotolerants and *E. coli* [18] at 37°C, for 2 days with Rapid coli Agar; *S. aureus* (6888-1; 2; 3) at 37°C, for 2 days with Baird Parker Agar [19] ISO 6888.

The results were expressed in colony forming units (CFU)/g of Product analyzed. Results interpretation was done according to criteria of the French Association for Standardization [19] and Codex Alimentarius [20].These criteria are for yoghurt samples: Lactic flora (≥10^6 CFU/g); Coliforms flora (< 10 CFU/g); thermotolerants coliform and *E. coli* (44ºC, < 1 UFC/g); *S. aureus* (37°C = 0 UFC/g).

Determination of titratable acidity

For the titratable acidity, after diluting 5 grams of each sample in 25 ml of distilled water. 10 ml of the above dilution, titration was made with KOH (0.1N) using the indicator phenolphthalein. Total acidity was calculated as a percentage of lactic acid.

Nutritional values determination

The assay was done according to the guidelines of «Association of Official Analytical Chemists» [21].

Fat content was determined by Soxhlet method with hexane. The study focused on 5 g (Pe) of each sample placed in Soxhlet cartridges was and then mounted between a flask containing 300 ml of hexane and connected to a refrigeration system. The system is connected to a cryostat. After 4 hours of extraction, fat was obtained by solvent evaporation at 60°C in a rotary evaporator. Contents were expressed in g/100g of yoghurt. Total sugars contentwas determined by the phenol sulphuric acid method according to [22] and the values were expressed in g/100g of yoghurt. The calcium contents were determined by atomic absorption method after digestion of 1 g of each sample of yoghurt [21]. The results are expressed in g/100 g of yoghurt.

Codex Alimentarius [20], which limits for yoghurt are titratable acidity (min. 0.6%); Lipids g/100g (< 15); [4] limits are: calcium (0.14–0.15 g/100g).

Treatment of results

From the chart developed for the audit The Percentage of compliance for each step was calculated by dividing the score assigned to the respective step multiplied by 100. It is those results which were used to plot the graph of Kiviat corresponding to HACCP.

For the company H, a control chart was done with total coliforms using the statistical tool Shewhart which highlights the inability of traditional control to be a source of improvement [23]. This chart permitted the elimination of fault and looking for causes. A correlation was established between product quality and efficiency of HACCP.

RESULTS

Audit result in the company by HACCP

From survey and audit results, it appears that this company produces every 96 hours and it has a good knowledge of qualitative behavious; HACCP is used in nearly 68%. The Company's level of compliance with requirements of HACCP is presented as Kiviat graph (Figure 2). The 12 steps of

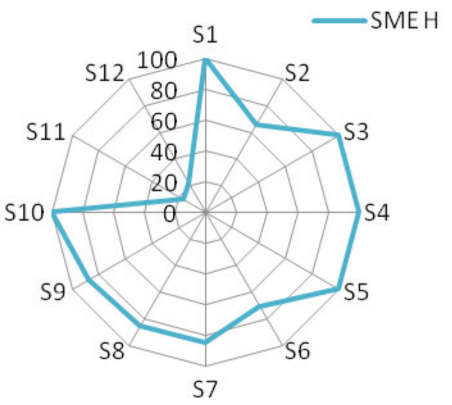


Figure 2: Kiviat graph of SME H

Figure 3: Visual quality of yoghurt

HACCP are peaks of the radar. First of all, we note that only steps S1; S3; S4; S5 and S10 are 100% compliant, followed by steps S9; S8; S7; S6 and S2 whose compliance is respectively 87.2; 85; 85; 70.7 and 66%. Secondly, a gap is found at steps S11 and S12, indicating significant gaps in implementation of HACCP by the company. Indeed, these points are those with which has the least compliance with HACCP requirements. During the audits, remarks such as «recordings slow work, «we must be always writing,» «Although recording is important, it should not occupy more time than the actual work «are noted. Moreover, the failure is recorded in part at step 6 (70.7% satisfied), which isn't under control and may cause damages. Preventative measures for these dangers are not clearly defined.

Sanitary and microbiological quality of analyzed yoghurt

Direct observations have revealed that products are quickly packaged in clean yoghurt containers and sealed (Figure 3).

The yoghurt had a smooth appearance. Microbiological analyzes of 27 samples from 3 productions of 3 yoghurt brands gave the results presented in Tables 1, 2. 3. Taking into account the criteria of [19] and [20], enumeration of germs sought (thermotolerant coliforms, *E. coli* and *S. aureus*) revealed 100% compliance with the exception of total coliforms (96.29%), in comparison with criteria of [19]. and [20]. Isolated bacteria are long bacilli, small Gram-positive bacilli and cocci. Long gram positive bacilli are the dominant flora.

The means values of bacteria are shown by the following Figure 4.

Control chart

The control chart obtained from the results of total coliform is presented in the graph of Figure 5. The loss of control is noted at the second production for Class II, although averages didn't exceed those of standards'.

Titratable acidity

The acidity values vary by product (Table 4, 5, 6; figure 6). They are respectively from 40.60 to 0.84 for the H_I product; from 0.60 to 0.65 for H_{II}; from 0.64 to 0.88 for

Table 1

Microbiological results of 3 series of the product (I) company H: yoghurt

Samples code	Lactic flora (10^7)	Totals coliform
H_Ia1	38	7
H_Ia2	42	6
H_Ia3	39	8
Mean H_Ia	39.67±2.08	7±1.00
H_Ib1	48	7
H_Ib2	59	7
H_Ib3	5	8
Mean H_Ib	34.09±28.54	7.33±0.58
H_Ic1	1.5	6
H_Ic2	1.3	7
H_Ic3	1.87	6
Mean H_Ic	1.56±0.29	6.33±0.58

Table 2

Microbiological Results of 3 series of the product (II) company H: yoghurt (continued)

Samples code	Lactic flora (10^7)	Totals coliform
H_{II}a1	11	8
H_{II}a2	16	7
H_{II}a3	11	7
Mean H_{II}a	12.67±2,89	7.33±0.58
H_{II}b1	0.92	8
H_{II}b2	1,01	9
H_{II}b3	1,20	10
Mean H_{II}b	1.04±0.14	9±1
H_{II}c1	2.4	7
H_{II}c2	1.9	8
H_{II}c3	1.7	6
Mean H_{IIC}	2±0.36	7±1

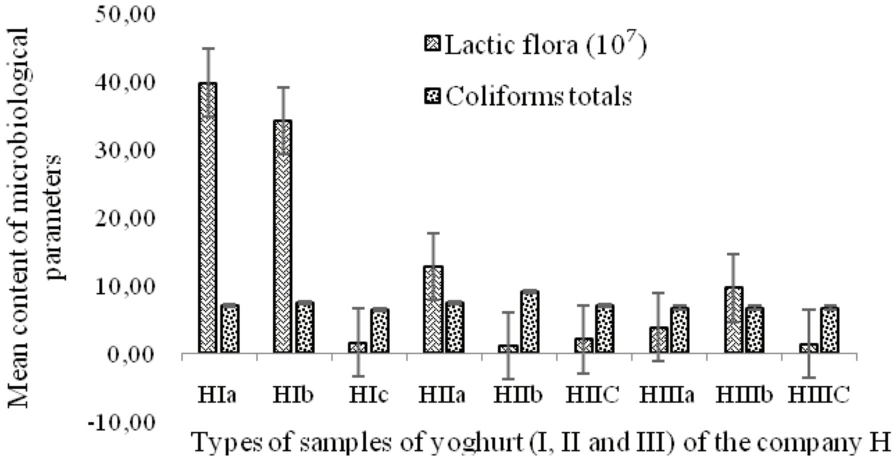


Figure 4. Variation of microbiological parameters

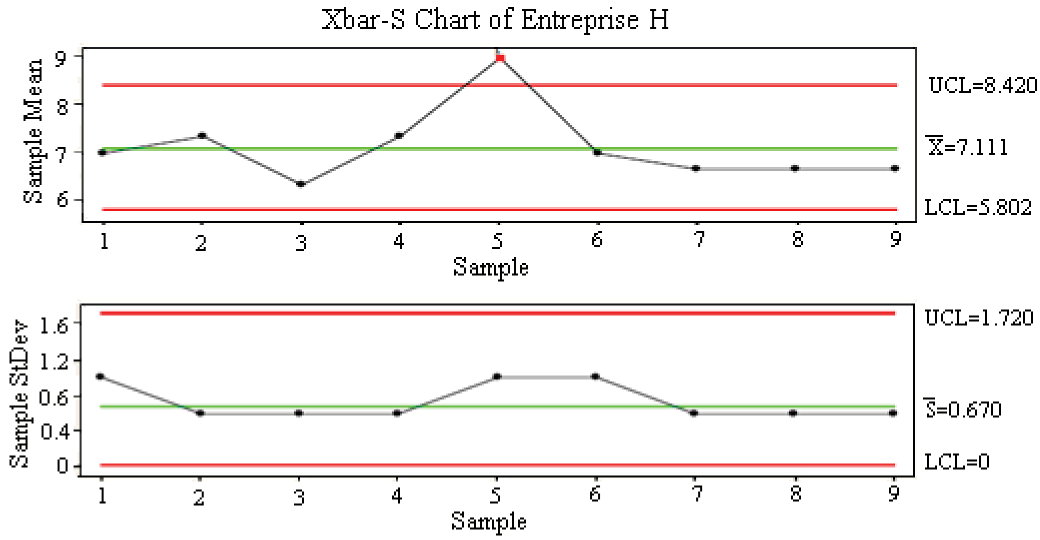


Figure 5. Control Chartof SME H

Table 3

Microbiological results and nutritional analysis of 3 series of the product (III) company H: yoghurt (continued and stopped)

Samples code	Lactic flora (10^7)	Total coliform
$H_{III}a1$	3.2	6
$H_{III}a2$	4.0	7
$H_{III}a3$	4.1	7
Mean $H_{III}a$	3.77±0.49	6.67±0.58
$H_{III}b1$	9.8	7
$H_{III}b2$	9.3	6
$H_{III}b3$	9.5	7
Mean $H_{III}b$	9.53±0.25	6.67±0.58
$H_{III}c1$	1.3	7
$H_{III}c2$	1.3	6
$H_{III}c3$	1.3	7
Mean $H_{III}c$	1.3±0.	6.67±0.58

Table 4

Results of nutritional analysis of the 3 series of the product (I) company H: yoghurt

Samples code	%Acidity	Fat (g / 100g)	Sugar (g / 100 g)	Calcium (g / 100 g)
H_Ia1	0.65	5.8	10.51	0.15
H_Ia2	0.64	6.00	10.33	0.13
H_Ia3	0.66	5.7	10.39	0.14
Mean H_Ia	0.65±0.01	5.83±0.15	10.41±0.09	0.14±0.01
H_Ib1	0.81	5.58	10.66	0.16
H_Ib2	0.84	5.6	10.7	0.16
H_Ib3	0.82	5.65	10.8	0.18
Mean H_Ib	0.82±0.02	5.61±0.04	10.72±0.07	0.17±0.01
H_Ic1	0.61	5.8	9.87	0.14
H_Ic2	0.60	5.6	9.68	0.16
H_Ic3	064	5.8	9.65	0.14
Mean H_Ic	0.62±0.02	5.73±0.12	9.73±0.12	0.15±0.01

Table 5

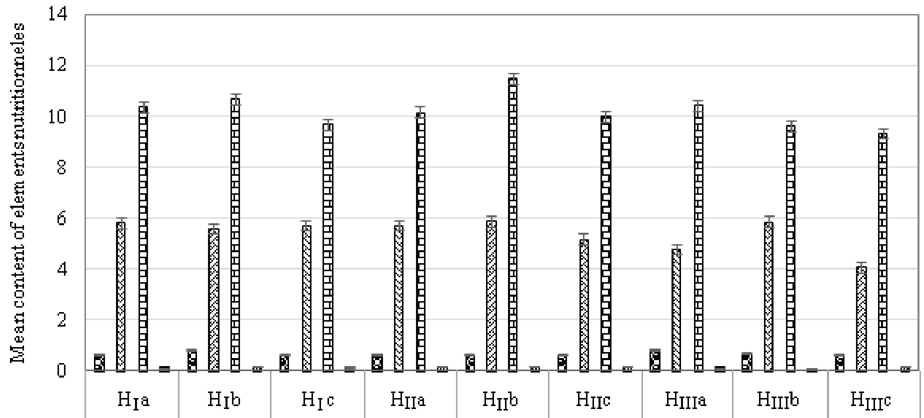
Results of nutritional analysis of the 3 series of the product (II) company H: yoghurt (continued)

Samples code	%Acidity	Fat (g / 100g)	Sugar (g / 100 g)	Calcium (g / 100 g)
$H_{II}a1$	0.63	5.80	10.15	0.16
$H_{II}a2$	0.64	5.72	10.10	0.18
$H_{II}a3$	0.65	5.68	10.30	0.15
Mean $H_{II}a$	0.64±0.01	5.73±0.06	10.18±0.10	0.16±0.02
$H_{II}b1$	0.64	5.80	11.53	0.17
$H_{II}b2$	0.63	6.00	11.60	0.16
$H_{II}b3$	0.61	5.92	11.39	0.18
Mean $H_{II}b$	0.63±0.02	5.91±0.10	11.51±0.11	0.17±0.01
$H_{II}c1$	0.63	5.10	10.10	0.17
$H_{II}c2$	0.62	5.23	9.98	0.15
$H_{II}c3$	0.60	5.25	9.96	0. 17
Mean $H_{II}c$	0.62±0.02	5.19±0.08	10.01±0.08	0.16±0.01

Table 6

Results of nutritional analysis of the 3 series of the product (III) company H: yoghurt (continued and stopped)

Samples code	% Acidity	Fat (g / 100g)	Sugar (g / 100 g)	Calcium (g / 100 g)
$H_{III}a1$	0.85	4.70	10.60	0.14
$H_{III}a2$	0.86	4.72	10.30	0.12
$H_{III}a3$	0.88	5.00	10.50	0.15
Mean $H_{III}a$	0.86±0.02	4.81±0.17	10.47±0.15	0.14±0.02
$H_{III}b1$	0.70	6.00	9.50	0.11
$H_{III}b2$	0.69	5.80	10.00	0.12
$H_{III}b3$	0.67	5.84	9.40	0.14
Mean $H_{III}b$	0.69±0.02	5.88±0.11	9.63±0.32	0.12±0.02
$H_{III}c1$	0.64	4.10	9.30	0.18
$H_{III}c2$	0.65	4.00	9.38	0.16
$H_{III}c3$	0.64	4.20	9.40	0.15
Mean H_{IIIC}	0.64±0.01	4.1±0.1	9.36±0.05	0.16±0.02



	H_Ia	H_Ib	H_Ic	$H_{II}a$	$H_{II}b$	$H_{II}c$	$H_{III}a$	$H_{III}b$	$H_{III}c$
%Acidity	0.66	0.82	0.62	0.64	0.63	0.63	0.86	0.69	0.64
Fat (g/100 g)	5.83	5.61	5.73	5.73	5.91	5.19	4.81	5.88	4.1
Sugar (g/100 g)	10.41	10.72	9.73	10.18	11.51	10.11	10.47	9.63	9.36
Calcium (g/100 g)	0.14	0.25	0.15	0.16	0.17	0.16	0.14	0.12	0.16

Figure 6. Means values of biochemical parameters

product H_{III}. Referring to criteria of [20], yoghurt productions of this company are complying.

Nutritional quality of the company's yogurt

Fat contents vary respectively from 5.58 to 6.00 for the product I; from 5.10 to 6.00 for H_{II} and from 4.00 to 6.00 for H_{III} (table 4, 5, 6). Results shown that from the three productions, the strongest fat value is 6.00 g/100g. Contents of total sugars are between 9.65 and 10.80g/100g (H_I); 9.96 and 11.60g/100g (H_{II}); 9.30 and 10.60g/100g (H_{III}). Calcium contents vary from 0.13 to 0.18 g/100g (H_I); 0.15 to 0.18 g/100 g (H_{II}) and 0.11 to 0.18 g/100 g (H_{III}). After comparison of average of nutrient, it appeared that H_{II} product is the richest in fat (5.91±0.10) followed by H_I (5.83±0.15). The product H_{II} is slightly richer in total sugars than H_I. Of all products, H_{III} is the one whose fat intake; total sugars and calcium is low (0.14 g).

The means values of biochemical parameters areshown by the following Figure 6.

Discussion

Implementation of HACCP system up to 68% by the company in yogurt production is explained by the fact that the company uses recommendations of Regulation 852 of hygiene package. This system is part of the most discussed and recommended to developing country firms in the quality during seminars and symposia about food industry. These are verification and transcription steps (HACCP manual, procedure guide, and recording) that seem heavy for the company. Statements of the company manager and manager in charge of quality, related to recordings, indicate a lack of control of importance of record process and documentation for proper traceability. Non-compliance with step 6 can be due to the poor definition made in Step 2 for manufactured yoghurt products.

Non-compliance with this step questions the validity of all dangers analysis approach. The process diagram made for yoghurt production (steps 4–5) by the company complies with that reported by [4]. Hazards analysis indicates that CCP are found in the collection of fresh milk, the milk processing temperature, ferments and flavors used. Let's note that the differences observed from step 1 to 8, maybe explained by the fact that they weren't implemented daily, but are reviewed during the update. However, HACCP is a holistic approach. So when one of the steps is mismanaged the system becomes inefficient. Nevertheless, what is important in this work for the company H, the requirements for which difficulties exist are known and in enhancements of skills, technical support is easy.

The presence of the total coliform in all samples is generally attributed to fecal contamination of the products by poorly cleaned equipment but the residual flora of milking system can be sourceof total coliform, which can lead to fecal or airborne contamination [24]. Similarly, cattle with subclinical mastitis due to coliform may be responsible. According [25, 8], pathogenic *E. coli* are of a small percentage of the total *E. coli* found in raw milk, so, if derivatives product have not been cross-contaminated, their absence is obvious. Furthermore, without, the inhibitory effect of lactic flora on pathogenic strains in fermented products [26, 27, 6], absence of staphylococci could be related to the observation of good hygiene practices recorded over the entire production chain. However, the company H must correct gaps observed by updating the system, especially on steps which aren't under control (HACCP manual, procedure guide, records).

The value of titratable acidity of food is linked to the process of fermentation and activity of lactic flora [28, 29].For nutrients, difference of values recorded for the three products, can be linked to the extrinsic and intrinsic factors [4]. 1For sugar, its content in a product is generally a function of the dose of raw sugar incorporated. Thus, sugar content of a fermented product is based on technology [30]. But that of fatty material is a function of its initial content of the milk used. Anyway, none of the productions has presented extraordinary nutrient values despite fluctuations between values. However, the values obtained are used to classify product H_{III} as less sweet and less rich in calcium compared to H_I and H_{II} products. This product may be advisable in the case of certain diets. The monitoring results are used not only for development but also to highlight possible improvements to upstream production level to limit apparent defects as well as those hidden [31]. In correlation with audit results and those of quality control, it appears that a single product category II ($H_{II}b_3$) is exceptional as well as the percentage of implementation of the approach and process control. Definitely, more the approach is intense the more the production process is under control and has the more compliant products.

CONCLUSION

This study sets out to appreciate the level of implementation of HACCP system on yoghurt production in SME H,a producer of dairy products in Benin Republic. The investigation has come up with a hold number of information on qualitative management. It appears that the company is not 100% for implementation of the 12 steps HACCP system. Efforts to documentation and registration remain the fundamental weaknesses recorded. However, results from microbiological analysis of 3 product categories indicated compliance 96.29%. *E. coli* and *S. aureus* contaminants are absent. Efforts should be made to avoid total coliform bacteria that may come from immediate environment.

Acknowledgements

The authors are thankful to the Manager of SMEH and all of his staff for their availability.

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