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EFFECT OF SUNLIGHT EXPOSURE ON THE NUTRIENT COMPOSITION OF TWO SELECTED COMMERCIAL MILK DRINKS

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ABSTRACT

Background: Healthy eating involves getting the most out of the nutrients in a particular food. Commercial milk drinks have been found to be good sources of important nutrients; however, the practice of displaying goods under sunlight by retailers, lead to loss of some of these nutrients.

Objectives: This study determined the effect of sunlight exposure on proximate, vitamin and mineral contents of two selected commercial milk drinks.

Methods: The study design was experimental and standard methods were used for nutrient analysis. Six samples each, of the brands were procured from Ogige Market, Nsukka, Enugu State and were randomly divided into treatment and control groups. Two treatment groups were exposed to sunlight, 8 hours daily for 5 days and 10 days respectively under the average weather temperature of 23.4^{o}C and 23.2^{o}C respectively. Two control groups were kept indoors at 21^{o}C average room temperature. Analysis for both treatment and control groups were carried out on days 0, 5 and 10 in duplicates, and mean values determined. Analysis of variance was used to compare mean values of the three tests while independent sample t test was used to compare means of the treatment and control groups

Result: In sample A, protein decreased by 38.9%, from 1.31% to 0.8% at day 10. Calories increased from 72.97% to 95.32% at day 10. Vitamin B_9 decreased by 100% by day 5 and Calcium decreased from 11.47mg/100ml to 2.56 mg/100ml at day 5 showing77.6% decrease. In sample B, fat decreased by 26.4%; Vitamin C decreased by 31.2% and phosphorus decreased by 40.6%. The two control groups also lost some nutrients during storage but significantly ($p < 0.05$) less than the treatment groups.

Conclusion: Thus, the study concludes that exposure of milk products to sunlight, leads to more nutrient depreciation compared to storage at room temperature.

Key words: *Sunlight exposure, Commercial, Milk drinks, Proximate, Vitamins, Minerals*

INTRODUCTION

Undernutrition especially in young children, is one of the aspects of malnutrition that is presently of global public health concern (1). This leads to diseases which has the capacity to cripple children's growth and development, and could lead to decline in cognitive abilities and poor academic performance among growing children (2). About 20–80% of school children in developing countries are suffering from poor nutrient consumption and under nutrition which contribute to 28% of child mortality, and morbidity (3). Healthy eating is currently being advocated as a strategy to combat deficiency diseases associated with insufficient nutrient intake. It involves the consumption of a variety of nutritious foods including milk and its products, for the provision of all the nutrients required by the body to maintain good health.

Milk is a good source of fat and contains high quality proteins in addition to carbohydrates, vitamins, and minerals particularly calcium, magnesium, phosphorous and potassium (4). The development of milk drink is among the various ways of using milk whey by dairy industries (5). Milk drink is a drink obtained by mixing fermented or plain milk with potable water with or without the addition of other non-dairy ingredients, and flavourings (6). It is one of the most nutritious drinks because of its high nutrient composition at production and are essential for adequate human nutrition especially among poor people in developing countries who have very little dietary diversity (7). Milk drinks which are produced as ready-to eat beverage for consumers are regarded as commercial milk drinks (8).

Consumption of commercial milk drinks has increased globally and dairy industries have engaged in more value-added productions (9). This has led to remarkable evolutions and innovations to incorporate a wide range of varieties such as sweetened or sugar-free, skimmed and non-skimmed as well as different flavours, packaging materials, and sizes. Commercial milk

drinks undergo the process of pasteurization, homogenization and fortification before it is ready for sale (10,11). These processes, in addition to prolonging the shelf life of the products are intended to make them more palatable and nutritious to the consumers. Milk is the major constituent in milk drinks and so a nutritious milk drink must contain almost all the nutrients that can be obtained in raw milk. In Nigeria, commercial milk products usually come in handy, when people seek portable nutritious drinks for children's school snacks and other occasions. There are various types and brands of milk drinks. However, market practices which involve open air display of drinks by the sellers in an effort to make them visible enough to the buyers, get the products exposed to sunlight.

Sunlight exposure of packaged food products involves keeping the products in such condition at which the rays of sunlight is reflected off the surface of the package, absorbed by the packaging material and transmitted through the food leading to photodegradation (12). The effects of sunlight exposure on food products depend on the intensity of the light wavelength, how long the exposure took place, the temperature, as well as the type of material used to make the container (13). Thus, various nutrients which are contained or incorporated into the product maybe destroyed or lost because of their sensitivity to heat, light, oxygen, pH of solvents or a combination of these (14). Sunlight exposure, could have deteriorating effects on the products, thereby making the products deficient in the valuable nutrients in addition to loss of flavor and taste (12).

Consumers expect that the commercial milk drinks they buy contains the nutritional qualities promised on the label, however, exposure to sunlight during the distribution process can significantly erode the nutritional content of milk drinks (15). Many studies conducted in Nigeria, on the effect of sun light/heat on foods nutrients, were focused on the processing stages of the foods. There is shortage of data on the effect of sunlight exposure on the nutrient values of packaged ready-to-eat food products especially milk drinks. Hence, this study determined the effect of sunlight exposure on the proximate, vitamins and mineral contents of two selected commercial milk drinks sold in Ogige market, Nsukka, Enugu state.

MATERIALS AND METHODS

Study design: The study adopted experimental research design.

Procurement of the sample: A market survey was carried out at Ogige market in Nsukka by the researchers to identify the commonly sold commercial milk drinks. A flavoured milk drink and a yoghurt drink were identified as two commercial milk drinks that have been in vogue in the market for years. The two brands were labeled Samples A and B for the purpose of the study. Sample A was packaged in 100ml (100g) polyethylene lined paperboard and sample B was packaged in 210ml (210g) plastic bottle. The samples were purchased from a wholesaler in Ogige market Nsukka Enugu state, Nigeria. Six samples of each brands of the commercial milk drinks were purchased which gave a total of twelve samples. The purchased samples were subjected to chemical analysis in the analytical laboratory of the department of Home science, Nutrition and Dietetics.

Preparation of the sample

Six samples of the two brands were randomly assigned to experimental and control groups which gave a total of two experimental/treatment groups and two control groups. The objects in the treatment group of sample A were labeled SA/BL, SA/T1 and SA/T2 while those in the control group of sample A were labeled SA/BL, SA/C1 and SA/C2. The objects in the treatment group of sample B were labeled SB/BL, SB/T1 and SB/T2 while those in the control group of sample B were labeled SB/BL, SB/C1 and SB/C2. The samples labeled SA/BL, SB/BL were initially analyzed in duplicates and their means obtained, to determine the baseline nutrients of the products. After that, the treatment groups were exposed to sunlight, eight hours (8a.m to 4p.m) daily for 5 and 10 days under the average weather temperature of 23.4^{o}C and 23.2^{o}C respectively. The number of days were chosen to correspond to the average length of time it takes the retailers to get a set of products sold out according to information obtained from personal enquiry from two retailers at Ogige Market in June 2019.

The samples were placed singly, in upright positions on an elevated surface very close to a building. When it rained, the samples were brought in under a shade. The control groups were kept indoors on a shelf at 21^{o}C average room temperature for equal number of days. The nutrient analyses were repeated at day 5 and day 10 both for the experimental groups and the control groups. The experiment took place in the month of July and the temperature readings were taken using the Google Daily Temperature of Nsukka town while room temperature reading were taken using Room Temperature mobile app for android.

Proximate analysis

Proximate analyses were carried out using standard methods of the Association of Official Analytical Chemists (16). Moisture was analyzed using hot air oven method, ash was analyzed with wet ashing method, protein was determined by the micro Kjeldahl

method and fat was determined by gas chromatography-mass spectrometry method (16).

Mineral Determination

Analysis of phosphorus was determined by the phosphovanado-molybdate method of AOAC (16). The ortho-phenanthroline method was used for iron analysis. Calcium, magnesium and zinc were analyze using titrimetric, spectrophotometric and flame-photometric methods respectively (16).

Determination of Vitamins

The mass spectrometry method described by Association of Vitamin Chemists (16) was used to determine the vitamins B and 2,6 dichlorophenolindophenols method was used to determine vitamin C contents of the samples (16).

Statistical analysis

All analyses were done in duplicates and the mean values computed and coded into IBM-SPSS Statistics version 23. Analysis of Variance (ANOVA) was used to compare mean values of the pretest, first and second post-test results and Duncan's multiple range test was used to separate means. Individual sample t-test was used to compare mean values of the treatment and control groups. Level of significance was established $p < 0.05$.

RESULTS

Table 1 shows the baseline nutrient composition of samples A and B and the nutritional information found on the label of the products. The data show that the two samples contained more nutrients than were stated on the labels. In sample A, protein was less (1.31 g) than the label information (2.6 g). Calcium on the label was 43.1 mg while 11.47 mg was detected. Vitamin C was detected in higher quantity (6.88mg) than 1.9mg that was stated in sample A. In sample B, proximate and vitamins were within the ranges stated, while calcium and iron were less than stated. Vitamin B_1 was not stated on the nutrition labels and was not found in the samples. Vitamin B_{12} was not detectable in two samples, but was stated on the label; 4.8 µg in sample A and 0.01 – 0.18 µg in sample B. Magnesium was stated on sample B (1.0-10 mg) but was not found in the two samples.

Table 1: Baseline nutrients composition and nutrient information of samples A and B

Baseline nutrients analyzed	Sample A	Nutritional information	Sample B	Nutritional information
Fat (g/100g)	2.37	2.5	1.29	≥ 1.0
Moisture (g/100g)	84.02	NS	92.51	NS
Ash (g/100g)	0.70	NS	0.32	NS
Protein (g/100g)	1.31	2.6	0.75	≥ 1.0
Carbohydrate (g/100g)	11.61	14.8	5.13	≥ 5
Calories/Energy (kcal/100g)	72.97	92.1	35.17	≥33.5
Vitamin B_1 (mg/100g)	0.06	NS	0.28	NS
Vitamin B_2 (mg/100g)	ND	NS	ND	NS
Vitamin B_3 (mg/100g)	1.67	NS	1.86	1.0-4
Vitamin B_6 (mg/100g)	1.06	NS	1.40	0.01-0.12
Vitamin B_9 (µg/100g)	0.57	NS	12.59	NS
Vitamin B_{12} (µg/100g)	ND	4.8	ND	0.01 – 0.18
Vitamin C (mg/100g)	6.88	1.9	9.17	≥ 0.012
Calcium (mg/100g)	11.47	43.1	8.93	≥ 20
Iron (mg/100g)	0.08	NS	0.24	NS
Zinc (mg/100g)	0.047	NS	0.037	NS
Phosphorus (mg/100g)	7.23	NS	7.54	NS
Magnesium (mg/100g)	ND	NS	ND	1.0 -10

ND = Not detectable, NS = Not stated on the label

Table 2 shows comparison of the nutrient composition of sample A treatment group at baseline, after 5 and 10 days of sunlight exposure. The result shows that there was significant ($p < 0.05$) decrease in most of the nutrients. About a third (38.9%) of protein was lost by day 10. Carbohydrates increased by 57.9% from 11.61±1.08 to 18.33±0.06 on day 5 and to 18.89 ±0.03 (62.7% increase) by day 10. Moisture, iron and phosphorus significantly ($p < 0.05$) decreased after 5 and 10 days. The rest of the nutrients were depreciated significantly after 5 days, but remained stable after 10 days. After 5 days, Vitamin B_1 decreased by 96.7% from 0.06 mg to 0.002 mg and Vitamin B_9 depleted by 100% from 0.57 mg to 0.00 mg. Calcium and iron reduced by 88.9% and 75% respectively at day 10. Zinc increased insignificantly from 0.047 mg to 0.06 mg. increase in zinc content Vitamins B_2, B_{12} and

magnesium were not found in the samples at baseline analysis.

Table 2: Comparison of nutrient composition per 100g of sample A treatment group at baseline, after 5 days and 10 days of sunlight exposure

Parameters	SA/ BL	SA/T1	SA/T2	Percentage difference at day 5	Percentage difference at day 10
Proximate					
Fat (g)	2.37 [a] ±0.035	1.84 [b] ±0.03	1.84 [b] ±0.04	22.4% ↓	22.4% ↓
Moisture (g)	84.02 [a] ±0.057	78.60 [b] ±0.13	78.14 [c] ±0.04	6.5% ↓	7.0% ↓
Ash (g)	0.70 [a] ±0.01	0.33 [b] ±0.01	0.33 [b] ±0.01	52.9% ↓	52.9% ↓
Protein (g)	1.31 [a] ±0.11	0.90 [b] ±0.02	0.80 [b] ±0.01	31.3% ↓	38.9% ↓
Carbohydrate (g)	11.61 [a] ±1.08	18.33 [b] ±0.06	18.89 [c] ±0.03	57.9% ↑	62.7% ↑
Calories (kcal)	72.97 [a] ±3.56	93.48 [b] ±0.59	95.32 [c] ±0.33	28.1% ↑	30.6% ↑
Vitamins					
B_1 (mg)	0.06 [a] ±0.00	0.002 [b] ±0.00	0.001 [b] ±0.00	96.7% ↓	98.3% ↓
B_3 (mg)	1.67 [a] ±0.01	0.29 [b] ±0.01	0.29 [b] ±0.01	82.6% ↓	82.6% ↓
B_6 (mg)	1.06 [a] ±0.01	0.05 [b] ±0.00	0.04 [b] ±0.00	95.3% ↓	96.3% ↓
B_9 (µg)	0.57 [a] ±0.06	0.00 [b] ±0.00	0.00 [b] ±0.00	100% ↓	100% ↓
Vitamin C (mg)	6.88 [a] ±0.00	2.96 [b] ±0.03	2.97 [b] ±0.04	56.9% ↓	56.8% ↓
Minerals					
Calcium (mg)	11.47 [a] ±1.8	2.56 [b] ±0.01	1.27 [b] ±0.02	77.7% ↓	88.9% ↓
Iron (mg)	0.08 [a] ±0.00	0.03 [b] ±0.00	0.02 [c] ±0.00	62.5% ↓	75% ↓
Zinc (mg)	0.047 [a] ±0.01	0.052 [a] ±0.00	0.06 [a] ±0.00	0.0%	2% ↑
Phosphorus (mg)	7.23 [a] ±0.11	5.60 [b] ±0.03	4.48 [c] ±0.05	22.5% ↓	38.0% ↓

Values are means of duplicate analysis. Mean scores with different superscript letter on the same row differ significantly ($p<0.05$).
SA/BL = Baseline values, SA/T1= Sample A treatment 1 (exposed to sunlight for 5 days), SA/T2= Sample A treatment 2 (exposed to sunlight for 10 days); arrow up = increase; arrow down = decrease.

Table 3 presents data on the comparison of nutrient contents of sample A control groups at baseline, after 5 and 10 days at room temperature. The result shows that most of the nutrients decreased significantly ($p < 0.05$) after 5 days but not after 10 days. Fat, protein, zinc and phosphorus were relatively stable after 5 and 10 days of storage at room temperature. Ash decreased by 34.3% from 0.70 to 0.46 at day 10. Vitamins B_1, B_3, and B_6 depreciated by 50%, 68.2% and 88.7% respectively at day 5. Almost a quarter (24%) of Vitamin C was lost by day 10. Calcium decreased by 74.6% from 11.47 mg to 2.91 mg at day 5 and to 2.57 mg (77.6%) at day 10.

Table 4 presents the comparison of nutrient composition of sample A treatment versus control groups after 5 and 10 days. The samples exposed to sunlight were significantly ($p < 0.05$) lower in all vitamins and minerals than the control group except zinc which was significantly higher in the control at 10 days of exposure. Among the proximate parameters, carbohydrates and calorie contents of the treatment samples were significantly ($p < 0.05$) higher after 5 and 10 days of exposure, while fat, moisture, ash and protein were significantly lower in the samples exposed to sunlight.

Table 3: Comparison of nutrient contents per 100g of sample A control groups at baseline, after 5 and 10 days at room temperature

Parameters	SA/BL	SA/C1	SA/C2	Percentage change at day 5	Percentage change at day 10
Proximate					
Fat (g)	2.37 ^{a} ±0.035	2.37^{a}±0.03	2.35 ^{a} ±0.06	0.0%	0.8% ↓
Moisture (g)	84.02 ^{a} ±0.057	84.82^{b}±0.25	85.16 ^{b} ±0.06	1.0% ↑	1.4% ↑
Ash (g)	0.70 ^{a} ±0.01	0.50 ^{b} ±0.01	0.46 ^{c} ±0.01	28.6% ↓	34.3 ↓
Protein (g)	1.31 ^{a} ±0.11	1.28 ^{a} ±0.01	1.12 ^{a} ±0.01	2.3% ↓	14.5% ↓
Carbohydrate (g)	11.61 ^{ab} ±1.08	11.05^{bc}±0.20	10.90^{c}±0.13	4.8% ↓	6.1% ↓
Calories (kcal)	72.97 ^{ab} ±3.56	70.47^{bc} ±1.10	69.39 ^{c} ±0.03	3.4% ↓	4.9% ↓
Vitamins					
B_1 (mg)	0.06 ^{a} ±0.00	0.03 ^{b} ±0.00	0.03 ^{b} ±0.00	50% ↓	50% ↓
B_3 (mg)	1.67 ^{a} ±0.01	0.53 ^{b} ±0.01	0.51 ^{b} ±0.00	68.2% ↓	69.5% ↓
B_6 (mg)	1.06 ^{a} ±0.01	0.12 ^{b} ±0.00	0.11 ^{b} ±0.00	88.7% ↓	89.6% ↓
B_9 (µg)	0.57 ^{ab} ±0.06	0.53 ^{bc}±0.01	0.43 ^{c} ±0.02	7.0% ↓	24.6% ↓
Vitamin C (mg)	6.88 ^{a} ±0.00	5.72 ^{b} ±0.02	5.23 ^{c} ±0.06	16.9% ↓	24.0% ↓
Minerals					
Calcium (mg)	11.47 ^{a} ±1.8	2.91 ^{b} ±0.05	2.57 ^{b} ±0.02	74.6% ↓	77.6% ↓
Iron (mg)	0.08 ^{a} ±0.00	0.06 ^{b} ±0.00	0.06 ^{b} ±0.00	25% ↓	25% ↓
Zinc (mg)	0.47 ^{a} ±0.01	0.046 ^{a} ±0.00	0.046 ^{a} ±0.00	0.0%	0.0%
Phosphorus (mg)	7.25 ^{a} ±0.11	7.23 ^{a} ±0.04	7.13 ^{a} ±0.01	0.3% ↓	1.7% ↓

Values are means of duplicate analysis. Mean scores with different superscript letter on the same row differ significantly ($p<0.05$). SA/BL= Baseline values, SA/C1= sample A control 1 (stored at room temperature for 5 days), SA/C2= Sample control 2 (stored at room temperature for 10 days)

Table 4: Comparison of nutrient composition per 100g of sample A treatment versus control groups after 5 and 10 days

Parameters	SA/T1	SA/CI	SA/T2	SA/C2
Proximate				
Fat (g)	1.84 ^{a} ±0.03	2.35 ^{b} ±0.03	1.84 ^{y} ±0.04	2.37 ^{z} ±0.06
Moisture (g)	78.60 ^{a} ±0.13	84.82^{b} ±0.25	78.14 ^{y} ±0.04	85.16 ^{z} ±0.06
Ash (g)	0.33 ^{a} ±0.01	0.50 ^{b} ±0.01	0.33 ^{y} ±0.01	0.46 ^{z} ±0.01
Protein (g)	0.90 ^{a} ±0.02	1.28 ^{b} ±0.01	0.80 ^{y} ±0.01	1.12 ^{z} ±0.01
Carbohydrate (g)	18.34 ^{a} ±0.06	11.05 ^{b}±0.20	18.89 ^{y} ±0.03	10.90 ^{z} ±0.13
Calories (kcal)	93.48 ^{a} ±0.59	70.47 ^{b}±1.10	95.32 ^{y} ±0.33	69.39 ^{z} ±0.03
Vitamins				
B_1 (mg)	0.001 ^{a} ±0.00	0.032 ^{b}±0.00	0.002 ^{y} ±0.00	0.03 ^{z} ±0.00
B_3 (mg)	0.29 ^{a} ±0.01	0.53 ^{b} ±0.01	0.29 ^{y} ±0.01	0.51 ^{z} ±0.00
B_6 (mg)	0.05 ^{a} ±0.00	0.12 ^{b} ±0.00	0.04 ^{y} ±0.00	0.11 ^{z} ±0.00
B_9 (µg)	0.00±0.00	0.53 ^{b} ±0.01	0.00 ^{y} ±0.00	0.43 ^{z} ±0.02
Vitamin C (mg)	2.96 ^{a} ±0.03	5.72 ^{b} ±0.02	2.97 ^{y} ±0.04	5.23 ^{z} ±0.06
Minerals				
Calcium (mg)	2.56 ^{a} ±0.00	2.91 ^{b} ±0.05	1.27 ^{y} ±0.02	2.57 ^{z} ±0.02
Iron (mg)	0.03 ^{a} ±0.00	0.06 ^{b} ±0.00	0.02 ^{y} ±0.00	0.06 ^{z} ±0.00
Zinc (mg)	0.047 ^{a} ±0.00	0.046 ^{a}±0.00	0.06 ^{y} ±0.00	0.046 ^{z} ±0.00
Phosphorus (mg)	5.60 ^{a} ±0.03	7.25 ^{b} ±0.04	4.48 ^{y} ±0.05	7.13 ^{z} ±0.01

Values are means of duplicate analysis. Mean scores with different superscript letter on the same row differ significantly ($p<0.05$).
SA/T1= Sample A treatment 1 (exposed to sunlight for 5 days), SA/T2= Sample A treatment 2 (exposed to sunlight for 10 days), SA/C1= Sample A control 1 (stored at room temperature for 5 days), SA/C2= Sample A control 2 (stored at room temperature for 10 days);

Table 5 shows the nutrient composition change in sample B from baseline to days 5 and 10 of sunlight exposure. Ash was not significantly changed after day 5 and slightly increased by 3.1% after 10 days of exposure. Protein significantly ($p < 0.05$) reduced by 50.7% from 0.75% to 0.37% at day 10, while carbohydrate and calorie increased by 70.4% and 27.8% respectively after 10 days of exposure to sunlight. Vitamins B_1, B_3 and B_6 decreased significantly ($p < 0.05$) by 64.2%, 66.7% and 39.3% respectively after 5 days and remained relatively stable by day 10 while Vitamins B_9 and C continued to

depreciate at day 10. After 5 days, Calcium reduced from 8.93 mg to 2.56 mg (71.3% reduction) and iron reduced by 87.5% from 0.24 mg to 0.3 mg while zinc increased by 43.2% after 10 days.

Table 5: Comparison of nutrient composition per 100g of sample B treatment group at baseline, after 5 and 10 days of sunlight exposure

Parameters	SB/BL	SB/T1	SB/T2	Percentage change at day 5	Percentage change at day 10
Proximate					
Fat (g)	1.29^{a}±0.07	0.97^{b}±0.02	0.95^{b} ±0.02	24.8% ↓	34% ↓
Moisture (g)	92.51^{a} ±0.50	91.53^{b} ±0.08	89.62^{b} ±0.03	1.1% ↓	3.1% ↓
Ash (g)	0.32^{a} ±0.01	0.32^{a} ±0.01	0.33^{a} ±0.02	0.0%	3.1% ↑
Protein (g)	0.75^{a} ±0.16	0.45^{bc}±0.05	0.37^{c}±0.01	40% ↓	50.7% ↓
Carbohydrate (g)	5.13^{a} ±0.42	6.74^{b} ±0.16	8.74^{c} ±0.02	31.4% ↑	70.4% ↑
Calories (kcal)	35.17^{a} ±1.68	37.41^{a} ±0.26	44.93^{b} ±0.23	6.4% ↑	27.8% ↑
Vitamins					
B_1 (mg)	0.28^{a} ±0.00	0.10^{b} ±0.23	0.09^{b} ±0.00	64.2% ↓	67.9% ↓
B_3 (mg)	1.86^{a} ±0.03	0.62^{b} ±0.00	0.59^{b} ±0.00	66.7% ↓	68.3% ↓
B_6 (mg)	1.40^{a} ±0.01	0.85^{b} ±0.04	0.84^{b} ±0.18	39.3% ↓	40.0% ↓
B_9 (µg)	12.59^{a} ±0.10	6.64^{b} ±0.07	5.20^{c} ±0.05	47.3% ↓	58.7% ↓
Vitamin C (mg)	9.17^{a} ±0.00	7.54^{b} ±0.04	6.31^{c} ±0.04	17.8% ↓	31.2% ↓
Minerals					
Calcium (mg)	8.93^{a} ±1.61	2.56^{b} ±0.02	2.47^{b} ±0.02	71.3% ↓	72.3% ↓
Iron (mg)	0.24^{a} ±0.01	0.03^{b} ±0.16	0.04^{b} ±0.03	87.5% ↓	83.3% ↓
Zinc (mg)	0.037^{ab} ±0.01	0.048^{bc} ±0.31	0.053^{c} ±0.00	29.7% ↑	43.2% ↑
Phosphorus (mg)	7.54^{a} ±0.12	5.82^{b} ±0.01	4.48^{c} ±0.03	22.8% ↓	40.6% ↓

Values are means of duplicate analysis. Mean scores with different superscript letter on the same row differ significantly ($p<0.05$).
SB/BL = Baseline values, SB/T1= sample B treatment 1 (exposed to sunlight for 5 days), SB/T2= Sample B treatment 2 (exposed to sunlight for 10 days); ND = not detectable

Table 6 below shows the comparison of nutrient composition of sample B control group at baseline, day 5 and day 10 at room temperature. All the proximate, zinc and phosphorus content of the sample remained relatively stable after 5 and 10 days of storage with a slight 4.5% and 2.8% increase in carbohydrate and calorie. There were significant reductions in Vitamins B_1 (57.1%), B_3 (60.8%), B_6 (22.1%), B_9 (41.7%), and C (9.6%) after 5 days. Calcium and iron significantly ($p < 0.05$) depleted by 64.4% and 75% after 5 days and remained stable after 10 days of storage. Zinc decreased by 25% from 0.04 mg to 0.03 mg, but the decrease was not significant.

Table 6: Comparison of nutrient composition per 100g of sample B control group at baseline, day 5 and day 10 at room temperature

Parameters	SB/BL	SB/CI	SB/C2	Percentage change at day 5	Percentage change at day 10
Proximate					
Fat (g)	1.29^{a}±0.07	1.30^{a} ±0.01	1.31^{a} ±0.01	0.8% ↑	1.6% ↑
Moisture (g)	92.51^{a} ±0.50	92.30^{a}±0.05	92.27^{a} ±0.02	0.2% ↓	0.3% ↓
Ash (g)	0.32^{a} ±0.01	0.32^{a} ±0.01	0.32^{a}±0.00	0.0%	0.0%
Protein (g)	0.75^{a}±0.16	0.76^{a} ±0.01	0.76^{a} ±0.01	1.3% ↑	1.3% ↑
Carbohydrate (g)	5.13^{a} ±0.42	5.33^{a}±0.04	5.36^{a}±0.02	3.9% ↑	4.5% ↑
Calories (kcal)	35.17^{a} ±1.68	36.04^{a}±0.30	36.14^{a}±0.16	2.5% ↑	2.8% ↑
Vitamins					
B_1 (mg)	0.28^{a} ±0.00	0.12^{b} ±0.00	0.11^{b} ±0.00	57.1% ↓	60.7% ↓
B_3 (mg)	1.86^{a} ±0.03	0.73^{b} ±0.00	0.72^{b} ±0.01	60.8% ↓	61.3% ↓
B_6 (mg)	1.40^{a} ±0.01	1.09^{b} ±0.03	0.95^{b} ±0.01	22.1% ↓	32.1% ↓
B_9 (µg)	12.59^{a} ±0.10	7.34^{b}±0.29	6.94^{b}±0.09	41. 7% ↓	44.9% ↓
Vitamin C (mg)	9.17^{a} ±0.00	8.29^{b} ±0.04	8.20^{c}±0.01	9.6% ↓	10.6% ↓
Minerals					
Calcium (mg)	8.93^{a} ±1.61	3.18^{b} ±0.07	3.13^{b} ±0.04	64.4% ↓	64.9% ↓
Iron (mg)	0.24^{a} ±0.01	0.06^{b} ±0.00	0.06^{b} ±0.00	75.0% ↓	75.0% ↓
Zinc (mg)	0.04^{a} ±0.01	0.03^{a} ±0.00	0.03^{a} ±0.00	25.0% ↓	25.0% ↓
Phosphorus (mg)	7.54^{a} ±0.12	7.62^{a} ±0.03	7.64^{a} ±0.05	1.1% ↑	1.3% ↑

Values are means of duplicate analysis. Mean scores with different superscript letter on the same row differ significantly (p<0.05).
SB/BL = Baseline values, SB/C1= Sample B control 1 (stored at room temperature for 5 days), SB/C2= Sample B control 2 (stored at room temperature for 10 days); arrow up = increase; arrow down = decrease

Table 7 shows the comparison of nutrient composition of the treatment versus control groups of sample B after 5 and 10 days. The group exposed to sunlight contained significantly ($p < 0.05$) less nutrients than the group stored at room temperature after 5 and 10 days. No significant ($p > 0.05$) difference was found in ash content of the two groups after 5 and 10 days, while the treatment group had significantly ($p < 0.05$) lower Vit. B9 only after 10 days. The group exposed to sunlight contained significantly ($p < 0.05$) more carbohydrate, calories and zinc than the group stored at room temperature.

Table 7: Comparison of nutrient composition per 100g of the treatment versus control groups of Sample B after 5 and 10 days

Parameters	**SB/TI**	**SB/C1**	**SB/T2**	**SB/C2**
Proximate				
Fat (g)	0.97^{a} ±0.02	1.31^{b}±0.01	0.95^{y}±0.02	1.30^{z} ±0.01
Moisture (g)	91.53^{a} ±0.08	92.27^{b} ±0.05	89.62^{y} ±0.03	92.30^{z} ±0.02
Ash (g)	0.33^{a} ±0.01	0.32^{a} ±0.01	0.32^{y} ±0.02	0.32^{y} ±0.00
Protein (g)	0.45^{a} ±0.05	0.76^{b} ±0.01	0.37^{y} ±0.01	0.76^{z} ±0.01
Carbohydrate (g)	6.7^{a} 4±0.16	5.36^{b} ±0.04	8.74^{y} ±0.02	5.33^{z} ±0.02
Calories (kcal)	37.41^{a} ±0.26	36.14^{b} ±0.30	44.93^{y} ±0.23	36.04^{z} ±0.16
Vitamins				
B_1 (mg)	0.10^{a} ±0.23	0.12^{b} ±0.00	0.09^{y} ±0.00	0.11^{z} ±0.00
B_3 (mg)	0.62^{a} ±0.00	0.73^{b} ±0.00	0.59^{y} ±0.00	0.72^{z} ±0.01
B^6 (mg)	0.85^{a} ±0.04	1.09^{b} ±0.03	0.84^{y} ±0.18	0.95^{z} ±0.01
B_9 (µg)	6.64^{a} ±0.07	7.34^{a}±0.29	5.20^{y} ±0.05	6.94^{z} ±0.09
Vitamin C (mg)	7.54^{a} ±0.04	8.29^{b} ±0.04	6.31^{y} ±0.04	8.20^{z} ±0.01
Minerals				
Calcium (mg)	2.56^{a} ±0.02	3.18^{b} ±0.07	2.47^{y} ±0.02	3.13^{z} ±0.04
Iron (mg)	0.03^{a} ±0.16	0.06^{b} ±0.00	0.04^{y} ±0.03	0.06^{z} ±0.00
Zinc (mg)	0.048^{a} ±0.31	0.033^{b} ±0.00	0.053^{y} ±0.00	0.03^{z} ±0.00
Phosphorus (mg)	5.82^{a} ±0.01	7.62^{b} ±0.03	4.48^{y} ±0.03	7.64^{z} ±0.05

Mean scores with different superscript letter on the same row differ significantly (p<0.05). Values are means of duplicate analysis.
SB/T1= Sample B treatment 1 (exposed for 5 days), SB/T2= Sample B treatment 2 (exposed for 10 days), SB/C1= Sample B control 1 (stored for 5 days), SB/C2= Sample B control 2 (stored for 10 days)

DISCUSSION

The nutrition information labels on commercial food products state the nutrients and quantities contained in the products. The information on the labels of the two brands of milk products showed fewer nutrients than the findings of the study. This could be because the manufacturers analyzed and reported only the nutrients of interest to them. Many of the stated nutrients were found in less quantity than were stated, indicating that depletion of nutrients might have started before the samples were analyzed. Bastin (17) observed that soon after production, nutrients in foods begin and continue to decrease until the foods are consumed. In addition, vitamin B_{12} and magnesium which were not found but appeared on the nutrition label of the yoghurt sample may have been lost during production or already depleted before the purchase of the products. Tarar, Ali, Jamil, and Begum (22) observed that boiling milk even for 5 to 10 minutes causes reduction in water soluble vitamins levels.

Nutrients contained in foods such as vitamins and minerals are usually sensitive to exposure to heat, air and light (17,18). Sunlight affects foods and food products through transfer of heat and light rays to the products, both of which have been found to alter the nutrient contents of the food in addition to changes in flavor, colour and texture. There was a significant reduction in the moisture contents of both samples within the 10 days of sunlight exposure compared to the samples stored at room temperature. This could be as a result of evaporation by the heat of the sun. Moisture loss was more evident in the sample packaged with paperboard than the sample in plastic bottle, even when stored at room temperature. Fat and protein were also depleted after five days in both samples as moisture decreased. Another study of effect of heating on fish nutrients found that protein, fat and ash increased as moisture reduced (19). Fats and proteins undergo oxidation on exposure to light, a process known as photooxidation which leads to degradation of the nutrients (20). This degradation could result to loss of the nutrients in addition to causing off-flavour in milk drinks at extreme cases (13).

Ash, which is an indication of total mineral contents of foods decreased in both samples on exposure to light. Much decrease was observed in the yoghurt sample after 5 days of sunlight exposure, but only a slight decrease was observed in flavoured milk drink, after 10 days exposure to sunlight. The yoghurt sample lost considerable amount of ash even under storage while ash content of the flavoured milk drink was relatively stable during storage. These findings further buttress the fact that paper packaging tends to enable evaporation of moisture more than plastic bottle packaging. On the other hand, it could also be that the fermentation process of making yoghurts, affect stability of nutrients after production (21). Bekbolet (13) suggested that paperboard packages would be preferable for greater protection of milk drinks from losing flavour due to exposure to light, when compared with blow-molded plastic containers. It is possible then that paperboard encourages loss of nutrients in products even as it protects from loss of flavour.

Further findings showed that carbohydrate and calorie contents of the products increased within the ten days of exposure at a much higher rate than the control groups. Carbohydrates and calories were calculated by difference methods, which implies that they increase as other proximate parameters decrease. This supports the finding of Olaiya and Karigidi who observed that crude carbohydrate content were significantly increased in tomato and cucumber on exposure to ultraviolet rays (22). This suggests that continuous exposure of milk drinks to sunlight could eventually lead to the products being high in energy content but much less nutritious than originally manufactured. Increase in carbohydrates and calories with remarkable reduction in proteins, vitamins and minerals could have health implications for children as consumers as they might end up consuming empty calories.

Much of the B vitamins and vitamin C were lost in the two samples within five days of the experiment. The samples under room temperature were also depleted, but at a lesser degree than those exposed to sunlight. Vitamins B and C are water soluble, therefore with considerable loss of moisture from the samples, the vitamins tend to reduce. In addition, they are very susceptible to high temperature (19), hence vitamin B_1 in the yoghurt sample reduced by 96.7% and vitamin B_9 was found to be 100% depleted at day 5 of exposure to sunlight while a minimal loss was observed after ten days of room storage. Studies have found that milk exposed to sunlight for as little as one to two hours could lose substantial amount of its nutrients especially vitamins if not well protected from light (15,23). Previous studies found that ultraviolet rays were found to cause loss of Vitamin C in milk (24) and vitamin B_9 (folates) are found to be highly susceptible to sunlight exposure (25). As observed earlier, flavoured milk had less percentage loss of all the vitamins both at storage and during exposure, compared to yoghurt sample, still suggesting processing and packaging differences. Dimari and Hati (26) in a similar study, reported loss of vitamin C in fruit juices packaged in Nigeria and attributed the

loss to temperature, storage method and packaging materials. Noluma (15) also stated that the amount of nutrients lost during exposure of milk drinks to light depends on the type of milk and the container used for packaging the product. Hence, protection from light has become one of the considerations of dairy industries in making choice of packaging materials for commercial drinks (27).

Further findings show that calcium, iron and phosphorus contents of both milk drinks were significantly diminished after five days. Products that were stored at room temperature also lost calcium and iron, but in significantly smaller amount than the samples exposed to sunlight. A study by Anyalogbu et al. (14) also reported that vital minerals such as iron and phosphorus decreased with increase in heat processing time of African walnut. Karimian-khosroshahi (19) also found a decrease in phosphorus after boiling of fish. In another study, exposure of foods to ultraviolet rays caused a reduction in the values of ascorbic acid and all mineral micronutrients except iron (22). Zinc was found to increase in both samples after ten days of sunlight exposure with greater increase in flavoured milk drink than in the yoghurt sample, but remained relatively stable at room temperature. Anyalogbu et al. (14) also found increase in zinc during the heat processing of African walnut.

Sunlight exposure through heat and light, therefore has more adverse effect on the vitamins B and C than on the proximate and mineral contents. This suggests that packaged milk drinks which are not sold off as quickly as possible or stored for long period of time even under room temperature, could lead to loss of nutrients.

CONCLUSION

Commercial milk drinks contain various nutrients which are needed for good health especially among children. However, continuous exposure of the products to sunlight at the point of sales, reduces the nutritive value of the products. Prolonged storage even at room temperature also affected the nutrient content but at lower rate than when exposed. The minerals such as iron and calcium as well as the water-soluble vitamins were more prone to depletion because of their sensitiveness to light and heat. It is therefore important that consumers watch out for the display practices of dealers of commercial drinks when buying, so as to ensure they get value for their money. Additionally, manufacturers need to test packaging containers to determine how much light is reaching and changing the quality of the product.

RECOMMENDATIONS

1. Consumers of commercial milk drinks should watch out for display practices of retailers and ensure that as much as possible, they buy products that are less exposed to sunlight.
2. Government should also establish mobile food safety agency which ensures that manufacturers and marketers of milk drinks and other beverages adhere to practices that prevent loss of nutrients from products.

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