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Application of Haccp System on Mango Nectar Production Line

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ABSTRACT

Hazard Analysis Critical Control Point(HACCP) is a system, which gives us a proactive common sense approach to the safety management of our food products. HACCP is a preventative system used by the food industry to help ensure food safety and reduce food safety risks. An important portion of fruit production is processed into nectar. “Nectar” typically refers to beverages produced by dilution of fruit pastes or juices with or without the addition of sweeteners. Nectars are commercialized as from a single fruit or as blends. “nectar” must contain at least 25–50% fruit juice, depending on the specific fruit. This study presenting guidelines for the application of HACCP and focuses on the flow diagrams based on the production line of manufacture Mango Nectar in Egyptian canning company. It also presents an analysis of the hazards and of the critical control points (CCP) and monitoring them then verification to confirm that the HACCP system is working effectively.

Keywords: HACCP; Mango Nectar

INTRODUCTION

Hazard assessment and critical control points (HACCP) is worldwide considered as an effective and rational means of assuring food safety, which can be applied throughout the food chain from primary production to final consumption. It is a system aiming at the production of zero defective products which separates the acceptable from the non-acceptable (Mauropoulos and Arvanitoyannis, 1999).

In the early 1960s, HACCP concept was originally developed as a microbiological safety system by the Pillsbury Company, in a joint effort with the National Aeronautic and Space Administration (NASA) and the US Army Laboratories at Natick. It was used as a zero defect program aiming at the safe production of foods that would be consumed in zero gravity to ensure that the foods for the space program were free of all pathogens that could cause illness to astronauts during space travel. Thereafter, the food industry introduced the same system to prevent any risk to the health of its consumers. (Michalis and Ioannis 2000).

The Codex Committee on Food Hygiene (FAO/WHO, 1996) stated that, microbiological safety of foods is principally assured by control at the source, product design and process control, and the application of good hygienic practices during production, processing, and handling, distribution, storage, sale, preparation and use. This philosophy is the basis of the HACCP.

While Taylor (2008) reported that, in 1993 the Codex Alimentarius Commission elaborated a 12-part method (guidelines) for the application of HACCP. This has achieved international recognition and as such, has become the definitive method of applying HACCP principles. These guidelines include a sequence of activities for the application of HACCP principles, which are outlined in:

1:Assemble the HACCP team.
2:Describe product.
3:Identify intended use.
4:Construct flow diagram.
5:On-site verification of flow diagram.
6:Conduct a hazard analysis: Listing potential hazards and identify preventive measures for significant hazards to reduce or eliminate them.
7:Determine the critical control points (CCPs).
8:Establish critical limit(s) for each CCP: Set target levels and tolerances, which must be met to ensure the CCP is under control.
9:Establish a monitoring system for each CCP: it must be able to detect loss of control at the CCP (those occurrences outside the Critical Limits).
10:Establish the corrective actions to be taken when monitoring indicates that a particular CCP is not under control (a critical limit has been exceeded).
11:Establish procedures for verification to confirm that the HACCP system is working effectively.
12:Documentation and record keeping: documentation examples include the hazard analysis, all the reference documents used in the risk assessment, CCP determination and critical limit determination. Record keeping examples include deviations and corrective action reports. This may be the only part of the HACCP plan that will be audited or reviewed by customers or regulators.

Considering that, the first 5 steps are preliminary procedures while subsequent 7 steps are HACCP principles.

Fruit juice producers have traditionally relied on the acidity of their products to assure microbiological safety. However, recent outbreaks of food borne illness related to these products have increased the concerns of public safety authorities.

Fruit and vegetables are major components of a healthy diet, but eating fresh uncooked produce is not exempt of risk. Attention has focused on evaluating the microbiological or toxicological risks that may be involved in applying novel preservation processes, and their effect on food safety, in order to obtain “fresh” products that do not present health risks (Esteve and Frigola, 2007). In addition, it is a good source of vitamin A, omega-3 and -6 polyunsaturated fatty acids, dietary fiber, potassium, magnesium and antioxidant pigments such as carotenoids and polyphenols (Mahattanatawee *et al.,* 2001).

The aim of this research is expositions that, how to apply the HACCP system on line of mango nectar production through conducts a hazard analysis, determine CCPs, monitoring them; documentation and verification for obtained the high safe product.

MATERIALS AND METHODS

Materials:

Fruits (Mango (*MangiferaIndica L.*)):

Fruit is obtained from different regions of suppliers to the Egyptian canning company (BEST) at July 2012, to be received in accordance with approved certificate from the supplier and after the testing of receipt and evaluation of the product, and there are different varieties of the same type mix together to make juice**.**

Sugar:

Sucrose used was of commercial grade (95.8% purity) with no further purification. Daqahlya Company at Al-Daqahlya, Egypt produced it.

Water:

Is the use of groundwater extracted from the ground and the plant depends on three water wells, which are processed before they enter the industry and filtered and water microbiological analysis was carried out on a regular basis to ensure its safety.

Other ingredients :

Citric acid :

Citric acid monohydrate (Elementary), Exported by Liaoning pharmaceutical foreign trade corporation, Imported by New A.W.A. company.

Mango flavor :

Organic Mango flavor from Aroma Labs S.A.E. company.

Pectin :

E 440 pectin standard with sugar, Imported by Mefad company.

Glass bottle :

Bottle of glass 1L &1/4L volume from Wadi glass co.

Culture media for the microbiological assay:

Total plate bacterial counts medium, Coliform bacteria medium, Yeasts and Molds medium and Staphylococcus aureus medium :

Was used according to (American Public Health Association "A.P.H.A", 1976 and Difco, 1984)

Bacillus cereus medium:

Introduced by Mossel and his co-workers in 1967 for the enumeration of Bacillus cereus in food, this formula was shown to be the most effective for this purpose by Inal in 1972.

Methods:

Application of HACCP system:

Horchner *et al.,* (2006) recommended these steps to implementation the HACCP system.

Assemble the HACCP team (Step1):

Fill out product description and intended use forms (Steps 2 and 3):

Construct a process flow diagram and conformable with real steps on plant (Steps 4 and 5):

Principle 1: Conduct a hazard analysis (Step 6):

Principle2: Determine Critical Control Points (CCPs)(Step 7): For each process step where a significant hazard has been identified using CCP decision tree Fig. (1) and your own common sense to determined CCPs.

Principle 3: Establish critical limits for each CCP (Step 8):

Principle 4: Establish CCP monitoring requirements (Step 9):

Principle5: Establish corrective actions (Step 10): Fill out "HACCP plan worksheet" to fulfillment previously steps.

Principle 6: Establish verification procedures (Step 11):

Microbiological analysis methods:

Samples were taken from steps, which considered CCPs: Analyses were made of fruit and fruit nectar along the production line of the first pick-up and even the final product was the work of the analysis of chemical, physical as well as Microbiology. During and immediately after processing (analysis time zero) and then after 3 and 6 months of storage at room temperature 20 ± 5 ˚C .

Also some microbiological and chemical analysis were used to monitor and verification HACCP system to insure producing high quality and safe products for consumers according to the Egyptian Standards 1602-1/2005 as critical limits.

Chemical quality attributes:

Chemical composition:

Gross chemical composition of nectar (Fat, Ash, Crude fiber, Crude protein, and Dry matter) was determined according to the methods described by A.O.A.C. (1995). While the amount of total carbohydrates was calculated by difference.

Minerals:

Minerals (Phosphor, Calcium, Magnesium and Potassium) in samples were determined was determined according to the methods described by AOAC method No 968.08 using atomic absorption spectrophotometer (Shimadzu UNICAM 919, Cambridge, UK) (AOAC 1995).

Determination of pesticide residues

Pesticide residues and heavy metal were determined at Pesticide residue analysis center.

Sample preparation:

The samples were extracted with slight modification according to Quechers method described by Anastassiades *et al.***,** (2003). 10 ml of the homogenized samples were weighted in a 50 ml centrifuge tube and 10 ml of acetonitrile (1.0% acetic acid) were added, the screw cap was closed, and the tube was vigorously shaken for 1 min using a vortex mixer at a maximum speed.

Afterwards, 4g of anhydrous magnesium sulfate and 1g of sodium chloride were added, Then extracted by shaking vigorously by hand up to down for 10 min, and centrifuged for 10 min at 4000 rpm and 4°C. An aliquot of 4 ml was transferred from the supernatant to clean 15 ml centrifuge tube and cleaned by dispersive solid-phase extraction with 100mg PSA, 20 mg GCB, and 300 mg of magnesium sulfate. Afterwards, centrifugation was carried out as mentioned above.

An aliquot of 1 ml was transferred from the supernatant to new clean 15 ml centrifuge tube and cleaned by dispersive solid-phase extraction with 50mg PSA, and 300mg of magnesium sulfate. Afterwards, centrifugation was carried out as mentioned above.

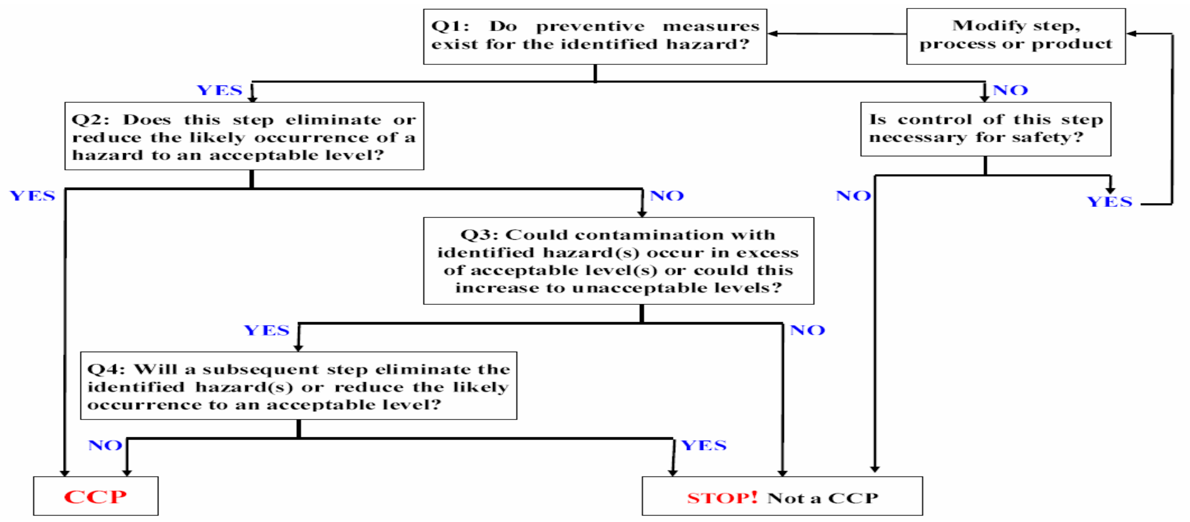

Fig.(1): CCP Decision Tree

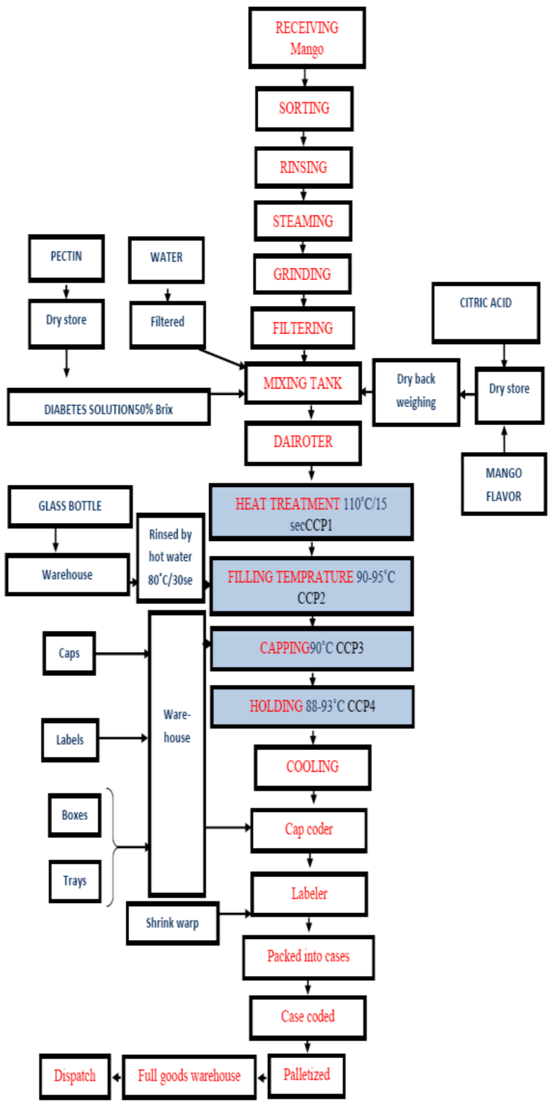

Fig. (2): Flow diagram of mango juice preparation.

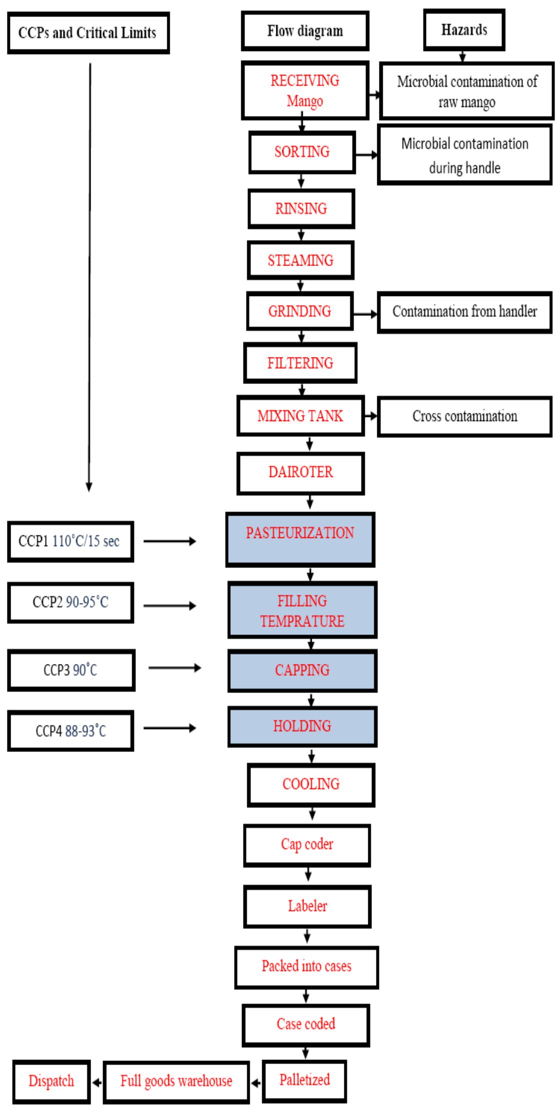

Fig. (3): HACCP Flow diagram of mango juice preparation.

Then, aliquot of 1ml of the supernatant was taken and filtered through 0.45µm PTFE filter.

Heavy metal:

Heavy metals composition of food is of interest because of their essential or toxic nature. For example, iron , zinc, copper , chromium , cobalt, and manganese are essential, while lead, cadmium, nickel, and mercury are toxic at certain levels (*Jarup et. al 2003*). Heavy metals (Pb, Cu, Zn, Hg, As) were determined according to the methods described by *IUPAC 1978* by Microwave Plasma – Atomic Emission Spectrometer (MP-AES-4200)

Principle 7: Documentation and record keeping (Step 12):

Processing/Preparation of mango juice :

Fresh fruit juice was prepared as described by Egyptian Standard 1602-1/2005 manufactures Fruit nectar. Mango are stored and removal of the damaged and immature .Is then heated in water to 95-97˚C for 3-4 minutes. The pulp is separated by mashing in the device contains rackets spin in opposite directions. After this is done to get rid of the remnants of the outer parts of the fruit by Arriver device. The pulp is collected in tank and send it by pumps to juice processing tank .Then add water to mango pulp to reduce the focus to the firs focus, which is required to increase it followed the final texture. In the end, add the sugar syrup interview preparation and focus are until we come to final concentration required (15 % Brix). As for the rest of the additives are well-thawing pectin solution with diabetes during preparation, and flavor is added after the end of the preparation of tin and then turns a bit before product description and intended use (Steps 2 and 3): packing, and citric are affixed customized to adjust the pH to 3.9 but not more than 5 mg/L . The next stage is heat treatment juice at a temperature of 105˚C for 15 second and then is filled with juice at a temperature of 90 ˚C in glass jars liter and quarter liter, and after packing is locked bottles well and transferred to the functioning of cooling and then to packaging, storage and sale.

RESULTS AND DISCUSSIONS

Application of HACCP system during manufacture mango juice:

Assemble the HACCP team (Step1):

The core HACCP team includes Safety manager/ technical director, operations director, engineering manager, microbiologist and HACCP experts, line engineering.

Establish verification procedures (Step 11):

Catherine (1990) showed that, the HACCP system was designed to ensure the safety of products, since receiving raw materials and during processing operations by controlled all steps of production. In our investigation, From Fig. (2- 3), which presented flow diagram for manufacture of Mango juice with estimating the CCPs, we determined four critical control points, including:

1) Heat treatment step.
2) Filling step.
3) Capper step.
4) Holding step.

PRODUCT DESCRIPTION WORKSHEET

Product: Mango nectar	**Plant**: Line of manufacture mango nectar
Brand: Soft drink	**Date:** July, 2012
Prepared by: HACCP team	

The following questions need to be answered when developing the product description:

1. What is this product?
   This is a caned nectar product, containing mango pulp 25%, The ph is 3.8 – 4, filtered through a 0.6 Micron filter before mixing with other ingredients and other ingredients (water, sugar 50% Brix sugar solution, pectin, flavor, and citric acid).
2. What is its common name?
   Mango nectar.
3. What is the length of shelf life? At which temperature?
   12 months at room temperature 25°C, store at cooled and dry place.
4. What is labeling instructions are needed?
   Keep in refrigerator after opining.
5. Where it will be sold?
   At the supermarkets.
6. What is the kind of consumers (Identify intended use)?
   The product is targeted for the public and may therefore, be consumed by high-risk groups (infant and aged).
7. How is it to be used?
   Drink it cooled.

HACCP plan work sheet (Steps 6, 7, 8, 9 and 10):

Control point information worksheet					
Product: Mango nectar		**Plant:** Line of manufacture mango nectar			
Brand: Soft drink		**Date:** July, 2012		**Prepared by:** HACCP team	
CCP process step	**Hazard**	**Means of control**	**Frequency of control**	**Specifications for CCP**	**Corrective action**
1.Heat treatment	Less temperature -Microbial contamination	-Microbial analysis	-Continuous -Maximum Weekly -Minimum daily	-Egyptian standard -Egyptian standard	-Reheat treatment.
2.Filling	Cross contamination -Microbial contamination	-Microbial analysis	-Continuous -Maximum Weekly -Minimum daily	-Egyptian standard -Egyptian standard	-Reheat treatment.
3.Capping	Cross contamination -Microbial contamination	-Microbial analysis	-Continuous -Maximum Weekly -Minimum daily	-Egyptian standard -Egyptian standard	-Reheat treatment.
4.Holding	-Microbial contamination	-Microbial analysis	-Continuous -Maximum Weekly -Minimum daily	-Egyptian standard -Egyptian standard	-Reheat treatment.

In addition, used some microbiological analysis such as Total bacterial, coliform group, Staphylococcus aureus, Bacillus cereus and yeast and mold counts. Chemical analysis such as chemical composition (moisture, protein, fat and ash %) and chemical quality attributes (Heavy metal). Physical characteristics such as pH value, Acidity and Brix. To monitor system and finding any deviation and control it, and insure it was in agreement with Egyptian Standards 1602-1/2005, finally produced high safety and quality products for consumers.

Microbiological analysis of raw materials :

Fruits during growth, harvest, transportation and handling at any stage can be contaminated with pathogens from human and animal sources (Beuchat, 1996).

Table (1) showed that total bacteria count in Mango fruit before rinsing were 7.7×10^4 /cm and this contamination may be due to transportation and trading while Coliform count was 1.2×10^4 /cm, Yeast and molds were 8.02×10^3/cm it is present in abundance in the surrounding air, Bacillus cereus was 1.07×10^2/cm and Staph. bacteria 0.8×10^2/cm that pollution out could be of the presence of wounded in the hand of the workers. These data were agreement with (Beuchat, 1996) who reported that Potential pre-harvest sources of contamination include soil, feces, irrigation water, water used to apply fungicides and insecticides, dust, insects, inadequately composted manure, wild and domestic animals, and human handling. On the other hand, after rinsing total bacteria count and yeast and molds decreased to 2.23×10^4/cm and 2.4×10^3/cm ,respectively. Also, Coliform decreased to 0.09×10^4 /cm. While Bacillus cereus and staff. disappeared. Washing removes excess dirt and bacteria that may be on the produce. (Zander and Bunning, 2010).clean running water are effective way to further eliminate water and ward off harmful organisms (Crowe, *et. al* 2011). Washing is designed to remove dirt, pesticide residues and microorganisms responsible for quality loss, as well as to pre-cool cut produce and remove cell exudates that may support microbial growth (Zagory, 1999).

The results of Table (1) showed that the total bacteria count in water, glass bottle and cap were 2×10^2, 1.25×10^3 /cm, and 0.03×10^3/cm respectively. While, sugar total count was 5/g.

Microbiological analysis during manufacturing mango nectar:

Data given in Table (2) revealed the total bacteria count in pulp was 8.64×10^3 /cm, while, yeast and molds in pulp were 3.482×10^3/cm. Nectar microbiological before heat treatment at 105°C total count bacteria were 1.5362×10^3/cm and yeast and molds number were 6.400×10^3/cm. This increase was may be due to the presence of yeast and molds formed in nectar as they are in the growth and increase until heat treatment. While, after heat treatment at 105°C (CCP1) microbiology contamination does not appear, and it demonstrates the importance of pasteurization. Also during filling (CCP2), Capping (CCP3), Holding (CCP4) and after storing six months there were no changed in results.

The data obtained is in accordance with result of Stanley, (1998) who reported that proper heat treatment kills deadly bacteria in food.

Table (1) Microbiological analysis of raw materials

Microbial analyses	**Main material**		**Additives**				**Packaging material**	
	Mango fruit before rinsing	**Mango fruit after rinsing**	**water**	**sugar**	**Citric acid**	**Flavor**	**Glass bottle 1L**	**Cap**
T.B. count	7.7×10^4 /cm	2.23×10^4 /cm	2×10^2/ cm	5/g	0.0×10^3/cm	0.0×10^3/cm	1.25×10^3/cm	0.03×10^3 /cm
Coliform count	1.2×10^4 /cm	0.09×10^4 /cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm
Y&M count	8.02×10^3/cm	2.4×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm
Bacillus cereus count	1.07×10^2/ cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm
Staph. count	0.8×10^2/ cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm	0.0×10^3/cm

T.B. = Total bacteria count.
Y&M = Yeast and mold.
Staph. count = Staphylococcus aureus bacteria count.

Heavy metal in mango nectar before and after heat treatment (mg/100g):

Juice can become contaminated with lead if lead-contaminated produce is used to make the juice. Lead contamination of produce can occur because of past use of lead in agricultural settings. Lead is especially hazardous to young children. In 1993, FDA established an emergency action level of 80 ppb and above for lead in juice packed in lead soldered cans. (Federal Register notice of April 1, 1993, 58 FR 17233). When detected of heavy metals in Mango Nectar , it was carried out with the aim to assess the levels of lead (Pb), copper (Cu) , mercury (Hg) and arsenic (As) in mango nectar . The results in Table (3) showed that the average concentrations detected before heat treatment at 105°C were 0.111, 0.061, 0.052 and 0.0 mg/100g for Pb, Cu, Hg and As respectively, and after heat treatment heavy metal was Increased to 0.226, 0.114, 0.08 and 0.0 mg/100g for Pb, Cu, Hg and As respectively, This means that heavy metals are concentrated by heat treatment. The data obtained is in accordance with result of Carpenter, K.E *et. al*.(1927)and Anwar *et. al*. (2014) who reported that temperature may increase heavy metal level and its toxicity. These results are in accordance with Egyptian Standards 1602-1/2005 as critical limits.

Table(2)Microbiological analysis during manufacturing mango nectar

Microbial analyses	**Mango pulp**	**Juice From mixing tank**	**Heat treatment [CCP1]**	**Filling [CCP2]**	**Final Product after capping [CCP3]**	**Final Product After Holding [CCP4]**	**Final Product After Storing 6 months**
T.B. count	8.64×10^3 /cm	.5362$\times10^3$ /cm	0.0×10^3 /cm	).0$\times10^3$ /cm	0.0×10^3 /cm	0.0×10^3 /cm	0.0×10^3 /cm
Coliform count	2 /cm	0.0×10^3 /cm	0.0×10^3 /cm	).0$\times10^3$ /cm	0.0×10^3 /cm	0.0×10^3 /cm	0.0×10^3 /cm
Y&M count	3.482×10^3/cm	6.4×10^3 /cm	0.0×10^3 /cm	).0$\times10^3$ /cm	0.0×10^3 /cm	0.0×10^3 /cm	0.0×10^3 /cm
Bacillus cereus count	0.0×10^3 /cm	0.0×10^3 /cm	0.0×10^3 /cm	).0$\times10^3$ /cm	0.0×10^3 /cm	0.0×10^3 /cm	0.0×10^3 /cm
Staph. count	0.0×10^3 /cm	0.0×10^3 /cm	0.0×10^3 /cm	).0$\times10^3$ /cm	0.0×10^3 /cm	0.0×10^3 /cm	0.0×10^3 /cm

T.B. = Total bacteria count.
Y&M = Yeast and mold.
Staph. count = Staphylococcus aureus bacteria count.

Table (3): Heavy metal in mango nectar before & after heat treatment (mg/100g)

Heat treatment	**Pb** mg/100g	**Cu** mg/100g	**Hg** mg/100g	**As** mg/100g
Before Heat treatment	0.111	0.061	0.052	0.0
After Heat treatment	0.226	0.114	0.08	0.0

Pb= Lead Cu= Copper Hg= Mercury As= Arsenic

Documentation and record keeping (Step 12):

Documentation was completed previously by listing of the HACCP team, product description and intended use, flow diagram of the entire process indicating CCPs, hazards and preventive measurements for each CCP, critical limits for each CCP, monitoring systems, corrective actions for deviations, record keeping, and procedures for verification.

CONCLUSION

The results in this research indicated that, the raw materials used in mango nectar production were highly safe thus the final product was also highly safe due to application of HACCP system. Implementation of HACCP system is necessary in order to produce a final safe food products.

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تطبيق الهـاسـب علـى خـط إنتــاج نكتار المانجو

جيهان على غنيم ، محمود بدوي دومة و وائل محمود أحمد محمود
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تحليل المخاطر ونقاط التحكم الحرجة (الهاسب) هو نظام يعطينا توقع سليم لإدارة سلامة المنتجات الغذائية لدينا. والهاسب هو نظام وقائي يستخدم في صناعة المواد الغذائية للمساعدة في تأكيد ضمان سلامة الأغذية والحد من المخاطر التي تهدد سلامة الغذاء. ويتم تصنيع جزءا كبيرا من إنتاج الفاكهة إلى نكتار . والنكتار يعد من المشروبات التي تنتج من تخفيف معجون أو عصير الفاكهة مع أو بدون إضافة مواد التحلية. والنكتار يتكون من نوع واحد من الثمار أو مزيج من الفاكهة، ويجب أن يحتوي على ٢٥-٥٠٪ على الأقل من عصير الفاكهة الطبيعي، اعتمادا على الفاكهة الأساسية. وتقدم هذه الدراسة مبادئ توجيهية لتطبيق نظام تحليل المخاطر ويركز على مخططات التدفق على أساس خط إنتاج تصنيع نكتار مانجو في شركة المعلبات المصرية " بست"، ويقدم تحليلا للمخاطر ونقاط التحكم الحرجة ومراقبتها ثم التحقق للتأكد من أن نظام تحليل المخاطر يعمل على نحو فعال.