Evaluation of Microbial and Nutritional Values of Commercially Packaged Soymilk Sold in Akure, Nigeria

Oluwole Olakunle Oladele* and Prudent Oseyomon Ofure

Department of Biology, Federal University of Technology, Nigeria

*Corresponding author: Oluwole Olakunle Oladele, Department of Biology, Federal University of Technology, PMB 704, Akure, Nigeria

Abstract
The sale of soymilk is quite popular in Akure but there is no related information on its microbial safety and nutritional status.

Objectives: To determine the microbial and nutritional values of selected commercially packaged soymilk sold in Akure, Nigeria.

Materials and methods: The branded samples were coded HL, GD, VT and SF while a soymilk locally produced (unbranded) served as control. Microbial counts and isolation was carried out using pour plate technique. Microbial count was carried out with a digital colony counter (Gallenkamp model). Morphological and biochemical characteristics were used in the identification of bacteria isolates while fungal isolates were identified based on their cultural morphology and microscopy.

Results: Results showed that the bacterial counts (x10¹ cfu/ml) of branded samples which ranged from 0.00 ± 0.00 in VT to 0.80 ± 0.70 in GD were not significantly different (p > 0.05) from each other but significantly different (< 0.05) from the unbranded samples (20.00 ± 0.40). However, there was no fungi growth in all the branded samples but the unbranded recorded fungi count of 18.00 ± 0.08 x 10¹ sfu/ml. Similarly, there was no coliform growth in both the branded and unbranded samples. The probable bacterial isolates in both branded and unbranded samples were Lactobacillus sp and Bacillus sp while the only fungi isolate was Rhizopus sp in the unbranded.

Conclusion: Remarkably, absence of coliforms in both the branded and unbranded samples and the microbial load obtained which did not exceed the acceptable limit (3 x 10⁴ cfu/ml) for pasteurized milk suggests good manufacturing practices in the production of the soymilk samples. Consequently, industries producing soymilk and soymilk vendors should follow suit in ensuring that their products are consistently produced hygienically with regards to quality control measures to avoid microbial contaminants.

Keywords
Soymilk, Branded, Unbranded, Microbial, Nutritional, Public health

Introduction
Soyabean (Glycine max) is incorporated into so many food formulation for both children and adults to enhance nutritional value of foods [1], in preparations such as “dawadawa”, allele, moi-moi, akara, soy-ogi and most recently as soymilk [2] which is a high protein, iron-rich milky liquid produced from pressing ground, cooked soybeans [3]. The milk which is a white or creamy emulsion resembles cow milk in both appearance and consistency [4].

The diets of people in many developing countries lack animal sources of proteins such as milk which are expensive and out of reach for low income families. Hence, soymilk which is a cheap source of protein is therefore used to supplement such diets. Soybeans and products derived from them have served as an important source of protein in the diet of millions of oriental people for nearly 5,000 years [5]. In fact, the increasing popularity of soymilk is credited to health benefits and being a good alternative to animal protein [6]. Besides, it is a good nutrient for vegetarian diet [7].

Nevertheless, soymilk can also serve as a source for transmitting food borne infections. In addition to poor handling and unhygienic practices of local producers of soymilk products, the nutrient composition of soymilk makes it an excellent bacteriological medium [1]. Bacterial pathogens identified with food poisoning, gas-
troenteritis and enteric fever can be harbored in soy-
milk that was not hygienically prepared [4]. Hence, this
study was carried out to assess microbial and nutritional
status of selected commercially packaged soymilk sold
in Akure, Nigeria.

Materials and Methods

Source and collection of sample

Four selected commercially branded soymilk sam-
ples were obtained from super markets and stores in
Akure metropolis, Ondo state, Nigeria. The branded
samples were designated HL, GD, VT and SF while a soy-
milk locally produced (unbranded) served as control.
They were then taken to the Department of Biology lab-
atory, Federal University of Technology, Akure, Nige-
ria and preserved at 4 °C for microbial and proximate
analyses.

Counting and isolation of microorganisms

Pour-plate technique was used for microbial counts
and isolation. One ml of each soymilk sample was seri-
ally diluted to x10^4 dilution factor and 1 ml of the dilu-
tion factor was then pipetted aseptically into a sterilized
Petri-dish. This was followed by the pouring of already
prepared sterilized molten nutrient agar and potato
dextrose agar media for bacteria and fungi counts re-
spectively. The Petri dish was later incubated at 37 °C
for 24 h (bacteria) and 28 ± 2 °C for 72 h (fungi) after
being allowed to solidify. After 24 h, bacteria count was
washed, dried and weighed. About 20 ml of the soymilk sample was measured out and fur-

The method of Pearson [8] was used to determine the moisture content of the soymilk samples. The
weight of an empty aluminium dish can (W0) was deter-
mained before the sample was introduced into it. About
20 ml of the soymilk sample was measured out and fur-
ther weighed (W1) in the aluminium dish can. The alu-
ninium dish can was then dried in a hot air oven for 24
hours and cooled in a dessicator and weight (W2) mea-
sured. Percentage of moisture content was determined
as follows:

\[
\text{Percentage of moisture content} = \frac{(W_1 - W_0) - (W_2 - W_0)}{(W_1 - W_0)}
\]

Where:

- W0 = Weight of empty moisture can
- W1 = Weight of moisture can and sample
- W2 = Weight of dessicated sample

\[
(W_1 - W_0) - (W_2 - W_0) = \text{Weight loss}
\]

\[
(W_1 - W_0) = \text{Weight of sample}
\]

Also, standard methods according to AOAC [9] were
used to determine protein, ash, fat, fibre and carbohy-
drate contents of the soymilk samples. Crude protein
of the soymilk sample was determined using Kjeldahl
method. For digestion at high temperature, 10 ml of
concentrated sulfuric acid and 1.1 g digestion mixture
were added to 0.5 g of the soymilk sample in digestion
tube. Then the digestion tubes were set in digestion
chamber fixing at 420 °C for 45 minutes. Thereafter, the
digestion tubes were allowed to cool and 5 ml of sodium
thio-sulphate (Na₂S₃O₃, 33%) and 30 ml sodium hydrox-
ide (NaOH) solution was added to the digestion tube.
Then the distilled extraction was collected with 25 ml of
Boric acid (4%) and titrated with standard hydrochloric
acid (0.2N). The nitrogen values obtained was convert-
ed into percentage of crude protein by multiplying with
a factor of 6.25.

Ash content was determined by heating 1 ml of the
soymilk sample inside a weighed crucible in a muffle furn-
ace at 550 °C for 5 h. Crude lipid (fat) was determined
by extracting 3 mls of each soymilk sample with ana-
lytical grade acetone using Soxhlet method. Extraction
was allowed to continue by heating at 70 °C for 3 h. For
fibre content determination, 1 ml of the soymilk sample
was defatted, followed by successive treatment with
boiling solutions of H₂SO₄ and KOH, then, the residue
was filtered, washed, dried and weighed after which it
was ashed in a muffle furnace at 550 °C where the loss in
weight after ashing is the crude fibre content. Amount of
carbohydrate was determined by difference:

\[
100\% - \% \text{ protein + ash + fat + fibre}
\]

Statistical analysis

All experiment was conducted in triplicates. Mi-
crobial counts and proximate values were subjected
to analysis of variance (ANOVA) using SPSS, version
16.0 and where significant, means were separated by
Tukey-posthoc test at p = 0.05.
Results

The result of the microbial counts of the soymilk samples is presented in Table 1. Bacterial counts ($\times 10^1$ cfu/ml) of the branded samples were not significantly different ($p > 0.05$) from one another. The least count (0.00 ± 0.00) occurred in VT while the highest count (0.80 ± 0.70) occurred in GD. However, these counts were significantly different ($p < 0.05$) from the unbranded samples (20.00 ± 0.40). Meanwhile, there was no fungi

<table>
<thead>
<tr>
<th>Soymilk samples</th>
<th>Sample code</th>
<th>Bacterial count $\times 10^1$ cfu/ml</th>
<th>Fungi count $\times 10^1$ sfu/ml</th>
<th>Coliform count $\times 10^1$ cfu/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branded</td>
<td>HL</td>
<td>0.50 ± 0.70a</td>
<td>0.00 ± 0.00a</td>
<td>0.00 ± 0.00a</td>
</tr>
<tr>
<td></td>
<td>GD</td>
<td>0.80 ± 0.70a</td>
<td>0.00 ± 0.00a</td>
<td>0.00 ± 0.00a</td>
</tr>
<tr>
<td></td>
<td>VT</td>
<td>0.00 ± 0.00a</td>
<td>0.00 ± 0.00a</td>
<td>0.00 ± 0.00a</td>
</tr>
<tr>
<td></td>
<td>SF</td>
<td>0.50 ± 0.70a</td>
<td>0.00 ± 0.00a</td>
<td>0.00 ± 0.00a</td>
</tr>
<tr>
<td>Unbranded</td>
<td>LOCAL</td>
<td>20.00 ± 0.40b</td>
<td>18.00 ± 0.08b</td>
<td>0.00 ± 0.00a</td>
</tr>
</tbody>
</table>

Each value is a mean of triplicate determination ± SE and means having the same letter in the column are not significantly different ($p > 0.05$) by Tukey test at $\alpha = 0.05$.

Note: HL, GD, VT and SF = codes for branded soymilk samples.

Table 2: Identities of bacterial isolates found associated with the soymilk samples.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Morphological and Biochemical Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour of colony</td>
<td>Yellowish, Whitish</td>
</tr>
<tr>
<td>Elevation of colony</td>
<td>Raised, Flat</td>
</tr>
<tr>
<td>Edge of colony</td>
<td>Entire, Crenated edge</td>
</tr>
<tr>
<td>Texture of colony</td>
<td>Smooth, Smooth</td>
</tr>
<tr>
<td>Size of colony</td>
<td>Medium, Large</td>
</tr>
<tr>
<td>Gram's reaction</td>
<td>+, +</td>
</tr>
<tr>
<td>Shape of colony</td>
<td>Circular, Circular</td>
</tr>
<tr>
<td>Shape of cells</td>
<td>Rod, Rod</td>
</tr>
<tr>
<td>Catalase</td>
<td>+, -</td>
</tr>
<tr>
<td>Coagulase</td>
<td>-, -</td>
</tr>
<tr>
<td>Glucose</td>
<td>-, +</td>
</tr>
<tr>
<td>Galactose</td>
<td>-, +</td>
</tr>
<tr>
<td>Sucrose</td>
<td>-, +</td>
</tr>
<tr>
<td>Lactose</td>
<td>-, +</td>
</tr>
<tr>
<td>Likely Organisms</td>
<td>Lactobacillus sp, Bacillus sp</td>
</tr>
</tbody>
</table>

Key: + = Positive or present
- = Negative or absent

Table 3: Occurrence of microorganisms in soymilk samples.

<table>
<thead>
<tr>
<th>Soymilk samples</th>
<th>Sample code</th>
<th>Bacterial isolates</th>
<th>Fungi isolate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lactobacillus sp</td>
<td>Bacillus sp</td>
</tr>
<tr>
<td>Branded</td>
<td>HL</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>GD</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>VT</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>SF</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Unbranded</td>
<td>LOCAL</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

HL, GD, VT and SF = codes for branded Soymilk samples.

Note:
+ = Positive or present
- = Negative or absent
growth in all the branded samples but the unbranded recorded fungi count (18. 00 ± 0.08 × 10³ sfu/ml) that was also significantly different (p < 0.05). Interestingly, there was no coliform growth in all the samples.

Various bacteria isolates from both the branded and unbranded samples are presented in Table 2 and were \textit{Lactobacillus} and \textit{Bacillus} while \textit{Rhizopus} was the only fungal isolate from unbranded samples (Table 3).

The result of the pH values is shown in Table 4 and ranged between 7.2 in VT to 7.9 in the unbranded while Table 5 showed the proximate compositions of the soymilk samples. The moisture contents (%) of all the branded and the unbranded samples were not significantly different (p < 0.05) and ranged from 77.90 ± 0.73 in VT to 79. 00 ± 0.00 in the unbranded while protein contents (%) of the branded (except GD) and the unbranded samples were also not significantly different (p < 0.05) and ranged from 2.01 ± 0.10 in GD to 3.07 ± 0.73 in HL. Similarly, fat content (%) of the branded (aside GD and SF) and the unbranded were not significantly different (p < 0.05) and ranged from 1.76 ± 0.73 in SF to 3.00 ± 0.00 in VT. Meanwhile, the fibre content (%) for both branded and unbranded samples was 0.00 ± 0.00. Ash content (%) in both branded and unbranded samples were also not significantly different (p < 0.05) and ranged from 0.29 ± 0.01 in HL to 0.38 ± 0.08 in SF. In the same vein, there was no significant difference in the carbohydrate contents of both the branded (except VT and SF) when compared with the unbranded samples and the values ranged from 5.83 ± 0.88 in GD to 11.67 ± 0.33 in VT.

### Table 4: pH of soymilk samples.

<table>
<thead>
<tr>
<th>Soymilk samples</th>
<th>Sample code</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branded</td>
<td>HL</td>
<td>7.3</td>
</tr>
<tr>
<td></td>
<td>GD</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>VT</td>
<td>7.2</td>
</tr>
<tr>
<td></td>
<td>SF</td>
<td>7.3</td>
</tr>
<tr>
<td>Unbranded</td>
<td>LOCAL</td>
<td>7.9</td>
</tr>
</tbody>
</table>

\textbf{Note:} HL, GD, VT and SF = codes for branded soymilk samples.

### Table 5: Proximate compositions of soymilk samples.

<table>
<thead>
<tr>
<th>Soymilk Samples</th>
<th>Sample code</th>
<th>Moisture content (%)</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Fibre (%)</th>
<th>Ash (%)</th>
<th>CHO (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branded</td>
<td>HL</td>
<td>78.01 ± 0.07a</td>
<td>3.07 ± 0.73b</td>
<td>2.63 ± 0.88b</td>
<td>0.00 ± 0.00a</td>
<td>0.29 ± 0.01a</td>
<td>5.93 ± 0.67a</td>
</tr>
<tr>
<td></td>
<td>GD</td>
<td>78.00 ± 0.00a</td>
<td>2.01 ± 0.10a</td>
<td>1.78 ± 0.88a</td>
<td>0.00 ± 0.00a</td>
<td>0.30 ± 0.11a</td>
<td>5.83 ± 0.88a</td>
</tr>
<tr>
<td></td>
<td>VT</td>
<td>77.90 ± 0.73a</td>
<td>3.00 ± 0.11b</td>
<td>3.00 ± 0.00c</td>
<td>0.00 ± 0.00a</td>
<td>0.30 ± 0.05a</td>
<td>11.67 ± 0.33c</td>
</tr>
<tr>
<td></td>
<td>SF</td>
<td>78.00 ± 0.00a</td>
<td>2.73 ± 0.67b</td>
<td>1.76 ± 0.88a</td>
<td>0.00 ± 0.00a</td>
<td>0.35 ± 0.08a</td>
<td>7.06 ± 0.67b</td>
</tr>
<tr>
<td>Unbranded</td>
<td>LOCAL</td>
<td>79.00 ± 0.00a</td>
<td>3.00 ± 0.00b</td>
<td>2.73 ± 0.67bc</td>
<td>0.00 ± 0.00a</td>
<td>0.30 ± 0.00a</td>
<td>5.93 ± 0.67a</td>
</tr>
</tbody>
</table>

Each value is a mean of triplicate determination ± SE and means having the same letter in the column are not significantly different (p > 0.05) by Tukey test at α = 0.05.

\textbf{Note:} HL, GD, VT and SF = codes for branded Soymilk samples.

### Discussion

From the results, it was observed that both the bacterial and fungal loads in the unbranded samples were higher than the branded. This observation was supported by the work of Adeleke, et al. [10] that branded soymilk samples purchased from selected markets in Ibadan had lower microbial counts than the unbranded samples. Although the observation contradicted the work of Adebayo-Tayo, et al. [4] who reported higher microbial population in branded samples than the unbranded samples. The contradiction unarguably may be as a result of the fact that Adebayo-Tayo, et al. [4] work on powdered soymilk samples while this work investigated already prepared liquid soymilk samples. Again, the observed microbial load in this study must have been influenced by pH as buttressed by Adeleke, et al. [10] that pH favours bacteria growth.

Meanwhile, absence of coliform growth observed in this work was consistent with the work of Adebayo-Tayo, et al. [4] who equally detected no coliforms in their soy milk samples. The various bacteria isolates from both the branded and unbranded were \textit{Lactobacillus} and \textit{Bacillus} while the only fungal isolate from the unbranded samples was \textit{Rhizopus}. This observation contradicts the earlier works of Soomro [11] who reported the presence of \textit{Staphylococcus aureus} in samples obtained from different locations in India. In a similar work on microorganisms associated with locally processed milk products (nono and Wara) at Ilorin, \textit{E. coli}, and \textit{Staph. aureus} were also isolated [12]. Similarly, none of these bacterial isolates was identified in soymilk on sale in Makurdi as reported by Liannege, et al. [13].

Nevertheless, Ozoh and Umeakwu [14] in their own work identified \textit{Bacillus sp} and \textit{Rhizopus}. In the same vein, Mbajjuka, et al. [15] also reported similar isolates of \textit{Bacillus cereus} and \textit{Lactobacillus} species in soymilk. The occurrences of \textit{Bacillus sp}. can be said to be as a result of prevalence of their spores in the environment. \textit{Bacillus} species are spore formers whose spores could survive high temperatures of processing. \textit{Bacillus} has equally been isolated from non-alcoholic beverages [16,17]. Likewise, the presence of \textit{Rhizopus sp} could not
but be connected with contamination from the environment. This observation was supported by the report of Arotupin, et al. [18] that environmental contamination was responsible for the presence of Aspergillus niger, Aspergillus flavus and Rhizopus sp. since their spores are common contaminants.

Remarkably, the microbial population obtained in both branded and unbranded samples in this work was below the acceptable limit of $2.0 \times 10^4$ cfu/g recommended for general bacterial count by the Soy Foods Association of America (SFAA) and did not also exceed the acceptable limit for pasteurized milk ($3 \times 10^4$ cfu/ml). Besides, the absence of E. coli in this work suggests non faecal contamination of the soymilk samples and consequently renders the liquid drink fit for consumption because a large number of microorganisms such as mesophilic aerobic bacteria, coliforms and fungi, are known to be responsible for the spoilage of soymilk, producing undesirable changes [19,20].

Proximate results showed that all the soymilk samples had high moisture contents and this is because soymilk is an emulsion containing high water and water soluble proteins, carbohydrate and oil droplets [3]. Although the protein values observed in this work was lower than 7.78-10.47% reported by Ozoh and Umeakwu [14] in ready to drink soy milk sold in Onitsha while the fat content was higher than 1.44% reported by Ozoh and Umeakwu [14], also in ready to drink soy milk sold in Onitsa. Meanwhile, the fibre content obtained in this work was the same as the one earlier obtained by Onuorah, et al. [21]. The ash content falls within the range of values (0.27-0.57%) for ash contents of ready to drink soyabean milk sold at different locations in Makurdi metropolis. This has further showed that soymilk is highly nutritional and in agreement with Adebayo-Tayo [4] that soymilk samples have a high nutritional value, excellent food for man, and also provides an excellent growth medium for microorganisms. In fact, the increase in the consumption rate of soybean milk cannot but be connected to its high protein content which has encouraged low scale production of the soymilk under house hold condition with little or no regard to the quality control measures [22].

Conclusion

The result of the study revealed that the soymilk samples had no fungi count and lesser bacterial count below the acceptable limit as established by regulatory agency. Consequently, industries producing soymilk and other soymilk vendors should follow suit in ensuring that their products are consistently produced hygienically with regards to quality control measures to avoid microbial contaminants. Interestingly, absence of coliforms in both branded and unbranded samples was another index of good manufacturing practice in the production of the soymilk samples.

Acknowledgement

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Competing Interests

The authors declare no conflict of interest.

Author’s Contributions

Oluwole Olakunle Oladele and Prudent Oseyomon Ojure designed the research concept, performed data analysis and interpretation, reviewed and approved the final version of the article.

References

15. Mbajiuka CS, Obeagu EI, Ifediora AC, Ugwu GU (2014) 
Isolation and identification of microorganisms involved in 

ico-chemical evaluation of some non-alcoholic beverages. 

17. Amusa NA, Ashaye OA, Ayegbayo AA, Oladapo MO, On-
imO, et al. (2005) Microbiological and nutritional quality 
of hawked sorrel drinks (Zoborodo) (the Nigerian locally 
brewed soft drinks) widely consumed and notable drinks in 

quality of selected commercially packaged chocolaty bev-

19. Agboke AA, Uduma E, Osonwa C, Emmanuel O, Ibezim C 
(2011) Evaluation of microbiology quality of some soybean 

20. Arekemase MO, Babashola DR (2019) Assessment of the 
effectiveness of Ginger (Zingiber officinale), Clove (Syzyg-
ium aromaticum) and sodium benzoate on the shelf life of 

physicochemical evaluation of soymilk and soya cake pro-
duced by three different methods. Nig Food J 34: 2-5.

22. Chukwu A (2012) Instability of pharmaceutical products in 
the tropics. In A text book of pharmaceutical technology 
and industrial pharmacy, Ofoeule, SI ed. Samakin Enter-
prises, Lagos, Nigeria. 234-255.