

APPLICATION OF HACCP SYSTEM, BASED ON ISO 22000:2005 METHODOLOGY FOR PRODUCING STRAWBERRY CONCENTRATES

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ABSTRACT

This work aims to present a methodology to carry out hazard and control measures assessments to properly establish operational prerequisite programmes (oPRPs) and the HACCP plan in the Strawberry concentrates industry according to the ISO 22000 standard, this study focused on the manufacture of Strawberry concentrated, which sold as raw materials to juice filling factories.

In this study, the presence of (sterilization, Packing & Firm closure), were identified as critical control points. (CCP) and presence of (Pesticide residues at the receiving stage, Magnetic trap) were identified as Operational Pre-Requisite Program Points. after the implementation of HACCP. This was due to stricter controls in terms of GMPs, GLPs, GHPs and CCPs.

Total bacteria count , Yeast & Mold counts were 2.08 , 2.48 ($^{log} cfu/cm^2$) ; respectively but E-Coli ,Salmonella sp. Hepatitis A Virus The results were negative .The heavy metals detected were Fe, Zn, and Mn were positive results and values were reduced by thermal treatment . As, P b, c d, Hg the results were negative and the results were in accordance with CODEX STAN 193-1995, Pesticides residues were detected and the results were in accordance with CODEX STAN 193-1995.The values were reduced by thermal treatment and storage, The water used in the production process has been analyzed physically, chemically and microbiologically; although it is used only for washing fruit.

Generally, the study emphasized that the required disciplined approach is best provided by the ISO 22000 procedure applied as an integral element of total quality management principles, which include (HACCP, GMP, GHP, GLP and document control (e.g., ISO 9001 Quality Systems). ISO 22000 FSMS embracing

Conclusively, implementation of the ISO 22000 standard in the fruit concentrates industry guarantees food safety and helps improve their competitiveness in the global market.

Key words: Food Safety, Quality, ISO 22000, (HACCP), Fruit, Strawberry Concentrates

INTRODUCTION

There are several public health concerns, with which we have to deal on daily basis. In this regard, Soman & Raman . (2016) think that food safety is considered as one of the most prominent major public health concerns. Thus, it is a real challenge to provide food supplies that are safe and conforming;

Therefore, in order to face the fast growing and increasingly complicated sets of the global food chain, we shall analyze, evaluate and manage these risks thoroughly. Thus, food safety can be ensured through the adoption of the basic principles of food hygiene across the food chain in consistence with the Hazard Analysis and Critical Control Point System. In this sense, a new procedure was introduced for hazard analysis and risk assessment, in accordance with the ISO 22000:2005 methodology.

In addition, according to (CAC, 1997), Food Safety refers the guarantee that food will not cause any harms to the consumer, when it is prepared and/or consumed. Hence, food safety can be defined as the level of security that we attain by ensuring food hygiene.

Botanically, all fruits are similar plant organs, fruits vary widely in their shape, size, color, texture, flavor, nutritional properties, potential for extended shelf-life and ability to withstand different types of processing. In spite of being delicious, nutritious and desirable components of our diet, fruits suffer from being extremely perishable. Therefore, it is always

preferred to preserve them for longer shelf-life, and to provide easier transport to any locations distant to the site of production.

Simply strawberry is a widely grown hybrid species of the genus *Fragaria*, collectively known as the strawberries. The fruit is widely appreciated for its characteristic aroma, bright red color, juicy texture, and sweetness. It is consumed in large quantities, either fresh or in such prepared foods as preserves, juice, pies, ice creams, milkshakes, and chocolates (Wikipedia, 2018).

Therefore, the aim of this study application of HACCP system, based on ISO 22000:2005 methodology for producing strawberry concentrates.

MATERIALS AND METHODS

MATERIALS

Strawberry Fruits Festival variety was obtained from the market of fruit and vegetables in New Damietta, Damietta, Egypt, during season 2016.

METHOD OF MANUFACTURE

Manufacture of Strawberry Concentrate

Fruit Concentrate processing includes several steps (receive of raw materials, First Washing, Sorting, Final Washing, Crushing /extraction, Pre-heating, Filtration, Concentration pasteurization, Filling and Storage. Processing steps can be summarized in Figure (1).

Application of ISO 22000

ISO 22000- 2005 specifies the requirements for a food safety management system that combines the following generally recognized key elements to ensure food safety along the food chain, up to the point of final consumption:

- interactive communication;
- system management;
- prerequisite programmes;
- HACCP principles.

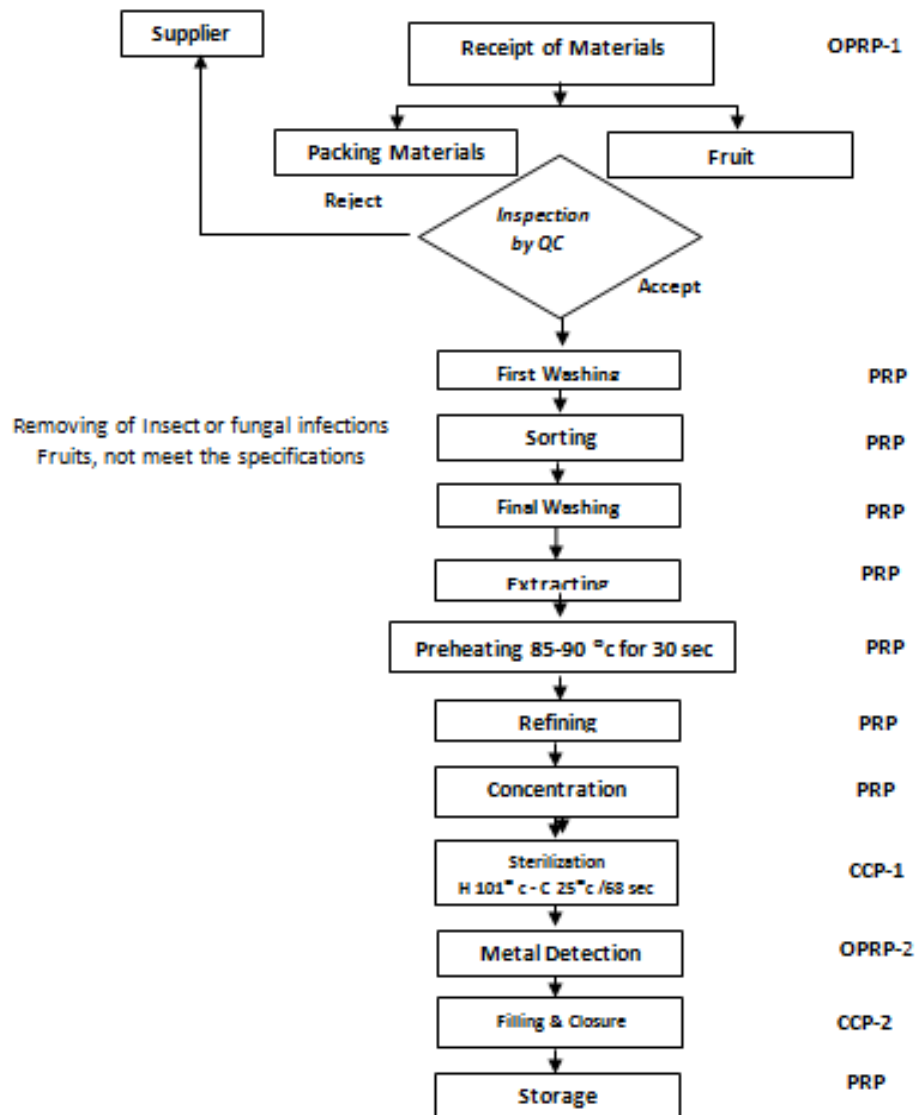


Figure (1). Flow Diagram for the manufacture of Strawberry Concentrate

According to Sikora, and Nowicki (2007). ISO 22000 standard the organizations should plan and improve all processes that are needed to realize safe products through effective improvements, planned actions implementing and monitoring as well as keeping going the control measures connected to food safety. This standard came into force on September 1, 2005 is constructed of 8 chapters: (1) Scope, (2) Normative references, (3) Terms and definitions, (4) Food safety management system, (5) Management responsibility, (6) Resource management, (7) Planning and realization of safe products, and (8) Validation, verification and improvement of the food safety management system. Figure (2) describes the implementation order of food safety systems Sikora and Nowicki (2007).

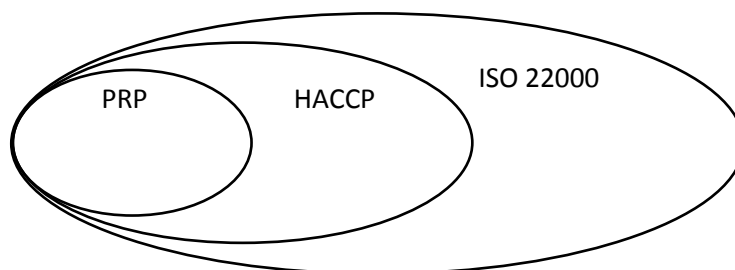


Figure (2): Description of the Implementation Order of Food Safety system

The PRPs are based on good manufacturing practices or good hygienic practices, Food safety experts have found that well-functioning PRPs simplify and strengthen the HACCP plan, in general Prerequisite programs (PRPs) provide the foundation for hazard analysis and critical control point (HACCP) to function. According to Scoti, and Stevenson, (2006) PRP include Facilities, including construction and layout of buildings, training and competencies, Personal hygiene, waste and sewage disposal, air, water and energy control, Cleaning and sanitizing, Preventive maintenance, Calibration, Prevention of cross contamination, Pest control, Glass and hard plastic control, Chemical control, Environmental monitoring, Product traceability and recall, Complaint investigation and Labeling.

Application of HACCP system

Application of HACCP system: Hazard analysis and critical control points (HACCP) consisted of observing food preparation to identify sources and modes of contamination, Processing line of manufacturing of Fruit concentrated based in the following seven principles: 1. Conduct a hazard analyses, 2. Identify the critical control points (CCPs), 3. Establish critical limits for preventive measures associated with each identified CCP, 4. Establish CCP monitoring requirements, 5. Establish corrective actions to be taken when monitoring indicates then a deviation from an established critical limit, 6. Establish verification procedures and 7. Establish record-keeping and documentation procedures. CCPs were determined according to the decision tree.

Figure (3), as described by Horchner *et al.* (2006), according to Lokunarangodage, *et al* (2016) The mandatory procedures in ISO 22000:2005 management elements are handled through food safety, that consists, (1). Control of records (2). Control of documents (3). Corrections (4). Corrective Actions (5). Potentially Unsafe products (6). Withdrawals (7). Internal Audits.

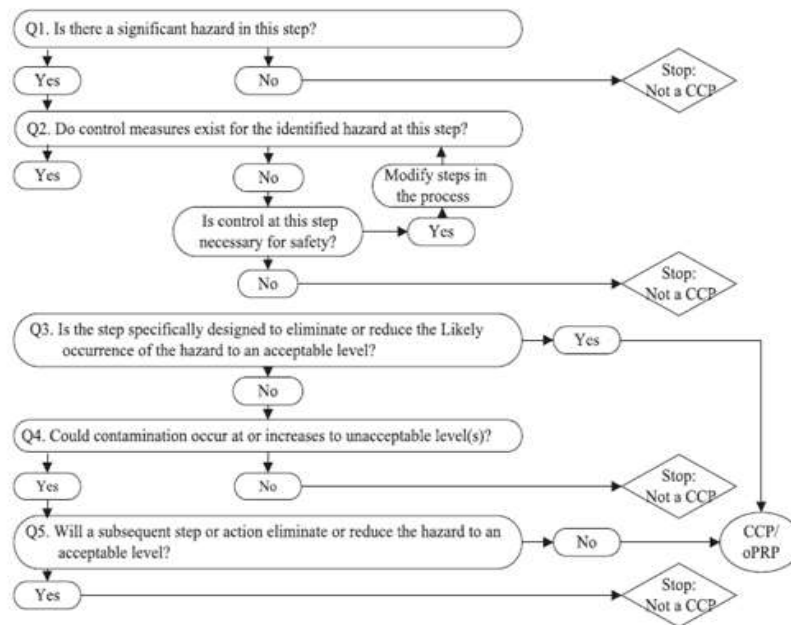


Figure.(3): Decision tree for HACCP implementation adopted from Horchner *et al.* (2006).

METHODS OF ANALYSIS

1. Chemical and Physical analysis

1.1. Total Soluble Solid (Brix):

Ph value and Titratable Acidity (TTA) were determined according to AOAC (2012) The measurement was carried out in the chemical laboratory at Misr Italy Co.-New Damietta , Damietta Government.

1.2. Color

Color was determined in Strawberry Concentrates according to Gomez *et al* (1998), measurements Color Tester LS2000 (Hunter Associates Laboratory, Reston, VA, USA).

1.3. Bostwick

Bostwick was determined in Strawberry Concentrates according to MARSH *et al.* (1980).

1.4. Heavy Metals

Heavy Metals was determined in Strawberry concentrates according to the method of ISO:8288(1986) by inductively coupled plasma optical emission spectrometry after high pressure microwave digestion, The measurement was carried out in Central Lab for soil, food and feed, Faculty of Technology and Development - Zagazig University, Certified laboratory in accordance with international standards of quality "ISO 17025".

1.5. Pesticide Residues

Pesticide Residues was determined in Strawberry Concentrates as Recommended by QuEChERS Method Quick and Easy Method (QuEChERS) the Standard Method EN 15662:2008 Cieřlik, *et al* (2011) The measurement was carried out in Central Lab of Residue Analysis of Pesticides and Heavy Metals in Food (QCAP Lab) Dokki, Giza Government, The Lab hold ISO 17025 Certificate.

1.6. Aflatoxins (Patulin)

Aflatoxins was determined in Strawberry Concentrate according to Liquid chromatography quantitative determination of Patulin in clear apple juice AOAC(2002), 49.7.03 according to Maragos, *et al* 2015, The measurement was carried out in Central Lab of Residue Analysis of Pesticides

and Heavy Metals in Food (QCAP Lab) Dokki, Giza Government, The Lab hold ISO 17025 Certificate.

1.7. Vitamin C

Vitamin C was determined in Strawberry Concentrate according to El-Ishaq, and Obirinakem, (2015). The measurement was carried out in Food Analysis Laboratory, Agricultural Research Center, Dokki, Giza Government, and EOS Lab.

2. Microbiological examination

2.1. Total bacterial counts (TBC)

Total bacterial counts TBC was determined according to ISO 4833, (2003) using plate count agar media.

2.2. Yeasts and molds count (Y&M)

The counts of yeast & molds were determined according to the method described by ISO 21527-1,2 (2008) using plate counts agar media.

2.3. Coliform counts

Coliform bacterial counts was carried out according to the method of ISO 4832, (2006) using MacConkey agar media.

2.4 Detection of *Escherichia coli*.

Detection of *E. coli* was carried out according to the method of Leong *et al.* (1985). *E. coli* detection was carried out on duplicate plates of Violet Red Bile Lactose agar (V.R.B.G).

All microbiological analyzes was carried out in the Microbiological laboratory at Misr Italy Co.- New Damietta ,Damietta Government.

2.5 Determination Hepatitis A virus

Determination Hepatitis A virus according to Mäde, *et al* (2013) International Methods for Microbiological food and water analysis ISO-TS 15216_2/2013, The measurement was carried out in the Microbiological laboratory at Misr Italy Co.- New Damietta, Damietta Government.

3. Sensory Evaluation

The sensory qualities evaluated were: Color, Flavor, Taste and Overall acceptability. The Strawberry Concentrated juice blends together with a reference sample (packaged in glass bottle). The sensory analysis was

carried out using twenty-member of well-trained. Each sensory attribute was on a 9 – point Hedonic Scale with 1 = disliked extremely while 9 = liked extremely as reported by Iwe (2010).

Statistical Analysis.

Statistical Analysis was performed using the SPSS and MS Excel procedure, Duncan's multiple comparison procedure was use to compare the means. A probability of $P \leq 0.05$ was used to establish statistical significance.

RESULTS AND DISCUSSIONS

1. Physical and Chemical Analysis of Strawberry Concentrate.

This part of study was planned to through some lights on quality and safety of Strawberry concentrate by three types of sample according to storage period; zero time, 6 months and 12 months, the chemical and physical analysis presented in Table (1).

The Color of the strawberry Pulp samples was characterized objectively. The L^* , a^* and b^* values of a pasteurized non-stored strawberry Pulp were 23.89, 25.26 and 9.36, respectively. a/b value 2.72. after concentrate the results were as follows a , L , b and a/b 31.24, 26.94, 12.20 and 2.21, (at Zero time), Kalbasi and cismeros (2007)

Vitamin C.: High temperature has effects on vitamin C content, strawberry pulp were 84 reach to 148 for Strawberry Concentrates (at zero time) and decreased after storage 6 months and 12 months to 125, 115, respectively.

Heavy Metals: The concentrations of heavy metals in strawberry pulp, Fe, Zn and Mn, was 3.1, 0.85 and 2.12; respectively but As, Cd, Hg and Pb, were negative. Strawberry concentrated Fe, Zn and Mn, was 4.79, 1.15 and 3.3; respectively, after storage for 6 months and 12 months the value of Fe decreased after concentration with continued decrease 25%, 9% and 20% of the initial value; respectively. While Zn decreased by 5%, 9% and 24%; respectively and Mn decreased by 22%, 16% and 22% %; respectively.

Table (1). Physical and Chemical Analysis of Strawberry Concentrate.

Items	Storage time (Month)			
	Pulp	0 Time	6M	12M
Chemical Analysis				
Brix	8.00 ^b	16.60 ^a	16.63 ^a	16.65 ^a
ph	3.84 ^c	3.74 ^a	3.72 ^a	3.68 ^a
ACIDITY	0.84 ^c	1.72 ^b	1.75 ^b	1.84 ^a
POSTWICK (cm/30sec.)	14.50 ^a	11.50 ^b	11.50 ^b	11.80 ^b
BLACK SPECS	None	None	None	None
Vitamin C	84 ^d	148 ^a	125 ^b	115 ^c
Color				
L (lightness)	23.88 ^c	31.24 ^b	34.12 ^a	35.49 ^a
a (redness)	25.26 ^a	26.94 ^a	25.45 ^a	25.11 ^a
B (yellowness)	09.36 ^d	12.23 ^c	14.88 ^b	15.90 ^a
a/b	02.71 ^a	02.21 ^b	01.70 ^c	01.57 ^d
Heavy Metals				
Iron Fe	3.10 ^c	4.79 ^a	3.60 ^b	2.88 ^c
Zink Zn	0.85 ^c	1.15 ^a	1.05 ^b	0.80 ^c
Manganese Mn	2.12 ^c	3.30 ^a	2.80 ^b	2.20 ^c
Arsenic As	ND	ND	ND	ND
Lead P b	ND	ND	ND	ND
Cadmium c d	ND	ND	ND	ND
Mercury Hg	ND	ND	ND	ND
Pesticide Residues				
Iprodione	0.01 ^a	ND	ND	ND
Malathion	0.02 ^a	ND	ND	ND
Omethoate	ND	ND	ND	ND
Dimethoate	0.16 ^a	ND	ND	ND
M: month	ND: not detected			

Pesticide residues: Different processing operations like washing, peeling, frying, freezing and cooking of fruits and vegetables can be effectively applied on fruits and vegetables to minimize the risk of pesticides on human health, cooking under open conditions resulted in 85 to 98 percent losses by volatilization. Cooking under closed conditions resulted in hydrolysis with 50 percent of the chlorothalonil being recovered unchanged on the crop

Ahmed, *et al* (2011) .this observation are in agreement with that reported by Szpyrka, *et al* (2015) , Bakrc, *et al* (2014). The concentrations of pesticides residues found in Strawberry concentrated samples analyzed were lower than the respective EU established MRLs, thus complying with the European legislation and Pesticide residues in food: toxicological evaluations. WHO, FAO (2017).

2. Microbiological examination of Strawberry concentrate

From Table (2) shown results of microbiological analysis of Strawberry Pulp for Total bacteria count, Yeast & Mold counts were 2.08, 2.48 *cfu/cm*²; respectively while *E-Coli*, *Salmonella* sp. Hepatitis A Virus and Aflatoxin were not detected both in pulp and concentrates during the storage period.

Table (2). Microbiological examination of Strawberry concentrate

Microbiological Analysis	Microbiological counts (log cfu/cm ²)			
	Pulp	Concentrate		
		0	6M	12M
TBC	2.08 ^a	ND	ND	ND
Y&M	2.48 ^a	ND	ND	ND
<i>E-Coli</i>	ND	ND	ND	ND
<i>Salmonella</i> sp.	ND	ND	ND	ND
Hepatitis A Virus	ND	ND	ND	ND
Aflatoxin (Patulin)	ND	ND	ND	ND

T.B.C : total bacterial counts, Y&M: yeast and mold counts, ND: not detected,

*: Average of three samples

3. Sensory evaluation of Strawberry concentrate

The sensory quality attributes of reconstituted Strawberry concentrated samples are stated in Table (3).

4. Application of ISO 22000 for manufacturing of Strawberry concentrate

The implementation of food safety system (ISO 22000) is a continuous process based on the management concepts of an iterative four-step management methods; the PDCA cycle (plan, Do, Check and Act).

Table (3). Sensory quality attributes of Strawberry concentrate

Items	Quality attributes				
	Taste	Color	Flavor	Textures	Over all acceptability %
12M	6.00 ^c	6.55 ^c	5.10 ^c	6.50 ^d	60.00
6 M	7.25 ^b	7.50 ^{ab}	7.10 ^b	7.00 ^{cd}	71.75
0 time	8.50 ^a	7.10 ^b	8.35 ^a	7.00 ^{cd}	81.50
Pulp	9.00 ^a	8.00 ^a	8.00 ^a	9.05 ^a	85.00
X1	9.00 ^a	8.00 ^a	8.05 ^a	7.45 ^{dc}	81.25
X2	7.50 ^b	7.50 ^{ab}	7.1 ^b	8.00 ^b	75.00
X 1,2 : Samples of competing companies					

4.1. Listing the prerequisite programs (PRPs)

The PRPs represent the conditions and/or the necessary basic activities to maintain a hygienic environment for the production, handling and the provision of safe finished products all along the food product process. daCruz, *et al.* (2006).

4.2. Preliminary steps to enable hazard analysis

4.2.1. Food safety team .

A multidisciplinary team, composed of nine people was created in the company to implement the requirements of the system. The members of this team were trained thoroughly on the HACCP system and ISO 22000: 2005 standard. These are food safety team leaders, Q.A manager, Hygienist, Production manager, Maintenance manager, Supply manager, Storage manager, Planning manager, Sales manager. The team was committed to the study, development, establishment and review of all problems concerning the safety and management of their products.

4.2.2. Product characteristics and intended use .

The food safety team preceded to a complete description of the foodstuffs, by identifying their composition, chemical, biological and physical characteristics, the undergone treatments, durability, storage conditions and distribution methods. The description concerns raw materials

(fruits) and finished products (fruit concentrates). Table (4) summarizes the characteristics and intended use of fruit concentrates.

4.3. Hazard identification and determination of acceptable levels.

The food safety team established a list of hazards recorded in the hazard identification and Hazard analysis.

4.4. Hazard assessment.

The identified hazards were evaluated during the scheduled meetings by the food safety team. Hazard analysis is carried out at all stages of Strawberry concentrates production. During hazard analysis, hazards were categorized into four general areas: biological (pathogens), chemical (toxic substances), physical (external particles) and allergens hazards.

A hazard is considered significant if the score resulting from the multiplication of the probability (P) by the severity (S) values ($P * S$) was above 4 Fernandez, *et al* (2014). A significant hazard is one of such a nature that their elimination or reduction to an acceptable level is essential to the production of safe foods ILSI, (1999).

4.5. Selection and assessment of control measures (ISO 22000, section 7.4.4.)

According to the hazard assessment results, control measures are selected with the help of the decision tree Figure (3). These measures are classified according to whether they should be managed through Operational Prerequisite Programs (oPRPs) or by the HACCP plan, using the following criteria Fernandez *et al.*, (2014); ISO 22000, 2005, Section 7.4.4.):

4.6. Establishing the operational prerequisite programs .

According to **(ISO 22000, Section 7.6.1.)** For each critical control point and oPRP, an HACCP plan and oPRP plan are established respectively by specifying the food safety hazards to be controlled, control measures, critical limits (for the CCP) or action limits or action criteria (for the oPRP), monitoring procedures and actions to be taken if critical limits or actions limits or action criteria are exceeded. Tables (5) and (6) illustrate an oPRP plan model and the HACCP plan.

4.7. Establishing the verification plan.

The food safety team established a verification plan to check if the HACCP plan is functioning as envisaged, which specifies the purpose, the

Table (4). Fruit Concentrates Description and intended use

Product	The product is the natural Strawberry concentrated obtained from crushing and refining of natural fruit and fully maturity, and free of seeds without additives and pasteurized at a temperature of not less than Heat 101 c and cooling 25 c for 68 seconds
Composition	Natural strawberries fruits full maturity
Origin	vegetarian
Packaging Size	Aseptic Bags in Drums 220 Kg
Shelf-life	24 Month
Storage and transport conditions	stored at a temperature not exceeding 25 c In a dry, clean and well-ventilated place.
Labelling relating to the food safety	Name of product - barrel number - net weight - date of production - expiry date - Brix.
Physical-chemical characteristics	Brix, Ph, Color, Bostwick, Acidity
Microbiological characteristics	Free from Any Viable Spoilage or Pathogenic Micro-Organisms
Use of the product	Intermediate product for the manufacture of juices and jams
	The product is used after the addition of other components (water - sugar - other additives by product type) and according to the instructions for the manufacture of juices and jams

methods, frequencies and responsibilities for the verification activities. End-product analyses (microbiological analyses) are made and compared with earlier established reference values. The verification plan model of the operational prerequisite programs and HACCP plan is represented in Table (5).

7.8. Establishing the documentation and record keeping .

Various documentation models were used for monitoring selected measures control and ensuring appropriate corrective actions., documentation and records are established to provide evidence of effective implementation of the system Mortimore (2001).

Conclusion

This study sets out a methodology that is applied to a practical example to carry out hazard and control measures assessment in order to properly establish operational prerequisite programmes (oPRPs) and the HACCP plan based on ISO 22000:2005 Methodology.

In this study, the presence of (sterilization, Packing & Firm closure), were identified as critical control points. and presence of (Pesticide residues at the receiving stage, Magnetic trap) were identified as Operational Pre-Requisite Program Points. after the implementation of HACCP. This was due to stricter controls in terms of GMPs, GLPs, GHPs and CCPs.

The results of microbiological analysis of Strawberry Concentrate showed that implementation of HACCP can improve the microbial quality of Fruit Concentrates. The heavy metals detected were Fe Zn, As, Mn, P, C, D, and Hg and the results were in accordance with CODEX STAN 193-1995, Fe, Zn, and Mn were positive results and values were reduced by thermal storage treatment .As, P b, c d, Hg the results were negative ., Pesticides residues were detected and the results were in accordance with CODEX STAN 193-1995.The values were reduced by thermal treatment and storage, The water used in the production process has been analyzed physically, chemically and microbiologically, although it is used only for washing fruit.

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تطبيق نظام الهاسب وفقا لمنهجية الأيزو ٢٢٠٠٠ - ٢٠٠٥ لإنتاج مركز الفراولة

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كان الغرض من هذه الدراسة هو تقديم منهجية للقيام بتقييمات المخاطر من أجل وضع برامج المتطلبات التشغيلية المسبقة (OPRPs) وخطة الهاسب HACCP Plan وفقاً لمنهجية ISO 22000 ركزت هذه الدراسة على تصنيع مركز الفراولة بداية من استلام المواد الخام حتي الوصول للمنتج النهائي (مركز الفراولة) ، والتي تباع كمواد خام لشركات تعبئة نكتار ومربي الفاكهة . تم تحديد (التعقيم ، التعبئة وإحكام الغلق) ، كنقاط تحكم حرجة CCP. وتم تحديد وجود (بقايا مبيدات الآفات في مرحلة الاستقبال ، مصيدة المعادن) كنقاط لبرنامج المتطلبات التشغيلية المسبقة OPRP. ويعزى ذلك إلى ضوابط أكثر صرامة فيما يتعلق بممارسات التصنيع الجيد (GMP) و ممارسات المعامل الجيدة (GLPs) والممارسات الصحية الجيدة (GHP) ونقاط التحكم الحرجة (CCPs). بلغ مجموع عدد البكتيريا و عدد الخمائر والعفن ٢.٠٨ ، ٢.٤٨ خلية /سم^٢ على التوالي ولكن *E-Coli* ، *Salmonella sp*. فيروس التهاب الكبدى Hepatitis A Virus والأفلاتوكسين كانت النتائج سلبية في جميع المعاملات. المعادن الثقيلة التي تم الكشف عنها هي Fe و Zn و As و Mn و Pb و CD و Hg وكانت النتائج متوافقة مع CODEX STAN 193-1995. كانت نتائج Fe و Mn و Zn إيجابية وانخفضت قيمتها بسبب المعالجة الحرارية والتخزين في

درجات حرارة منخفضة 3 ° م ، أما بالنسبة لـ Hg ، c d , P b كانت النتائج سلبية في جميع المعاملات .

تم الكشف عن بقايا المبيدات وكانت النتائج متوافقة مع -CODEX STAN 193 1995. وإنخفضت قيمتها بسبب المعالجة الحرارية والعمليات التصنيعية والتخزين في درجات حرارة منخفضة 3 ° م .

كما تم قياس درجة اللون في مركز الفراولة بشكل موضوعي. قيم L^* ، a^* ، b^* للرب الفراولة المبيستر غير المخزن كانت 23.89 ، 25.26 و 9.36 ، على التوالي. قيمة a/b 2.72 والعينة بعد التركيز النتائج كانت كالتالي ، L^* ، a^* ، b^* 31.24 ، 26.94 ، 12.20 ، وقيمة a/b 2.21 ، التغييرات في قيمة a/b الفراولة في لب الفراولة من 2.72 إلى 1.70 بعد تخزين 6 أشهر ثم إلى 1.57 بعد 12 شهر وهذا اتجاه متزايد لقيمة L بمرور الوقت ويرجع ذلك لفقدان اللون من الأنثوسيانين بسبب الحرارة وفترة التخزين .

التوصية: أكدت الدراسة على أن أفضل طريقة منضبطة مطلوبة توفرها إجراءات ISO 22000 المطبقة كعنصر متكامل في مبادئ إدارة الجودة الشاملة ، والتي تشمل HACCP و GMP و GHP و GLP ومراقبة الوثائق (على سبيل المثال ، ISO 9001 Quality Systems). شكلت ISO 22000 FSMS التي تحتضن نظام HACCP ومراقبة الوثائق إطارًا مهمًا يمكن من خلاله توصيل متطلبات الجودة بفعالية وبطريقة يمكن إثباتها ومراجعتها.