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Full Length Research Paper

Effects of two packaging materials and storage conditions on the quality of fresh taste, a natural and locally produced orange drink in Ghana

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Fresh Taste is a natural orange drink product produced in Ghana and packaged in high density polyethylene (HDPE) plastic sachets. The packaging material (sachet) used has been found to be ineffectively designed, particularly its aesthetic appeal and seal integrity. The study was thus conducted to assess the protective function of the alternative package (HDPE bottle) and the existing package (HDPE sachet) on some quality attributes of the product. Samples of the product were stored under refrigeration, room and outdoor conditions over a 7-week period. Microbial load (Yeast and Coliform), titratable Acidity (TTA %) and organoleptic perceptions of sensory panellists served as the measurable indicators for the protective function of the packages. A comparative study was also conducted on the effectiveness of the communication function of the two packaging materials. The results showed that, there was no significant difference between the effectiveness of the protection provided by the High Density Polyethylene bottle and the High Density Polyethylene sachet at 95% confidence level. A significant difference was observed between the communicative function of the bottle packaged product and the existing sachet-packaged Fresh Taste product. The overall rating of panellist for the sachet and labelled bottle however were satisfactory and very good respectively. More than half of the panelists (52%) indicated the illegibility of the displayed details on the HDPE sachet as the major deficiency.

Keywords: Fresh Taste, HDPE sachet and bottle packages, storage conditions

INTRODUCTION

Packaging is one of the most critical considerations in the value-addition chain of activities in the food or agro-processing industry. The primary functions of packages are to contain, protect and preserve products throughout their distribution, storage and handling. They are also used to communicate to potential users as far as product usage and nutritional content are concerned (Robertson, 1993). Food is packaged to preserve its quality, freshness, add appeal to consumers and to facilitate storage and distribution. For the majority of food products, the protection afforded by the package is regarded as the primary function of the package and is an essential part of the preservation process (Robertson, 2006) Fresh Taste, a natural orange drink produced in the Central Region of Ghana, has no preservatives in the formulation and a short shelf life. The primary package of Fresh Taste which is a high density polyethylene (HDPE) plastic sachet has been found to be ineffectively designed, particularly its aesthetic appeal and seal integrity. Marketability of Fresh Taste in the HDPE sachet is therefore low amongst the urbane and choosy category of persons in Ghana who may want to patronize the tasty and refreshing product. Due to the packaging design and seal quality, the product has limited acceptance for sale by supermarkets (Personal communication, Letsinam, 2005 Fruits and Flavours Ltd, Asebu, Central Region, Ghana,). The seal quality has been found to be ineffective as a result of which the product is vulnerable to leakage, contamination and deterioration due to

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imperfection in the form-fill-seal of the sachets. While products with long storage time such as pasteurized fruit juices have received enough attention from researchers and product manufacturers (Berlinet et al., 2005), there is dearth of information on unpasteurized beverages (Van Willige et al., 2000). Besides, only few studies have reported the influence of packaging on sensory properties of beverages (Pieper et al., 1992; Van Aardt et al., 2001) The study was carried out to evaluate the protective and communicative functions of two packaging materials, High Density Polyethylene bottle and High Density Polyethylene sachet as well as storage conditions on the quality of Fresh Taste, a natural, unpasteurized and locally manufactured orange drink.

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MATERIALS AND METHODS

Sources of Materials

Freshly produced samples of unpasteurized Fresh Taste used for the study were obtained from Fruit and Flavours Limited, the manufacturing company which produce Fresh Taste at Asebu in the Central Region of Ghana. Translucent HDPE bottles (500 mL) were obtained from Polyproducts Ghana Limited, Accra. HDPE sachets of 150 and 350 mL of unpasteurized Fresh Taste were thermally-sealed using an automatic form-fill-seal machine and secondarily packaged in HDPE bags at Fruits and Flavours Ltd, Asebu.

Evaluation of the protective function of the packaging materials

The microbial load, sensory perceptions and titratable acidity of Fresh Taste were used as measurable indicators for the evaluation of the protective function of the two packages containing unpasteurized Fresh Taste for a period of 7 weeks. Fresh Taste packaged in High Density Polyethylene (HDPE) sachets and HDPE bottles were kept under three storage conditions namely refrigeration (2-5°C), room(21-32°C) and outdoor/open market temperatures (>28°C) and sampled weekly for laboratory analyses.

Microbial load determination

Microbiological analyses were based on yeast and coliform counts.

Sample preparation

Glass test tubes were each filled with 10 mL distilled water, plugged with cotton wool and autoclaved at 121°C for 15 minutes. In preparing the serial dilutions of the Fresh Taste samples, each test tube now containing 9 mL of sterilized distilled water was unplugged, flamed with a Bunsen burner and 1 mL of the Fresh Taste drink sample was aseptically transferred into it using a micropipette. The sample was thoroughly mixed to obtain a dilution of 10^{-1}. This procedure was repeated with each dilution as stock from which serial dilutions of 10^{-2} up to 10^{-10} were prepared. (Atlas et al., 1995).

Inoculation of media with sample

The pour plate technique was used for the inoculation. This technique was used for all the microbial determinations using sterile distilled water as control. The microbial loads expressed as colony forming units per mL (CFU/ml) were calculated based on plates with colonies between 30 and 300 using the relation, CFU/ mL = Average Number of Colonies x Dilution Factor (Atlas et al., 1995).

Yeast load determination

Yeast extract agar was used as the media for the enumeration of the yeast load. After inoculation, the Petri dishes were incubated for 18-24 hours at 37°C in a Gallenkamp incubator (Model 1H-150, UK). The total yeast load after incubation was expressed as CFU/ mL after counting the colonies using the colony counter (Atlas et al., 1995).

Coliform load determination

Total coliform load was determined using the Most Probable Number (MPN) method. Mackonkey broth was used as the media for the determination. The broth was prepared based on the manufacturer's guidelines. Serial dilutions were prepared from 10^{-1} to 10^{-10} in triplicates. 1 mL of sample was then inoculated into the dilutions. These were then incubated at 37°C for 18 - 24 hours. The test tubes were observed for colour change from violet to yellow. The concentration of Coliforms in the original stock of Fresh Taste was determined using the Most Probable Number (MPN) estimation rules and a statistical probability table (Atlas et al., 1995). The results were an estimate of the mean density of Coliforms in the sample and were reported as MPN using the formula

MPN/100 mL = Number of microorganism (Statistical Table) x Dilution Factor of Middle Set of Tubes Selected.

Determination of titratable acidity (TTA) %

10mL of Fresh Taste samples were measured in triplicates and poured into 250ml conical flasks. Two drops of phenolphthalein indicator were added to each sample and titrated using standardized 0.1N NaOH solution. The endpoints of the titrations were noted when the colour of the sample solution changed to pale pink. The titratable acidity was calculated using the formula;

% Acidity (based on citric acid) = {(Titre x Factor) ÷ Weight of 10ml of Sample} x 100

Citric acid factor = 0.062

Sensory evaluation

The triangle test method was used to evaluate the sensory perceptions of between 20-40 trained sensory panelists (average of 31 per week) on unpasteurized Fresh Taste packaged in 500 mL HDPE bottles and 350 mL/150 mL HDPE sachets over a seven (7) week period. 50 adults were invited to avail themselves for training. Samples were introduced to the voluntary trainees and they were served with chilled, fresh samples of Fresh Taste. The properties agreed upon for the sensory evaluation were aroma, taste and texture (mouth feel and turbidity). The sensory evaluation was a comparison between freshly produced Fresh Taste (control) and samples of the unpasteurized Fresh Taste packaged in HDPE bottles and sachets, under three different storage conditions.. Each panelist was presented with the 3 samples of Fresh Taste and asked to identify two of the three samples that they perceived to be identical concurrently in terms of flavour (taste and aroma) and texture (mouth feel and turbidity). Results of panelists who could not detect the true differences in flavour and texture concurrently were rejected. The responses of the panelists were indicated on score sheets administered during the test. A critical value

(Probability, P) = 0.05 was used for the statistical evaluation where Probability (P) of correct judgment <0.05 meant that detection of change by panelists in product sensory properties was significant and probability (P) of correct judgment ≥ 0.05 meant that detection of change was not significant. The probability of correct judgment was determined from a triangle test statistical chart (Roessler et al., 1978).

Evaluation of the communication function of the two packages

The effectiveness of the communication function of the two packages (labelled HDPE bottle and HDPE sachet) of Fresh Taste was evaluated by 100 respondents. The assessors were made up of randomly selected consumers of packaged orange drink products. The panelists were presented with samples of Fresh Taste packaged in the two primary packaging materials (bottle and sachet) and asked to visually inspect and indicate their preferences on a questionnaire administered to them.

Statistical Analysis

The data obtained was expressed as means and their respective standard deviation were calculated. Statistical analyses were done using the program GENSTAT 5, Release 3.2. Analysis of variance (ANOVA) was used to establish differences in mean values. The level of differences by Least Significant Difference of means (LSD) (GENSTAT 5, Release 3.2)

RESULTS AND DISCUSSION

Evaluation of the protective function of the two packages under three storage conditions

The microbial load, sensory properties and titratable acidity of Fresh Taste were used as measurable indicators for the evaluation of the protective function of the two packages containing unpasteurized Fresh Taste for a period of 7 weeks

Microbiological analyses of Fresh Taste

The protective function of the alternative packaging material of Fresh Taste (labelled HDPE plastic bottle) was compared with that of the existing packaging design (HDPE sachet) using Yeast and Coliform loads as part of the measurable indicators. The results of the microbiological analyses are shown in Table 1 (a)-(c). Generally the initial microbial load in the orange drink products (Fresh Taste) was higher than the recommended levels by the Ghana Standards Board which are 1.0 $x10^2$ for Coliforms and 5.0 x 10^1 for Yeast and Moulds (Ghana Standards Board, 2003). This may be due to contamination of the whole fruit during harvesting or re-contamination during the upstream (bulk extraction) or downstream processing of Fresh Taste (Correa de Souza et al., 2004). The lack of preservatives and high water content of fruit drinks and juices predisposes them to microbial contamination during processing (Al-Jedah and Robinson, 2002).. The initial microbial levels for Yeast in the bottled samples were slightly higher than the sachet samples. This might have been due to re-contamination of the product during the filling of the bottles since it was done semi-manually as against the sachet filling which was automatically form-fill-sealed. Notwithstanding, since both the rigid HDPE bottle and flexible HDPE sachets can withstand pasteurization temperatures, the bottled product could be pasteurized to thermally reduce the microbial population after filling. There was no significant difference ($p > 0.05$) in the yeast loads for product samples packaged in bottle and sachet under the different storage conditions over the period**.** The same trend was recorded for coliform counts in the different packaging materials as well as storage conditions ($p > 0.05$). There was a sharp increase in yeast counts (10^4 to 10^5) during the first week of storage in both packages and this was followed by marginal increases throughout the storage period. The availability of nutrients such as sugar, pectin and organic acids favour the rapid growth of yeast and this could explain the sharp increases at the onset of the storage (Ros-Chumillas et al., 2007). The growth however became marginal because the growth enhancers of yeast particularly sugar and organic acids started depleting gradually with the sharp decrease in the citric acid levels (TTA %) at the initial period of storage. The microbial loads in the sachet samples were found to be slightly higher than the levels in the bottles during storage under the three conditions. The barrier properties of the sachets could have allowed easier penetration of oxygen since rigid HDPE materials offer a much decreased gas permeability compared with flexible HDPE film (Robertson, 1993).

Generally, the samples kept under outdoor conditions had the highest levels of microbial counts followed by the samples kept under room temperature with refrigerated samples recording the least microbial counts. This observation concurs with studies by Correa de Souza et al., (2004) that higher temperatures tend to enhance the growth of yeasts.

The titratable acidity of Fresh Taste (TTA %)

Generally, the sinusoidal pattern as observed by Miguel et al., (2004) in the organic acid levels of pomegranate juice stored over a period at 4°C was similarly observed in the citric acid content of Fresh Taste (Figure.1). The titratable acidity (predominately citric acid) of Fresh Taste samples was found to have decreased sharply between the initial storage period and the fourth week. The acidity in the bottle and sachet samples under refrigeration conditions continued to decrease gradually until the 6^{th} week after which it began to increase again gradually until the 7^{th} week. The samples under ambient condition generated a minor crest of the sinuous curve between week 4 and 7 (Figure.1). Notably, between the 4^{th} and 5^{th}

Table 1a: Microbial load of samples stored under refrigeration temperature of 2-5°C

Microorganism	Total Coliforms (MPN/ mL)		Yeast(CFU/ mL)	
Period	Bottle	Sachet	Bottle	Sachet
Week 0	6.40 x 10^{2}	7.50 x 10^{2}	3.20 x10^{6}±1.0x10^{6}	2.90x10^{6}±1.0x10^{6}
Week 1	6.20 x 10^{2}	9.40 x 10^{2}	1.30x10^{10}±1.0x10^{6}	2.80x10^{10}±2.0x10^{6}
Week 2	1.10 x 10^{4}	1.40 x 10^{5}	2.67 x10^{9}±2.0x10^{7}	2.66x10^{10}±1.0x10^{6}
Week 3	1.10 x 10^{5}	1.10 x 10^{5}	3.30x10^{10}±1.0x10^{6}	4.74x10^{11}±1.0x10^{9}
Week 4	1.60 x 10^{7}	1.60 x 10^{7}	2.80x10^{10}±2.0x10^{6}	1.25 x10^{9}±2.0x10^{7}
Week 5	2.90 x 10^{9}	1.60 x 10^{6}	1.23x10^{10}±2.0x10^{6}	3.21x10^{10}±1.0x10^{6}
Week 6	1.50x10^{10}	2.30 x 10^{9}	1.58 x10^{9}±1.0x10^{7}	1.14x10^{10}±2.0x10^{6}
Week 7	1.10x10^{12}	3.50 x 10^{12}	3.54 x10^{9}±2.0x10^{7}	1.69 x10^{9}±1.0x10^{7}

Table 1b: Microbial load after storing samples under room temperature of 25-32°C

Microorganism	Total Coliforms (MPN/ mL)		Yeast(CFU/ mL)	
Period	Bottle	Sachet	Bottle	Sachet
Week 0	6.40 x 10^{2}	7.50 x 10^{2}	3.20x10^{6}±2.0x10^{6}	2.90 x10^{6}±2.0x10^{6}
Week 1	7.40 x 10^{5}	1.10 x 10^{4}	2.90x10^{11}±1.0x10^{9}	3.10x10^{11}±2.0x10^{10}
Week 2	2.00 x 10^{6}	7.20 x 10^{5}	3.00x10^{10}±1.0x10^{9}	1.40x 10^{10}±1.0x10^{6}
Week 3	3.00 x 10^{6}	3.60 x 10^{6}	7.06x10^{11}±2.0x10^{6}	1.61x 10^{11}±2.0x10^{9}
Week 4	3.20 x 10^{6}	3.90 x 10^{7}	4.00 x10^{6}±1.0x10^{7}	1.48x 10^{10}±1.0x10^{7}
Week 5	6.40 x 10^{6}	2.30x10^{10}	5.25 x10^{9}±1.0x10^{7}	4.64 x 10^{9}±2.0x10^{6}
Week 6	1.10 x10^{12}	4.30x10^{11}	1.06x10^{10}±2.0x10^{6}	6.02 x 10^{6}±2.0x10^{7}
Week 7	1.10 x10^{12}	1.10x10^{12}	1.32x10^{10}±1.0x10^{8}	2.92 x 10^{9}±1.0x10^{7}

Table 1c: Microbial load of samples stored under outdoor temperature greater than 28°C

Microorganism	Total Coliforms (MPN/ml)		Yeast (CFU/ml)	
Period	Bottle	Sachet	Bottle	Sachet
Week 0	6.40 x10^{2}	7.50 x 10^{2}	3.20x10^{6}±1.0x10^{6}	2.90 x10^{6}±2.0x10^{6}
Week 1	1.50 x10^{5}	1.60 x 10^{5}	2.80x10^{11}±2.0x10^{9}	5.30x10^{11}±1.0x10^{10}
Week 2	1.50 x10^{5}	2.70 x 10^{6}	6.20x10^{10}±1.0x10^{6}	3.80x 10^{10}±2.0x10^{6}
Week 3	2.80 x10^{5}	1.10 x 10^{7}	4.11 x10^{9}±2.0x10^{6}	2.60x 10^{10}±2.0x10^{6}
Week 4	2.40 x10^{7}	4.60 x 10^{7}	8.40 x10^{6}±1.0x10^{7}	2.28x 10^{10}±1.0x10^{6}
Week 5	N/D**	N/D**	N/D**	N/D**

N/D** Not determined due to spoilage of samples after week 4 .MPN: Most probable number

weeks, both the bottle and sachet samples under ambient storage conditions increased slightly in the citric acid levels before decreasing again till the 7th week. Yeasts utilizes some citric acid as substrate for growth whiles other organic acids are among the metabolites produced during microbial breakdown of food and these accumulate and eventually suppress further microbial growth (Martinez et al., 1998). No significant differences ($p>0.05$) were observed in citric acid levels of samples in bottles and sachets kept under refrigeration and room conditions.

Sensory analysis of Fresh Taste using the triangle test

The sensory properties of Fresh Taste were monitored by between 20-40 trained sensory panelists for a period of 7 weeks. From Table 2, the probability (p) of correct judgment <0.05 meant that detection of change by panelists in product sensory properties was significant and probability (p) of correct judgment ≥ 0.05 meant that detection of change by panelists in product properties was not significant. No significant differences were observed in the sensory attributes (Flavour and Texture) of the Fresh Taste samples kept under the different storage conditions in the two packaging materials until the third week where panelists observed significant difference in taste, aroma and mouth feel of sachet packaged Fresh taste samples under outdoor conditions. Low temperature tends to ensure flavour stability of fruit juice products during storage (Ebbenser, 1998; Pieper et al., 1992). The prolonged stability observed in the sensory attributes of bottled compared to sachet samples indicate that rigid HDPE bottles could better protect an

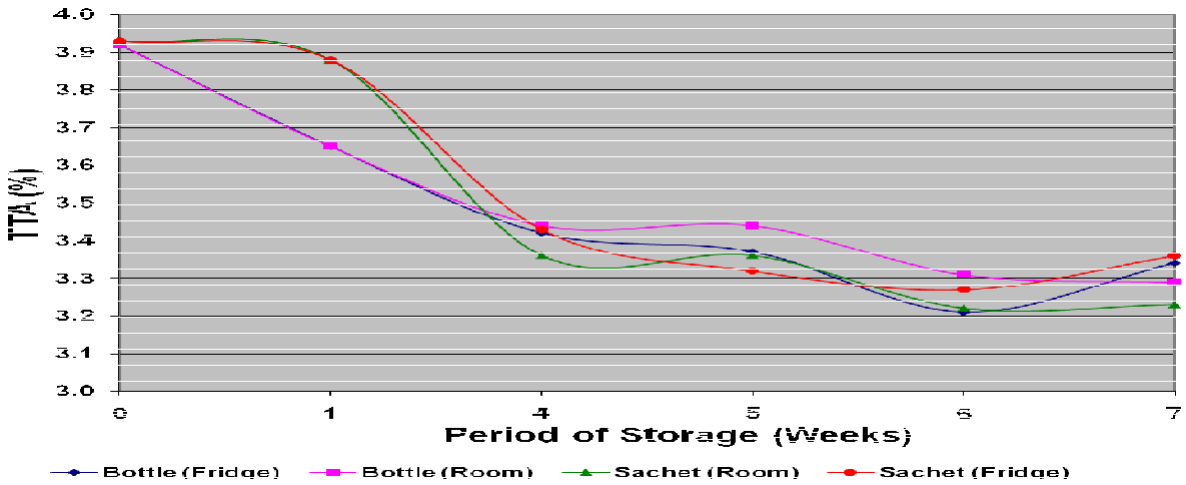

Figure 1: Changes in TTA% in Fresh Taste samples in two different packages

Table 2: Probability of Correct Judgment (CJ) of changes in Fresh Taste samples

Package/ condition	Storage	Probability of Correct Judgment						
		Week 0	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Bottle(Fridge)		0.778	0.940	0.240	-	0.293	0.996	0.999
Sachet(Fridge)		0.630	0.940	0.399	0.231	0.422	0.468	0.376
Bottle(Room)		0.462	0.191	0.581	0.083	0.293	0.213	0.087
Sachet(Room)		0.304	0.191	0.125	0.001	0.001	0.001	ND*
Bottle(Outdoor)		0.092	0.092	0.002	0.001	ND*	ND*	ND*
Sachet(Outdoor)		0.178	0.339	0.002	ND*	ND*	ND*	ND*

Not Determined (ND*) .Probability of CJ < 0.05 meant change in product stability is significant

Table 3a: Perception of panelists on package A (sachet)

	Percentage (%)
Perception of package A (HDPE Sachet)	
Poor	29.0
Satisfactory	**33.0**
Good	25.0
Very Good	12.0
Excellent	1.0
Total	100.0

orange juice from spoilage under the same storage conditions than flexible HDPE films formed into sachets. HDPE bottle are comparatively stronger thicker and have lower permeability to gases and moisture (Fellows, 1996). The fact that all the samples kept under the outdoor storage conditions became unwholesome by the third week confirms the assertion that favourable substrate and ambient temperature create an enabling environment for physicochemical and microbial changes as well as enzymatic reactions to proceed (Robertson,

Table 3b: Perception of panelists on package B

Perception of package B (HDPE Bottle)	Percentage (%)
Satisfactory	31.0
Good	13.0
Very Good	**36.0**
Excellent	20.0
Total	100.0

Table 4: Most obvious deficiency of package A (Sachet)

Deficiency Identified	Percentage (%)
Illegibility of information on package (How readable)	**52.0**
Quality of material	25.0
Closure or seal quality	11.0
Handling (less convenient)	4.0
Artistic appeal of graphic design	5.0
Containment Design (shape, form ,style, etc)	3.0
Total	100.0

1993 and Correa de Souza et al., 2004) and thus accelerate fruit juice spoilage. Lower refrigeration temperatures tend to inhibit microbiological and enzymatic reactions that cause food spoilage (Ebbenser, 1998; Pieper et al., 1992).

Evaluation of the communication function of the two packages

A total of 100 consumers were asked to serve as panellists to visually assess Fresh taste samples in the two different packages (bottle and sachet). Tables 3a and 3b present a summary of the outcome of the evaluation of the general visual appeal of the two packaging designs.

Twenty- nine percent of the panelists indicated that, the existing package (HDPE sachet) was poor. 33% rated it as satisfactory, whiles 25%, 12% and 1% rated the HDPE sachet as good, very good and excellent respectively. 20%, 36% and 13% respectively rated the alternative packaging material (labelled HDPE bottle) as excellent, very good and good. 31% rated the labelled bottle as satisfactory while none of the panelists perceived it to be poorly designed. The analysis of variance between the level of acceptance of the sachet and labelled bottle was statistically significant ($p<0.05$). The overall rating for the sachet and labelled bottle however was satisfactory and very good respectively. 52% of the panelists indicated that, the most obvious deficiency of the existing package (HDPE sachet) was illegibility of information on the package. 25% of the panelists perceived the low quality of the packaging material to be the most obvious deficiency whiles another 11% identified the closure or seal quality of the sachet to be the most obvious deficiency (Table 4).

CONCLUSION

The effectiveness of the protection provided by the alternative package of Fresh Taste (HDPE bottle) was not significantly different from that of the existing HDPE

sachets based on the sensory, microbiological and physicochemical analysis of Fresh Taste over a 7-week period. However, the HDPE bottle extended the sensory quality of Fresh Taste under room storage conditions by about 2 weeks compared to the sachet based packaging material. The communicative power of the full colour 135GSM art paper label of the HDPE plastic bottle was found to be more effective compared to the two-colour graphic print of the HDPE sachet. The panelists engaged for the evaluation of the communication function of the two packages indicated that the HDPE sachet and HDPE bottle were satisfactory and very good respectively. The most obvious deficiencies of the existing package (HDPE sachet) were illegibility of information on the package followed by quality of packaging material and closure or seal quality.

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