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Effect of Storage Conditions on the Microbiological and Sensory Properties of Maize-Soy Flour Blend and "*Agidi*"

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Abstract
This study examined the effect of storage conditions on maize-soy flour blend. Preliminary research was conducted using ratio blends of 100:0 to70:30 of maize flour to Soy flour in order to ascertain the best blend formulation for the study. The sensory attributes showed that the ratio 85:15 maize-soy flour blend was preferred. It was packaged in LDPE and HDPE then stored at 30.5 ± 3 °C and relative humidity of 57 and 82 % for 4 months. Packaging significantly ($p > 0.05$) affected the microbiological and sensory qualities of "soy-fermented maize" flour during storage. Microbiological quality of the soy-fermented maize flour decreased significantly ($p > 0.05$) from 77 – 0.63 x 10^3. There was also a decrease in the sensory parameters of the *Agidi* produced from soy-fermented maize flour. Appearance ranged from 6.15 – 5.05, Aroma 5.70 – 4.50, Taste 6.00 – 4.45 and general acceptability 6.15 – 4.85. The samples packaged in HDPE were more acceptable than other packaging materials.

Keywords: storage, *Agidi*, maize-soy flour, low-density polyethylene, and high-density polyethylene

1. Introduction
Agidi is a local West African dish (mostly in Nigeria) made from fermented maize, sorghum or millet known as *Ogi* which is one of the popular products consumed widely in Nigeria. It is a fermented starchy mash obtained by soaking, wet milling, wet extraction (filter) and decanting of surface water to obtain *Ogi* [1]. *Ogi* is cooked with water to produce a semi-solid product called *Agidi* which is also known as *Eko* [1]. *Agidi* can be eaten alone or with vegetable soup and/or stew as well as with Moi-Moi or Akara (steamed or fried bean cake) by both infants and adults. *Agidi* has added advantage over *Ogi*, as it could be eaten either cold or warm. It could also be prepared and kept for later use, unlike *Ogi* which should be consumed warm, thereby requiring fresh preparation. Traditionally, during the preparation of *Ogi*, the grains are soaked in water for three days before wet milling, sieving and allowing to ferment for three days until sour. It is then boiled as pap, or cooked into a semi-solid product called *Agidi*. Its appearance or color depends on the type of cereal used for production [2].
Earlier attempts were geared towards improving the nutritional quality of this maize-based product "*Ogi*" but not much was found for *Agidi* [3]. *Agidi* is quite low in protein because it is mostly composed of starch. Overconsumption of such a product could lead to problems generally associated with protein malnutrition [4]. Due to its low protein content, soybean was added to improve the nutritional composition and to also add value to *Agidi*, because it is a cheap and available source of protein. Soybean is a versatile crop with many uses and among its products are soymilk, soy-cake, ice cream, and soybean vegetable oil. As a proteinous food, soybean is much better than any other legume in terms of protein quality. The protein content of other legumes varies from 20 – 25 % while that of soybean is about 39 % [5]. The meal is rich in mineral elements and vitamins such as thiamin, riboflavin, and niacin.
The storage of maize-soy flour is necessary due to the tedious and cumbersome unit operations required for the production of the flour. Storage of maize-soy flour for *Agidi* production is rare in other research articles on *Agidi* production. Thus the storage of the flour was carried out in order to ascertain the quality of the stored maize-soy flour overtime in producing *Agidi* with respect to its nutritional and sensory properties as the nutrients depreciate over time.
This study was geared towards assessing the effects of storage on the quality of maize-soy flour blends and the *Agidi* product.

2. Materials and Methods
2.1 Procurement of materials
Maize (*Zea mays*) and Soybean (*Glycine max*) seeds used in this study were purchased from the Teaching and Research Farm of the College of Agronomy, University of Agriculture Makurdi, Benue State Nigeria.

2.2 Sample Preparation
2.2.1 Preparation of fermented maize flour
The fermented maize flour was prepared by the wet milling process with slight modification [6-8]. The maize grains were sorted and cleaned to remove broken grains and foreign objects. The grains were soaked in water for 2 days. The soaked grains were wetly milled in a commercial maize mill and filtered through cheesecloth with excess water. The slurry obtained was left to sediment and ferment for 3 days at room temperature (27 ± 2 °C). The water was decanted and the paste obtained was dried for two days in an oven (GENLAB, England B6S, serial no: 85K054) (GENLAB, England B6S, serial no: 85K054) set at 60 °C. The dried sample was milled into flour in a maize mill (Model Corona - 2N, England) and stored in a refrigerator at 4 °C after sieving (150 µm).

2.2.2 Preparation of soy flour
The soy flour was prepared according to the method reported by [9, 10] with slight modification. Soybean seeds were sorted and soaked in water for 12 hours. Thereafter, the seeds were dehulled, washed, drained, boiled for 120 minutes and dried at 60 °C for 9 hours. The dried seeds were milled into flour. The flours were screened through a 0.25 mm sieve and stored at 4 °C in a refrigerator to prevent spoilage particularly rancidity until usage.

2.2.3 Preparation of soy-*Agidi*
Agidi was prepared according to the method reported by [11] with slight modification. 100 g of maize-soy flour was mixed with 700 ml of cold water. The mixture was heated with low heat and continue stirring for 15 minutes until it became completely thickened. The *Agidi* was poured into smaller plates and allowed to cool and solidify for 1 – 3 hours.

2.3 Storage Studies
The samples (85:15 of maize-soy flour blend) were packaged in low-density polyethylene film and high-density polyethylene film then stored in two desiccators with relative humidity of 82 % and 57 % and placed in a room at ambient temperature (32 ± 2 ºC) for 24 weeks. Samples were withdrawn at four (4) weeks intervals to analyze the moisture content, fungi count and sensory attributes of the maize-soy flour and *Agidi* product.

2.4 Microbiological Analysis
Yeast and Mold count of fresh and stored samples were determined by the pour plate method as described by [12]

2.5 Sensory Evaluation
"*Agidi*" samples were prepared and presented to a twenty-member panel comprising of staff and students of the Department of Food Science and Technology. The "*Agidi*" samples were evaluated in terms of appearance (color), taste, texture and overall acceptability. These attributes were evaluated on a 7 point descriptive hedonic scale [13]

2.6 Statistical Analysis
All the data obtained were reported as means of triplicates with standard deviation, variance and regression analysis. SPSS version 25 statistical package was used.

3. Results and Discussion
3.1 Effect of storage conditions on the Fungi count of maize-soy flour blend
The initial fungi count of fresh soy supplemented maize flour was 7.7 x 10^4 CFU/g as shown in Table 1. The microorganisms found in the flour include *Mucor*, *Aspergillus niger*, *Aspergillus flavus*, and *Aspergillus fumigatus*.

There was an initial increase in Fungi count during the first month of storage and a steady decrease was observed within the subsequent months. Samples with no packaging material at a relative humidity of 57 % had less decrease in fungi count while samples with high-density polyethylene had a higher decrease as shown in Fig 4. The lowest decrease for fungi at relative humidity of 82 % was recorded in samples with no packaging materials and highest decrease was observed in samples with high-density polyethylene (Figure 5).

For samples with low-density polyethylene, at relative humidity of 57 % samples were observed with the lowest fungi count values after storage while samples stored at relative humidity of 82 % had higher fungi count (Figure 6).

For samples with high-density polyethylene, the samples at relative humidity of 82 % were recorded with the lowest fungi count values after storage while samples stored at relative humidity of 57 % had higher fungi count (Figure 7).

For samples with no packaging material, at a relative humidity of 82 % samples were observed to have the lowest fungi count values after storage while samples stored at relative humidity of 57 % had higher fungi count (Figure 5).

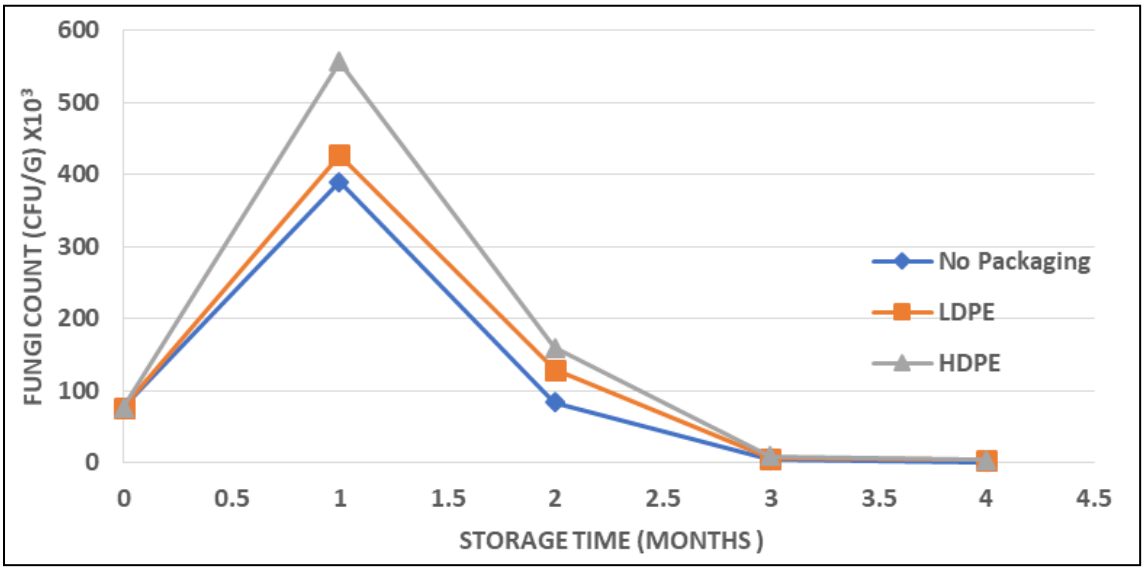

Fig 1: Effect of storage conditions on the Fungi count of soy supplemented maize flour blend at a relative humidity of 57 %

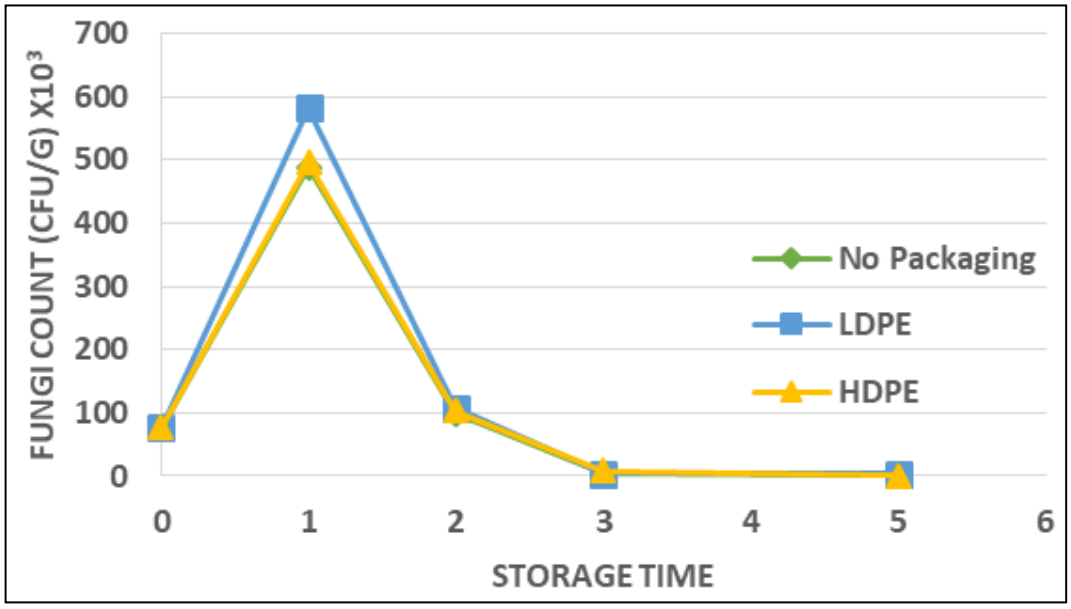

Fig 5: Effect of storage conditions on the Fungi count of soy supplemented maize flour blend at a relative humidity of 82 %

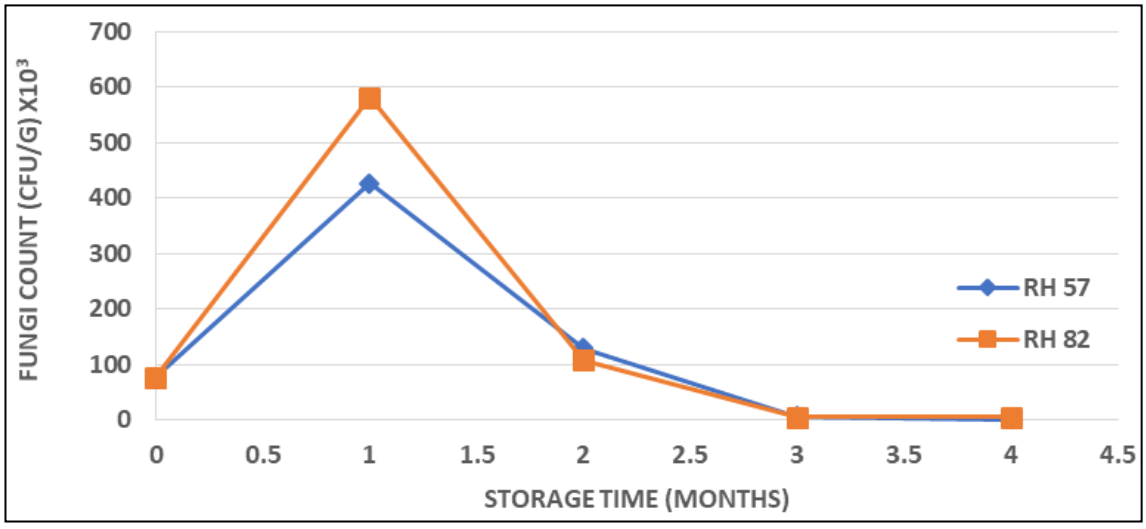

Fig 6: Effect of storage conditions on the Fungi count of soy supplemented maize flour blend at a relative humidity of 57 % and 82 % with LDPE

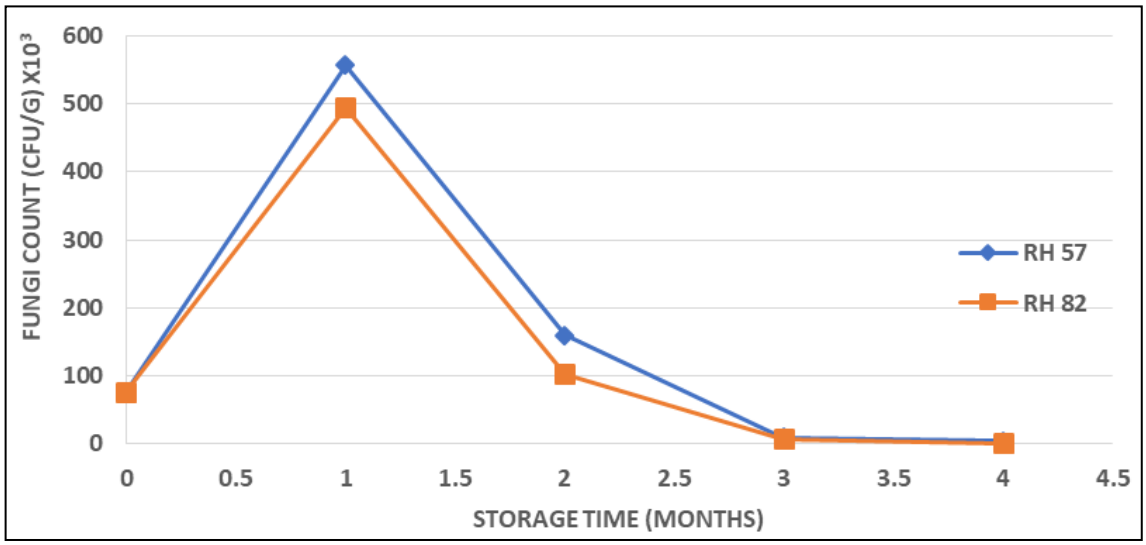

Fig 7: Effect of storage conditions on the Fungi count of soy supplemented maize flour blend at a relative humidity of 57 and 82 % with HDPE

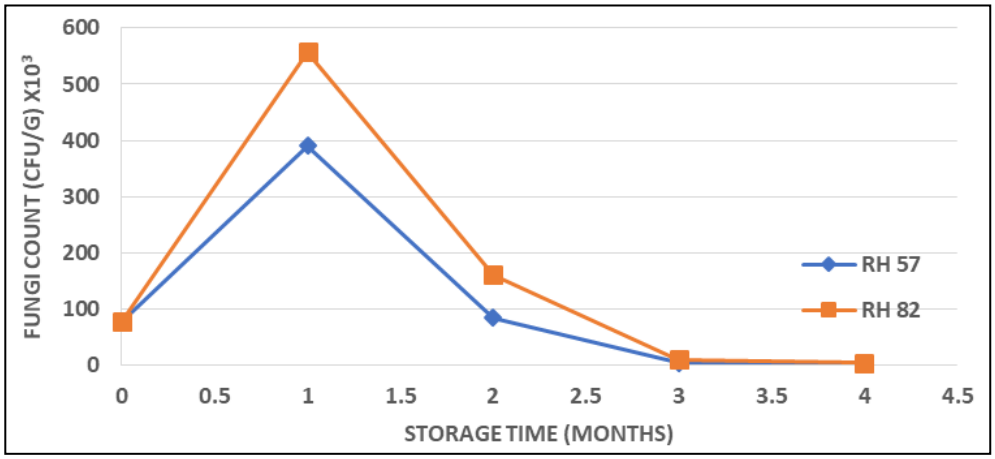

Fig 8: Effect of storage conditions on the Fungi count of soy supplemented maize flour blend at relative humidity for 57 and 82 % with no packaging Material

The initial drastic reduction recorded in the total fungi counts (for month one) may be attributed to the effects of processing (boiling, stirring, cooking at 78 ± 2.5 °C). While the subsequent rapid microbial proliferation during storage may be due to nutrient availability and favorable microenvironment with the resultant recovery of homeostatic imbalance [14, 15] The fungi count then decreased during the remaining months of storage. These results were contrary to the result obtained by [16] where a steady increase in fungi count in packaged yam-cassava "Poundo" flour was observed for 24 weeks but was in agreement with [17] where a steady decrease in fungi count was recorded in *Agidi* produced from maize for 8 weeks. This decrease is due to the decrease in nutrients during storage.

3.2 Effect of Storage Conditions on the Sensory Attributes of Maize Flour Blend

The sensory evaluation for fresh soy supplemented maize flour had initial values of 6.05, 5.75, 5.90 and 6.05 for appearance, aroma, taste and general acceptability respectively as shown in Figures 9 and 10.

After the first month, at relative humidity of 57 % the sensory evaluation values were appearance – 6.15, 5.80 and 5.60, aroma – 5.70, 5.80 and 5.70, taste – 6.00, 5.90 and 5.50 and general acceptability mean scores were 6.15, 5.70 and 5.60 for low-density polyethylene, high-density polyethylene, and no packaging material respectively. For month two appearance mean scores were 5.20, 5.05 and 5.10, aroma 5.15, 5.05 and 4.90, taste 5.00, 5.10 and 4.85 and general acceptability 5.10, 5.25 and 4.90. For the third month the values were appearance 5.65, 5.60 and 5.30, for aroma 5.35, 5.40 and 5.40, for Taste 4.55, 4.45 and 4.50 and for general acceptability 5.45, 5.30 and 5.20. For the fourth month appearance mean scores were 5.20, 5.05 and 5.10, aroma 5.15, 5.05 and 4.90, taste 4.55, 4.45 and 4.50 and general acceptability 5.10, 5.25 and 4.90 for low-density polyethylene, high-density polyethylene and no packaging materials, respectively, as shown in Figure 9.

While For relative humidity of 82 % the sensory evaluation after the first month was appearance- 5.35, 5.50 and 5.16, aroma 5.25, 5.20 and 5.40, taste 5.25, 5.45 and 5.15 and general acceptability mean scores were 5.10, 5.00 and 5.05. For month two appearance mean scores were 5.10, 5.05 and 5.05 aroma 5.00, 4.75 and 4.90, taste 4.80, 4.90 and 4.60 and general acceptability 5.10, 5.15 and 4.85. For the third month mean scores were appearance 5.40, 5.60 and 5.65, for aroma 5.25, 5.10 and 5.10, for taste 4.50, 4.80 and 4.85 and for general acceptability 5.10, 5.40 and 5.45. For the fourth month the mean score for appearance was 5.10, 5.05 and 5.05, aroma 5.00, 4.75 and 4.90, Taste 4.50, 4.80 and 4.90 and general acceptability 5.15, 5.10 and 4.85 for low-density polyethylene, high-density polyethylene and no packaging materials respectively (Figure 10).

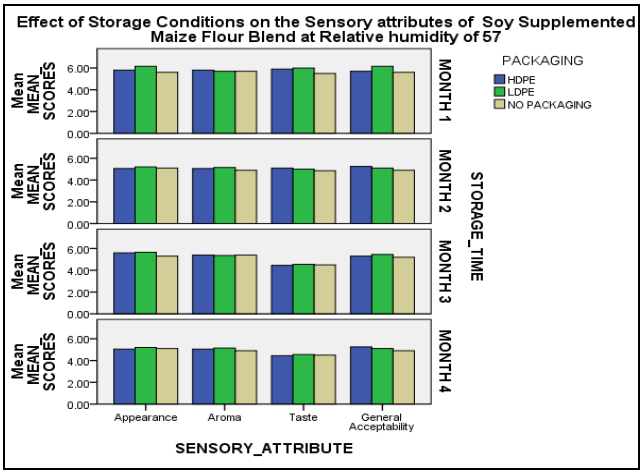

Fig 9: Effect of storage conditions on the sensory attributes of soy supplemented maize flour blend at a relative humidity of 57 %

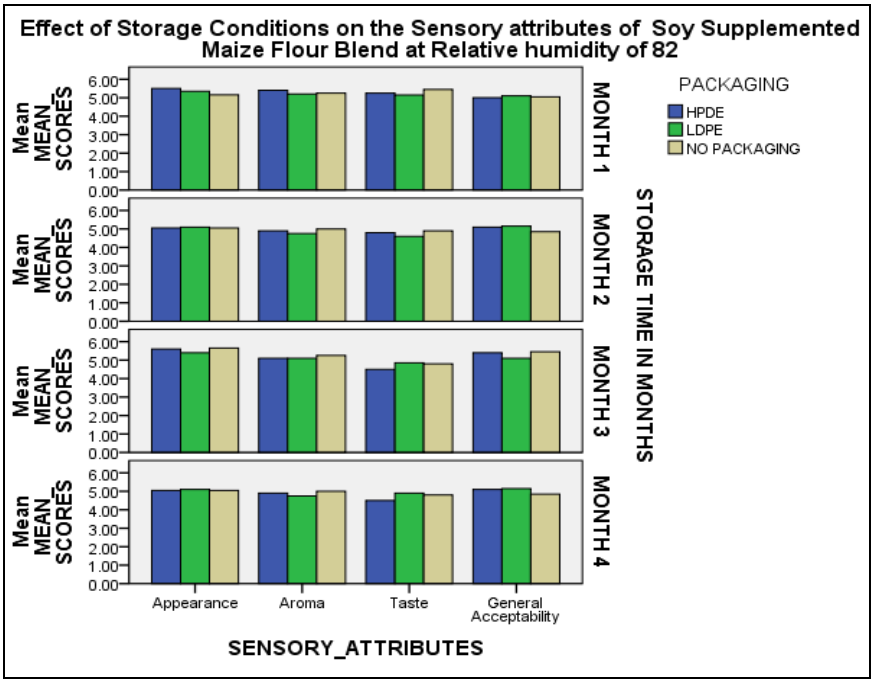

Fig 10: Effect of storage conditions on the sensory attributes of soy supplemented maize flour blend at a relative humidity of 82 %

There was a steady decrease in the sensory attributes as observed in months three and four of storage (Figures 9 and 10) for both relative humidities. Samples without packaging material had the lowest sensory scores while samples with high-density polyethylene had the highest sensory scores. This was in agreement with earlier findings of [18], where it was recorded that sensory attributes of samples in high-density polyethylene were higher than samples in low-density polyethylene during the storage of pupuru for 24 weeks. The reduction in sensory attribute scores could be attributed to rancidity [19].

5. Conclusion

This study shows that storage conditions could influence significantly microbiological and sensory qualities of maize soy-flour and "*Agidi*" High-density Polyethylene packaging material is recommended for storing Soy-Maize flour over low-density Polyethylene packaging material owing to its considerable maintenance of the flour's quality.

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