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The Microbiological Quality Assessment of Commercially Available Packaged Fruit Juices Sold in Owerri, Imo State, Nigeria

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Abstract

The microbiological quality assessment of 21 packaged single and multiple fruit juices sold in Owerri metropolis, Nigeria were assessed using standard methods. MacConkey agar and Sabouraud dextrose agar were used for yeast isolation, total coliform and fungal count at 37°C for 24-48 hours and 96 hours respectively. Different biochemical tests were conducted for the confirmation of the isolates from the fruit juice. Bacterial genera isolated included *Bacillus, Proteus, Staphylococcus, Pseudomonas* and *Escherichia coli.* Three genera of fungi were identified, *Penicillium, Aspergillus* and *Saccharomyces*. The total heterotrophic bacterial counts ranged from 0.01 × 10^4 to 2.45 × 10^4 cfu/mL, while the total fungal counts ranged from 0.70 × 10^2 to 2.00 × 10^4 cfu/mL and the total coliform count ranged from 7.00 × 10^3 to 1.25 × 10^4 cfu/mL. The analysis of variance (ANOVA) test was employed to test the equality of the different fruit juices in terms of total microbial count. The presence of microbial contaminants in all the products could be a reflection of the quality of the raw materials, processing equipment, environment, packaging materials, storage conditions and the personnel's involved in the production and distribution process.

Keywords: Microbiological quality; Microbial contamination; Commercial juices; Quality assurance

Introduction

Fruit juices are becoming an important part of the modern diet in many communities. They are nutritious beverages and can play a significant part in a healthy diet because they offer good taste and a variety of nutrients found naturally in fruits [1]. Juice is a liquid that is naturally contained in fruit or vegetable tissue. Juice is prepared by mechanically squeezing or macerating fruit or vegetable flesh without the application of heat or solvents [2]. Most fruit juices contain sufficient nutrients that could

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support microbial growth [3]. Reported that the microorganisms present in fruit juices often originate from the natural flora of the raw materials used for the preparation and those introduced during the course of the processing. Fomites may also make the fruits unsafe and these may have a role in the spread of *Salmonella, Shigella, Vibrio, Escherichia coli* and cause diseases as well as fruit spoilage [2]. Spoilage yeasts such as *Saccharomyces cerevisiae, Candida lipolytica* and *Zygosaccharomyces* spp. can tolerate mid-level of acidic environments. Before pasteurization, fruit juices contain a microbial load representative of the organisms normally found on fruits during harvest plus contaminants added through post-harvest. Pasteurization will rid juice of pathogens and other heat sensitive microorganisms; therefore, it will reduce the microbial load substantially and extend the shelf-life of the product. Many reports of bacterial growth in fruit juices exist in literature, but most of the ones describing human illness due to contaminated juice deal with unpasteurized juices [4,5]. Some investigations regarding fungal contamination of pasteurized fruit juices are also available [6]. Yeast spoilage of fruit juices can result in formation of haze, production of carbon dioxide, off odour and changes in colour [7]. The quality of fruit juices is strictly maintained in developed countries under several laws and regulations but in many developing and underdeveloped countries, the manufacturers are not concerned about the microbiological safety and hygiene of fruit juices because of lack of enforcement of the relevant laws [6]. The market for these fruit juice products continues to show a remarkable growth. In recent years these juices have been part of the diet of people in different age group. So, maintaining the quality of processed fruit juices is of importance. This paper reports on the microbiological quality assessment of commercially packaged fruit juices sold in Owerri metropolis.

Materials and Methods

Collection of samples

The fruit juice samples used for this study were collected from different retail shops, supermarkets, markets and roadside retailers from the study areas of Owerri. The fruit juice samples were made up of 11 mixed and 10 single fruit juices respectively. Each sample was put into a sterile nylon bag, properly labeled and brought to the microbiology laboratory for analysis within 2 hours of collection.

Isolation of microorganisms in fruit juice samples

Serial dilutions of each packaged fruit juice sample were made up to 10^{-4} with sterile normal saline. Ten-fold serial dilutions of each fruit juice were made. After shaking each test tube, 0.1 ml of the test sample was plated out on freshly prepared nutrient agar plate for total aerobic plate count, on MacConkey agar plate for total coliform count and Sabouraud dextrose agar (SDA) for total fungal count. The plates were incubated at 37°C for 24-48 hours before taking the total heterotrophic plate count and total coliform count. The SDA plates were incubated for 48 hours for yeast and 96 hours for moulds at room temperature and the different isolates were stored on agar slants [8].

Identification of bacterial isolates

The bacterial isolates from different fruit juices were identified using their morphological characteristics, microscopic examination, biochemical identification test, coagulase, oxidase, indole production, citrate utilization, urease production, hydrogen and sugar fermentation tests [8].

Identification of fungal isolates

A small portion of the mycelia growth of each isolate was carefully collected using a pair of dissecting needles and lactophenol cotton blue as a stain and viewed on the microscope. The texture, colour, forms and microscopic appearance of each isolate were compared with standard mycology atlas for identification.

Results

Testing for equality of the fruit juices

The analysis carried out deal with testing for equality of the fruit juices with respect to the constituent attributes contained in them, which is the microbial count. The ANOVA test technique was employed to accomplish the task. With respect to each of the constituent attributes contained in the juices, the test null and alternate hypotheses were stated in the form:

Ho: $\mu_{FACB}=\mu_{Do}=\ldots=\mu_{FUO}$

H_1: $\mu_1 \neq 0$, for all ï, ï=FACB, DO…,

FUO (this implies that at least one of the fruit juices is significantly different). The test rejects the null hypothesis in each case when the p-value is less than or equal to the α-value (which in this study has been chosen to be 5% $\sum\propto=0.05$).

TABLE 1. **Fruit juice sample information from manufacturer.**

Sample code	**Batch no**	**Date of manufacture**	**Date of expiration**	**Estimated shelf-life**	**NAFDAC Registration number**
SFF	14:32	12/07/2015	11/04/2016	8 months 3 days	A1-8682
SFC	100412B16	10/04/2015	09/01/2016	8 months 29 days	01-1313
SFD	160412A16	16/04/2015	15/01/2016	8 months 29 days	01-1314
SFE	05173830	17/05/2015	16/02/2016	8 months 30 days	A1-2126
SFA	200412016	20/04/2015	19/01/2016	8 months 29 days	01-3343
SFB	BT23FT	06/2015	03/2016	9 months	01-0902
SFG	NIL	02/04/2015	01/04/2016	11 months 30 days	01-6450

SFH	V110612A14	11/06/2015	10/03/2016	8 months 29 days	01-3384
SFI	NIL	1/1/20114	01/11/2016	19 months 31 days	A1-0813
SFJ	3031	12/03/2015	13/01/2016	10 months	01-7146
MFF	3032	16/04/2015	15/01/2016	8 months 29 days	01-7147
MFE	19:35	27/06/2015	26/03/2016	8 months 29 days	A1-8686
MFB	210412A16	21/04/2015	20/01/2016	8 months 29 days	A1-8274
MFA	250512AB	25/05/2015	24/02/2016	8 months 30 days	01-7288
MFG	T_2CIB_2	05/03/2015	05/03/2016	8 months 29 days	01-7022
MFI	NIL	12/04/2015	11/01/2016	8 months 29 days	A1-7122
MFJ	BN1822:23:45	08/06/2015	06/03/2016	11 months 28 days	A1-2139
MFK	1122	01/06/2015	31/01/2016	7 months 2 days	A1-9203
MFH	BN00619100:24	31/05/2015	28/02/2016	8 months 29 days	A1-2141
MFD	418: 21035	14/06/2015	13/03/2016	8 months 29 days	01-5715
MFC	040812BB	04/08/2015	03/05/2016	8 months 30 days	A1-7977
SF: Single Fruit Juices MF: Multiple Fruit Juices					

The fruit juices had different manufacture and expiration dates. The shelf life spans from 8 months 3 days to 11 months 31 days. This showed a long period of shelf life which provided ample time for the purchase and consumption of the fruit juices. They had different batch numbers and expiration dates (TABLE 1). All the tested samples had NAFDAC registration numbers. This ensured that the regulatory agency approved it for human consumption.

TABLE 2. **Mean microbial count (cfu/ml) of fruit juices.**

S/N	Sample code	No examined	Total aerobic plate count	Total coliform count	Total fungal count
1.	SFF	2	1.09×10^4	9.10×10^3	1.40×10^4
2.	SFC	2	2.13×10^4	1.02×10^4	2.00×10^4
3.	SFD	2	1.80×10^4	9.60×10^3	1.50×10^4
4.	SFE	2	1.94×10^4	9.30×10^3	0.70×10^2
5.	SFA	2	2.07×10^4	ND	5.90×10^3
6.	SFB	2	2.01×10^4	ND	4.60×10^3
7.	SFG	2	1.62×10^4	ND	1.20×10^4
8.	SFH	2	1.84×10^4	1.15×10^4	1.70×10^4
9.	SFI	2	2.45×10^4	1.25×10^4	5.50×10^3
10.	SFJ	2	1.20×10^4	ND	5.60×10^3
11.	MFF	2	1.21×10^4	1.05×10^4	5.60×10^3
12.	MFE	2	1.26×10^4	8.00×10^3	1.20×10^4
13.	MFB	2	1.90×10^4	1.00×10^4	8.90×10^3
14.	MFA	2	1.76×10^4	1.03×10^4	1.02×10^4
15.	MFG	2	1.04×10^4	ND	1.10×10^4
16.	MFI	2	1.58×10^4	1.09×10^4	6.20×10^3
17.	MFJ	2	1.72×10^4	1.12×10^4	1.40×10^4
18.	MFK	2	1.38×10^4	1.16×10^4	8.70×10^3
19.	MFH	2	1.89×10^4	ND	4.80×10^3
20.	MFD	2	1.03×10^4	7.00×10^3	9.00×10^3
21.	MFC	2	0.01×10^4	ND	5.60×10^3

ND: Not Detected

MF: Multiple Fruit Juice

SF: Single Fruit Juice

Cfu: Colony Forming Units

Total heterotrophic bacterial count

The total heterotrophic bacterial counts were enumerated. The bacterial count was presented in TABLE 2. The bacterial counts ranged between 0.01×10^4 and 2.45×10^4 cfu/mL. Sample MFC had the lowest bacterial count of 0.01×10^4 cfu/mL, while sample SFI had the highest bacterial count of 2.45×10^4 cfu/mL. The table also shows that the fungal counts to be from 0.70×10^2 cfu/mL to 2.00×10^4 cfu/mL. Sample SFE had the lowest count of 0.70×10^2 cfu/mL while sample SFC had the highest

count of 2.00×10^4 cfu/mL. The coliform count ranged between 7.00×10^3 and 2.25×10^4 cfu/mL. Sample MFD had the lowest count of 7.00×10^3 cfu/mL, while sample SFI had the highest count of 1.25×10^4 cfu/mL.

TABLE 3. **Characterization and identification of bacterial isolates.**

S/N	Growth morphology on nutrient agar	Growth on other media			Bacteriology tests			Biochemical identification tests									Sugar fermentation						Most Probable Organism
		MacConkeyAgar	SSA	TCBS	GRAM	SHAPE	MOTILITY	CA	OXI	Cit	In	Urease	MR	VP	NI	$H2^S$	Coag	MAL	LAC	MAN	GLU	SUC	OXIFE	
1.	Large opaque bluish-green colonies with smooth edges.	N LF	-	-	-	R	+	+	+	+	-	+	+	-	-	+	-	-	-	-	-	-	O	*Pseudomonas* spp.
2.	Small round milky colonies with smooth edges, raised and pinkish on MacConkey Agar.	LF	-	-	-	R	- +	-	-	-	+	-	+	-	+	-	-	+	+	+	A/ G	-	F	*Escherichia coli*
3.	Round irregular thick dull and opaque colonies.	N LF	-	-	+	R	+	+	-	+	-	-	-	+	+	+	-	-	-	-	A	-	F	*Bacillus* spp.
4.	Round raised white colonies with smooth or even edges and yellowish pigment.	LF	-	-	+	C	-	+	-	-	-	-	-	+	+	-	+	-	+	+	A	-	F	*Staphylococcus* spp.
5.	Large swarming milky white colonies with irregular edges and decaying fish odour.	N LF	-	-	-	R	+	+	-	+	+	-	+	-	+	+	-	+	-	-	A/ G	+	F	*Proteus* sp

CA: Catalase, LF: Lactose Fermenter, Coag: Coagulase, Man: Mannitol, VP: Voges Proskauer, Oxi: Oxidase, NLF: Non-Lactose Fermenter, NI: Nitrate, GLU: Glucose, R: Rod, Cit: Citrate, A: Acid-Production, MAL: Maltose, SUC: Sucrose, F: Fermentation, In: Indole, G: Gas production, LAC: Lactose, C: Cocci, O: Oxidation, MR: Methyl Red, A/G: Acid and Gas Production, +: Positive Reaction, -: Negative Reaction,

Based on morphological and biochemical characteristics, five genera of bacteria were identified, and they included *Bacillus* sp, *Proteus* spp., *Staphylococcus* spp., *Escherichia coli* and *Pseudomonas* spp. (TABLE 3).

TABLE 4. **Characterization and identification of fungal isolates.**

S/N	Cultural characteristics (on SDA)	Microscopic appearance with lactophenol cotton blue	Most probable organism
1.	Dark-brown/black colony spreading on the surface of the medium reaching a diameter of 4-5 cm within 7 days. The reverse side is yellowish and zoned.	Radiate conidia heads, conidiophores, stipes smooth walled, hyaline often in brown colour conidia globse or sub-globse (3.5-5 nm) brown, ornamented with irregular warth spines and ridges.	*Aspergillus* spp.
2.	Thick greenish powdery surface with white wooly margin and brownish reverse side.	Conidiophore stalked hyaline and smooth walled. Conidia head radiate becoming loosely columnar with age.	*Penicillium* spp.
3.	Large white round colonies on 24 hour culture with yellowish pigments later turning to yellow powdery surface and white back surface.	Unicellular thallus hyphae with budded yeast-like ascospores in a free ascles mycelia present.	*Saccharomyces* spp.

Three (3) genera of fungi were identified and they included *Penicillium* spp., *Aspergillus* spp. and *Saccharomyces* spp. TABLE 4 showed the microscopic and cultural appearances of the isolates.

TABLE 5. **Prevalence of bacteria in fruit juices.**

Sample code	Number examined	Bacterial isolates (%)				
		E. coli	***Pseudomonas*** spp.	***Proteus*** spp.	***Bacillus*** spp.	***Staphylococcus*** spp.
SFF	2	-	+	-	-	-
SFC	2	+	+	-	-	-
SFD	2	-	-	-	+	-
SFE	2	+	+	-	+	+
SFA	2	-	+	-	+	-

SFB	2	-	-	-	+	+
SFG	2	-	+	-	+	-
SFH	2	+	-	-	-	+
SFI	2	+	+	-	+	-
SFJ	2	-	+	-	-	+
MFF	2	+	-	+	+	-
MFE	2	-	+	-	-	-
MFB	2	-	+	-	-	+
MFA	2	-	+	-	+	-
MFG	2	-	+	-	+	-
MFI	2	+	+	-	-	+
MFJ	2	-	+	-	-	-
MFK	2	-	-	+	-	+
MFH	2	-	-	+	+	+
MFD	2	-	-	-	-	+
MFC	2	-	-	+	+	+
		6	13	4	11	10
Presence percentages		(=28.6%)	(=61.9%)	(=19%)	(=52.4%)	(=47.6%)
E. coli: *Escherichia coli*,			+: Presence of Organism,			
MF: Multiple Fruit Juice ,			%: Percentage Occurrence,			
SF: Single Fruit Juice,			-: Absence of Organism			

The percentage occurrence of bacterial and fungal isolates from fruit juices is presented in TABLES 5 and 6. The results obtained in TABLE 5 showed that 6((28.6%) samples contained *E. coli*, *Pseudomonas* sp. 13(61.9%), *Proteus* spp. 4(19%), *Bacillus* sp. 11(52.4%), and *Staphylococcus* sp. 10(47.6%). It follows that 15 (71.4%), 8 (38.1%), 17 (81%), 10(47.6%) and 11 (52.4%) samples did not contain *E. coli*, *Pseudomonas* sp, *Proteus* sp, *Bacillus* sp. and *Staphylococcus* sp.

TABLE 6. **Prevalence of fungal isolates from fruit juice samples.**

Sample code	**Fungal isolates (%)**		
	Penicillium spp.	***Aspergillus* spp.**	***Saccharomyces* spp.**
MFA	+	+	-
MFB	-	+	-
MFC	-	-	+
MFD	-	+	+
MFE	-	+	-

MFF	+	-	-
MFG	+	-	+
MFH	-	-	+
MFI	+	-	-
MFJ	+	+	+
MFK	+	-	+
SFA	+	-	-
SFB	-	-	+
SFC	+	+	+
SFD	+	+	-
SFE	+	+	-
SFF	+	+	+
SFG	+	+	+
SFH	+	-	-
SFI	+	+	+
SFJ	-	+	+
	14	12	12
Presence percentages	(=66.7%)	(=57.1%)	(=57.1%)

The results obtained in TABLE 6 shows that 14(66.7%) samples contained *Penicillium* sp, *Aspergillus* sp. 12 (57.1%) and *Saccharomyces* sp. 12(57.1%). It follows that 7(33.3%), 9(42.9%) and 9(42.9%) did not contain *Penicillium* sp, *Aspergillus* sp. and *Saccharomyces* sp.

TABLE 7. **Total aerobic, fungal and coliform counts in the fruit juices.**

Sample code	**Total aerobic plate (cfu/ml) (× 10^4)**	**Total fungal count (cfu/ml) (× 10^4)**	**Total coliform count (cfu/ml) × 10^4)**	**Total microbial count (cfu/ml) (× 10^4)**
MFA	1.76	1.02	1.03	3.81
MFB	1.90	0.89	1.00	3.79
MFC	0.01	0.56	-	0.57
MFD	1.03	0.90	0.70	2.63
MFE	1.26	1.20	0.80	3.26
MFF	1.21	0.56	1.05	2.82
MFG	1.00	1.10	-	2.10
MFH	1.72	0.48	1.12	3.32

MFI	1.58	0.62	1.09	3.29
MFJ	1.89	1.40	-	3.29
MFK	1.38	0.87	1.16	3.41
SFA	2.07	0.59	-	2.66
SFB	2.01	0.46	-	2.47
SFC	2.13	2.00	1.02	5.15
SFD	1.80	1.50	0.96	4.26
SFE	1.94	0.07	0.93	2.94
SFF	1.09	1.40	0.91	3.40
SFG	1.62	1.20	-	2.82
SFH	1.84	1.70	1.15	4.69
SFI	2.45	0.55	1.25	4.25
SFJ	1.20	0.56	-	1.76

The table contained the fungi, bacteria and coliform counts found in the fruit juices (TABLE 7). From the analysis there were no significant differences between the bacterial, fungi and coliform counts since the $F_{calculated}$ was less than the $F_{tabulated}$ in accordance with the stated hypothesis.

Discussion

Inspite of these benefits offered by fruit juices, concerns over their safety and quality have been raised especially due to the many unregistered brands in the Nigerian market [9]. Microbial contaminants (Total heterotrophic bacterial and fungal counts) of the fruit juice samples analysed were below 10^6 cfu/mL thus within acceptable limit for human consumption [10]. These result from this study corroborates the result of microbial contaminants count in the range of 10^2 to 10^5 cfu/mL in packaged fruit juices sold in South Eastern Nigeria [11,12]. It is stated that the standard plate count of different types of fruit juices varied from $2 \times 10^3 – 4 \times 10^3$ cfu/mL in their work on quality assessment of industrially processed fruit juices available in Dhaka city Bangladesh [13]. Also reported a total heterotrophic bacterial count in the range of 3.0×10^2 to 9.0×10^4 cfu/mL and a total fungal count in the range of 1.0×10^2 to 4.2×10^2 cfu/mL in some packaged fruit juices sold in Port-Harcourt metropolis, Nigeria. The presence of microbial contaminants in all the products could be a reflection of the quality of the raw materials, processing equipment, environment, packaging materials and the personnel in the production and distribution process [6]. Most fruits contain bacterial counts of 1×10^5 cfu/mL on their surfaces [14,15]. Improper washing of fruits adds these bacteria to juices leading to contamination [15]. The bacterial isolates from the samples were *Bacillus spp., Proteus spp., Pseudomonas spp., Escherichia coli and Staphylococcus spp.* The presence of different bacteria in supposedly bacteria-free commercially available fruit juice is of great concern. Their presence may pose risks to consumers' health and should not be taken for granted [16]. The highest bacteria contamination was observed in sample SFE which had 4 out of the 5 isolates identified while sample MFJ had the lowest of one isolate out of the 5 isolates. These results of bacteria isolated was in agreement with the results of *isolated S. aureus, B. subtilis, P. caseicolum, Enterobacter spp., Acetobacter spp., Staphylococcus spp., Bacillus spp. and*

Lactobacillus spp. in their work on commercially packed fruit juices sold in Nigeria [13]. Also has been reported the presence of *Bacillus spp., Micrococcus spp., Flavobacterium spp.* and *Lactobacillus spp.* in packaged fruit juices sold Port Harcourt, Nigeria. The observation of these organisms in fruit juices examined goes to confirm that bacteria and molds were associated with fruit juice spoilage in Nigeria as well as other parts of the world [17]. *Staphylococcus* species present may have been introduced during processing, since the organism is among normal flora of skin, mouth and upper nasopharyngeal cavity [18]. *Bacillus* species are spore formers whose spores could survive high temperatures of processing [19]. The presence of *Bacillus* spp. (52.4%) in almost all the fruit juices may be attributed to its ability to form spores which are heat resistant. *Bacillus* spp. was also reported in bottled drinks and juice in a study [20]. Samples, SFC, SFD, SFE, SFH, SFI and MFF, showed the presence of *Escherichia coli* while sample SFA, SFB, SFG, SFJ, SFF, MFG, MFH, MFE, MFB, MFA, MFI, MFJ, MFK, MFD and MFC showed absence of *Escherichia coli* in the fruit juice samples examined in this study. This corroborates with the study on NAFDAC approved fruit juices sold in Ilorin where he isolated *Escherichia coli* [21,22]. Also has been reported, the presence of *Escherichia coli* in vended and packaged fruit juices locally available in Dhaka city, Bangladesh. This result disagreed with the study reporting the absence of *Escherichia coli* in their studies on packaged fruit juices. Therefore, the presence of *Escherichia coli* in some of the packaged fruit juices in this study calls for serious concern by regulatory agencies and relevant stakeholders. The presence of *Escherichia coli* and other coliform bacteria could be due to inadequate hand washing by food workers and the absence of good manufacturing practices. Safe food consumption standard prohibits coliforms in fruit juices [23]. The fungal isolates identified from this study include *Penicillium spp., Aspergillus spp.* and *Saccharomyces spp.* This result corroborates the work reporting the presence of *Aspergillus spp., Rhizopus spp. and Saccharomyces spp.* in packaged fruit juices sold in Nigeria [24]. It is also reported the presence of *Saccaharomyces cerevisiae, Saccharomyces cerevisiae* var *ellipsoides, Penicillium casecolium, Penicillium notatum and Rhizopus stolonifer* in packaged fruit juices sold in Onitsha, Nigeria. The presence of yeast and molds in many of the juices suggest that handling of the fruits and extraction of the juices methods may fall short of acceptable standards [14]. The surrounding air, packaging materials and personnel concerned with the packaging processes could all serve as sources of these contaminants [25]. The isolation of *Penicillium* spp. and *Aspergillus* spp. gives serious cause for concern because these species are specially known to produce mycotoxins [26]. The presence of S*accharomyces* spp. is expected due to its preference for sugar and low pH, which highly favour yeast proliferation [26]. The data analysis showed that the bacterial, coliform and fungal counts showed no significant differences in the different samples analysed based on the fact that null hypothesis should be rejected when the value of the f-ratio exceeded or equals the tabulated value of F obtained from a statistical table [27].

Conclusion

Fruit juices are fat free, nutrient dense beverages rich in vitamins, minerals and naturally occurring polynutrients which are of healthy and therapeutic benefits. The presence of different bacteria and fungi in commercially available fruit juice is of great concern. This work has shown that the locally available fruit juices contain safe levels of microorganisms. But the isolation of coliforms in some of the samples in this study calls for serious concern and prompt response by relevant stakeholders. It is therefore better to monitor the proper management of the raw materials and the production plant to prevent or minimize microbial contamination of fruit juices. The essential requirements and quality factors as stipulated in the NAFDAC Fruit Juice

and Nectar Regulations 2003 and SON Industrial Standard document (NIS 235:1987) should be readily made available to intended processors by these regulatory agencies. Government regulatory bodies such as NAFDAC, SON, Ministry of Health should take intensive investigations to control the microbial quality of packaged fruit juices. Production and sell of these products should be under strict quality control to mitigate exposure to harmful microbes deleterious to consumer's health.

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