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Quality assessment of instant Zobo drink prepared by evaporation and spray drying

Abstract

In this research, Instant Zobo drink (IZD) was prepared by evaporating and spray drying into powder the triple strength Zobo Concentrate prepared from the Purple and Red sorrel calyx varieties; and both the samples (sample 414 is Red IZD) and (sample 424 is Purple IZD) were subjected to sensory evaluation using ten (10) panels of judges and data were subjected to t–test; and found that both samples of the IZD have similar sensory properties that were acceptable by the sensory panelists because the T-tabulated is 2.262, while all the T-calculated values were less than the T- tabulated value; hence, there was no significant difference between the both samples of the reconstituted instant Zobo drink (IZD), because values of T-calculated are not greater than the T-tabulated (P≥ 0.05). IZD was further subjected to functional, physicochemical and microbiological analyses. Both samples of IZD have similar properties in terms of all the conducted assessments. Also, IZD was found to be safe microbiologically for human consumption owing to the fact that both samples of the IZD recorded less than ten microbial cells counts.

Keywords: purple sorrel calyx, red sorrel variety, spray-drying, instant zobo drink, quality, safety

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Introduction to the study

This study exploits the use of spray drying process for the preparation of instant Zobo drink due to demand for particle-free, shelf stable and nutrients sustained instant Zobo drink to support the growing demand of Zobo drink by the consumers in the world, owing to the fact that research efforts need to be redirected towards better and modern Technology for instant Zobo drink preparation from Purple and Red varieties of Sorrel calyx (i.e. Hibiscus sabdariffa variety sabdariffa). Sorrel calyx is a native plant to the tropical regions; it is used in the preparation of liquid Zobo drink.[1-5] And Zobo drink is a traditional beverage usually prepared into liquid form by either boiling or steeping either from the red or purple calyx of Sorrel in potable water and sweetened by the addition of sweeteners such as the granulated industrial sugar and/or inverted sugar syrup, honey, and then refrigerated before serving chilled to consumers.[4,6,7]

Furthermore, scientific findings established that Sorrel calyx used in preparing Zobo drink is a rich source of appreciable amounts of amino acids, moisture, protein, fat, fibre, and ash; with considerable amount of minerals, vitamins; also another study reveals that calyx of Roselle is rich in anthocyanins, which is ideal for producing brilliant red colorings in fruit beverages, gelatin, and jellies.[8,9] Also a study reported by[10] suggested that DP 3-sambubioside is the major pigment responsible for the reddish-violet color of red and purple Sorrel calyces and in addition to the point stressed above, non-pathogenic and pathogenic microorganisms were isolated from Liquid Zobo drink prepared at cottage level and sold in local markets.[11,12] This necessitates the application of evaporation and spray drying technology in the preparation of Zobo (i.e. Sorrel) drink into powdery form so that a best quality, safer, easy-to-package and consumer appeal instant Zobo drink can be made available to the growing consumers of Zobo drink in Nigeria and around the world.[13]

Evaporation is boiling of a liquid food to partially remove water from it by boiling off water vapor for the purpose of increasing its solid content and preserve it by a reduction in water activity.[14] Also, evaporation is used to pre-concentrate liquid food to reduce its weight and volume prior to drying operations including freeze-drying and spray-drying, respectively. And Spray drying is a dehydration method that produces droplets of liquid feed into powdered products, and the conversion involved atomization of liquid feed, undergoing heat treatment for quick evaporation of free moisture present in the liquid feed.[15,16] Atomization has been defined as the conversion of bulk liquid into a Spray or Mist, often by passing the liquid through a nozzle; and the liquid which is sprayed through a nozzle will increase the surface area of the liquid which later will be contacted to hot-air and dried into a powder; and the droplet size ranges form 20-180 µm (i.e. micro metre) depending on the size of the nozzle; the atomization stage is to create a maximum heat transferring surface between the dry air and the liquid Zobo concentrated and evaporated to optimize heat and mass transfer.[17] According to the opinion of a researcher, the liquid properties relevant to spray drying includes solids content, density, surface tension, and viscosity, but high concentration of solutes in the liquid is desirable to increase dryer thermal efficiency; and hence it is expected that liquid components must be thermally stable to be able to withstand heat treatment in the spray dryer despite the fact that the feed materials varies in properties including viscosity and glass transition temperature (Tg); as well as understanding the spray drying of various feed materials on its wide range of processing and quality parameters of the powder obtained after drying requires clear understanding of the spray-drying concept; and powder recovery above 50% records a successful spray drying process; but the challenges of feed selection is always hindered by the complexity of spray drying operating parameters on the physicochemical properties of the powder.[18,19] And some of the numerous feed materials used for spray drying process include the Gum Arabic and Maltodextrin, respectively.

Gum Arabic is scientifically called Acacia gum; it consists of a combination of complex carbohydrates and protein (i.e. D-gluconic acid and L-rhaminose) in the proportion of 4:2:2:1; and it is the protein component of this additive that improves the emulsification properties of the powder; and it is as well used for its surface activity and film forming capacity; and spray-dried products obtained using Gum Arabic do not have crystalline configuration and their bulk density has been established to be low. Another feed material is the Maltodextrin, which are of two types including DE 36 and DE 5; the DE 36 has a molecular weight of 500 with a glass transition temperature (Tg) of

100°C; while DE 5 has a significantly higher Tg of 180°C; and an increase in Tg contributes to powder stability, it reduces caking and stickiness problem during the storage of the powder and at the point of spray drying process; also as the Tg increases with the increase in molecular weight; and the addition of Gum Arabic has a higher Tg compared to the addition of Maltodextrin; although the larger molecular weight of Maltodextrin has a direct relationship with faster reabsorption and rehydration of powdered particles due to the higher surface area over a volume ratio exposed to moisture owing to the fact that the molecular weight of the additives represents the molecular size of the additives which plays a significant role in spray drying process. And Tg has been defined as the temperature of product amorphous system interchanging between a glassy and rubbery states usually associated with appearance, boiling and melting points, respectively

Therefore, the central focus of this study is to prepare two samples of instant Zobo drink (IZD) prepared from two varieties of Purple and Red Sorrel calyces by evaporation and spray drying unit operations and as well subjecting both samples to relevant functional properties, physico-chemical, microbiological and sensory evaluations.

Materials and methods

Raw materials

Triple strength Zobo concentrate was readily prepared by the researchers, while glazed amber-colored Paper package primary package were designed by the authors; and printed by Phresh Idea Printers, Gusau, Zamfara state. This study was carried out at the department of Food Science and Technology, Federal Polytechnic, KauraNamoda, Zamfara state, and AlDusar Foods and Beverages Limited, Katsina, Katsina state, Nigeria, respectively.

Apparatus/equipment/package used for this study

The equipment and utensils used for this study includes; electronic compact weighing balance (Model No. KD-3N, Japan), laboratory Spray dryer (Model MCGS, China), high performance commercial blender (Model No. KTGB-01, Sony, Euro-Japan), stainless bowl, stainless pot, pH meter (Model GMbH, Metler-Toledo, Switzerland), Hand-held Pocket Refractometer (Model PAL-1 Q3810-E04, USA) Measuring Cylinder, Pipette, Spatula and beakers of various volumes.

Experimental design

Triple strength Zobo concentrate readily prepared from the Red, and Purple varieties of Sorrel calyces and granulated sugar were used in the preparation of Instant Zobo drink and both production phases were done under a hygienic condition. Functional, microbiological, physico-chemical and sensory evaluations were conducted on both the prepared IZD.[20-23]And t-Test (two-tail) was used for statistical analysis of all the data ($P < 0.05$) to compare the relationship between the two variables. All data were recorded in triplicates and results were presented in Charts, and Tables, respectively. The results of microbial analysis were converted according to FEPTU 557 $\log_{10}$ Conversion Table (2010).[24]

Recipe formulations for the preparation of ISD

To have a control over the preparation of samples of IZD, an ingredients formulation wasestablished as reported by the study.

Preparation of instant zobo drink by evaporation and spray drying

The Instant Zobo drink (IZD) was prepared by the method of evaporation and spray drying. In this method, the triple strength Zobo concentrate was evaporated at 100 °C for 6hr and then spray-dried using a laboratory Spray dryer with condition inlet air temperatures of 180 °C to 240 °C and an outlet temperature was controlled at 95 °C and the blower speed was adjusted in 2,500 revolution per minute.[25-27]Also, addition of spray drying additives such as the Gum Arabic and Maltodextrin was done to increase the molecular weight and as well as the glass transition temperature (Tg), which will reduce the particle stickiness and wall deposition during the spray drying process.[28]

Functional properties analysis

Water absorption capacity

Water absorption capacity of the sample was determined by adopting the method of Sample of (1 g) was mixed with 10 ml distilled water. The suspension was then stirred using magnetic stirrer for 5 mins. The resulting suspension was centrifuged at 1800×g for 30 min. The volume of supernatant measured in a 10 ml graduated cylinder was noted. Density of water was taken to be 1g/ml.

$$WAC(\%) = \frac{(w_2 - w_1)}{w_0} \times 100$$

Bulk density

Bulk density was determined according to the method of[29] Sample of IZD was placed in a 25 ml graduated cylinder and packed by gently tapping the cylinder on thebench top 10 times from a height of 5 cm and the volume of the sample was recorded. The procedure was repeated two times for each sample and the bulk density was computed as g/ml of the sample.

$$BulkDensity = \frac{weightofsample(g)}{volumeofsample(ml)}$$

Reconstitution index (RI)

RI was determined using the method described by 10 g of the sample was weighed into a 100 ml measuring cylinder and distilled water was added up to 100 ml volume. The mixture was stirred vigorously and allowed to stand for three hours. The volume of settled particles was recorded and subtracted from 100 to give a difference that willbe taken as percentage. The percentage reconstitution index = 100 – H

Where H is the volume of the sample after settling.

Wettability

1g of the both samples of IZD was poured from a height of 15mm on the surface of 200cm^3 beaker at an ambienttemperature. Wettability time was recorded as the time required for the product to become wettedand penetrated the surface of the distilled water. The wetting time provides useful information of the degree to which a dry powder is likely to possess instant characteristics on reconstitution with water.

Physico-chemical analysis

Measurement of degree brix

Degree of Brix of the samples of the IZD using a Digital hand-held Pocket Refractometer (Model PAL-1Q 3810-E04, USA) by placing a drop of the samples of the ISD on the surface of the Refractometer and its % was read from the side. Each sample reading was taken in triplicate and the average was calculated to ensure an accurate result.[30]

Analysis of pH value

Accurately 10g of the samples were weighed and dissolved in distilled water and thoroughly stirredwith a stirrer. A pH meter (Model

GMbH, Metler-Toledo, Switzerland) was used to determine the pH values of the samples. First the electrode of the pH was properly calibrated by dipping the electrode of the meter into distilled water and Standard Buffer solutions of 7 and 14 and then it was dipped in the dissolved solution of the samples to obtain their various values. The pH values of the samples were determined three consecutive times and the average was taken as the accurate pH values for all the samples.

Total titratable acidity (TTA) test

Accurately 10g of the sample was weighed and dissolved in distilled water and the mixtures were thoroughly stirred. 5ml of the dissolved samples were collected in a conical flask and 1ml of phenolphthalein was added to the solutions. These were then titrated with 0.1N NaOH solution until the end point was obtained with a pink color. The volume of NaOH solution used before the color change were noted and used to calculate the total titratable acidity of the samples by multiplying the volume of the NaOH solutions used by a factor 0.15.

Therefore, TTA of the samples = volume of 0.1N NaOH ×100

Determination of total soluble solid (TSS)

The TSS content of a solution was determined by the index of refraction. This was measured using a Digital Hand-held Pocket Refractometer (Model PAL-1 Q3810-E04, USA).

Determination of microbiological status of samples of IZD prepared

Preparation of samples and culture media

Samples of IZD were respectively blended in a Stomacher bag using a Stomacher (400 laboratory blender Type BA, 7021 Model, England, UK.). Serial dilutions were prepared, inoculated on selective media and incubated at 37 °C for 24-48 hr. After incubation, colonies of microbial cells were counted using the method of[31] Also, all the culture media (i.e. Agar) used in this study was prepared according to the instructions of the respective Manufacturers.

Microbiological analysis of samples instant sorrel drink

Ten (10) grams of each samples of IZD was homogenized with 90ml sterile buffer peptone water. Further ten-fold serial dilutions of the resultant homogenates were made to obtain 10^{-2}, 10^{-3}, 10^{-4} and 10^{-5} respectively.[32] From the appropriate dilutions, 0.1ml was plated in replicate onto different media using pour plate technique. At the end of the incubation periods, colonies were counted using illuminated colony counter (Gallenkamp, England). The counts for each plate were expressed as colony forming unit per ml of sample homogenate (cfu/g).

Viable bacterial cell count

After overnight incubation, growth on the PCA showing viable cells colonies of 30 to 300 was counted. And the bacterial count was expressed as the number of colonies multiplied by the dilution factor.

Sensory assessment of instant sorrel drink

The sensory evaluation of IZD were carried out using a panel of 10 sensory judges comprising of students and staff of the Department of Food Technology, Federal Polytechnic, Kaura Namoda, Zamfara state. The samples were assessed on a 9-point Hedonic scale. The samples were presented in a random pattern and the parameters evaluated include color, flavor, taste (mouth-feel), sweetness and overall acceptability.

Results and discussion

Results of physicochemical analysis

This part of the study presents and discusses the results of the physicochemical values obtained on the two samples of IZD prepared from the Red and Purple varieties of Sorrel calyces, respectively. Figure 1 represents the results of pH, percentage Brix, Total Soluble Solid (TSS) and Titratable acidity (TTA) of the both samples of the prepared IZD.

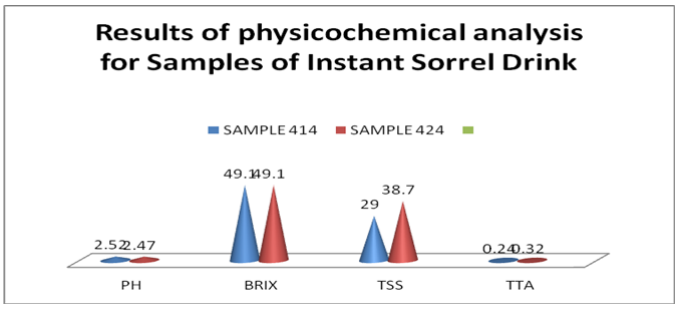

Figure 1 Results of physicochemical analysis for both samples of IZD prepared.

The pH values 2.52 (±0.70) and 2.47(±0.70) for sample 414 (Red IZD) and sample 424 (Purple IZD) obtained implies that both samples of the IZD can be classified as high acidic food products; and the merit of acidic food is that it does not support the survival of certain micro-organisms except some like Lactobacillus species. The high acidity of both samples of the ISD can be attributed to the presence of naturally occurring organic acid including the Citric, Malic, and Oxalic acids that are naturally present in the calyces. Also, a study reported by[20] suggests that Malic acid is known to have the ability to improve the flavour and tart-taste characteristics of food because of its sourness and acid nature; and it is involved in the Krebs cycle, a process the body use to make energy; it is also used for the nutritional management of fibromyalgia, fatigue and dry-mouth because its sourness helps to stimulate and produce more saliva to help with dry-mouth, but there is no tentative scientific evidence to support the management of fibromyalgia and fatique. Another study opined that biochemical reactions in cells which involve Oxalic acid indicates that this compound is required for the formation of uracil and Urotic acid because uracil is an element of ribonucleic acid (RNA) which is common to all cells in the human metabolism as reported by.[20]

Also, some studies suggested that Oxalic acid is a low molecular weight organic acid produced by fungi, bacteria, plants and animals; it has implications in the metabolic process of the above enumerated organisms; and in addition it possess varied unrelated roles in plant metabolism, including the pH regulation in association with nitrogen metabolism, metal ion homeostasis and calcium storage during plant growth.[20] While the Citric acid, due to its acidic nature, it is predominantly used as a flavouring, stabilizing agent serving as an Acidulant and as well as a preserving agent, most especially in the production of soft drinks and candies because of its general recognition as safe by the joint FAO/WHO Expert Committee on Food Additive; thus, Citric acid is ubiquitous in nature because it is an intermediate in aerobic metabolism through the tricarboxylic acid (TCA) cycle where carbohydrates are oxidized to carbon dioxide.[20] The percentage Brix values of 11.43% and 41.90% (±0.30) for both samples 414 (Red IZD) and 424 (Purple IZD) obtained implies that both samples of the IZD are having similar sugar content. And the percentage Total Soluble Solid (TSS) of 38.70% (±1.01) and 29.00% (±1.41) for both samples 424 and 414 obtained implies that both samples of the IZD are having

marked different in the TSS. And the Titratable acidity (TTA) of the both samples of the prepared IZD for sample 414 is 0.32% (±0.00) and for sample 424 is 0.31% (±0.00), respectively. And the acidity of both samples of the ISD are in agreement with the results of acidity reported by.[20]

Results of the functional properties for samples of instant zobo drink

Table 1 presents the results of the functional properties of the samples of the IZD prepared fromboth varieties of Sorrel calyces.

(Table 2) The results for Bulk density [for sample 414 is 1.09 g/cm^3 (±0.70) and for sample 424 is 1.16 g/cm^3 (±0.7)] and Wettability [for sample 414 is 1.38 Sec (±0.70) and for sample 424 is 1.22 Sec (±0.70)] are closely related to one another; but the results of Water Absorption Capacity [for sample 414 is 6.00% (±0.05) and for sample 424 is 5.10% (±0.05)] and Reconstitution Index [for sample 414 is 72.00% (±0.71) and for sample 424 is 68.00%(±0.71)] shown marked difference from each other. From the results obtained, Bulk density and Wettability of both samples of the IZD show that they possess a good instant characteristics, but results of the Water Absorption Capacity and Reconstitution Index indicate poor water absorption and reconstitution index ability,and this could be attributed to the presence of high amounts of sugar in the IZD. Furthermore, Water Absorption Capacity is an index of ability of proteins to absorb and retain water which in turn influences the texture and mouth feel of the IZD. The results of the Water Absorption Capacity were moderate, although this functional property of the IZD is reduced at substitution levels. Moreover, the increase in the sugar content of IZD substitution levels increase may also be responsible for the reduced Water Absorption Capacity. This is because sugars are known to inhibit the hydration of starch. This reduction may, however, be an advantage since low Water Absorption Capacity is desirable for formulation of less bulky IZD owing to the fact that Bulk density is a measure of heaviness of flour and an important parameter that determines the suitability of flours for the ease of packaging and transportation. The results of Bulk density of the IZD is averagely low. This reduction may be attributed to the high sugar content in the IZD. Although high Bulk Density is important due to the packaging advantage it offers powdery products; but low Bulk Density could be an advantage in the formulation of IZD where high nutrient density to low bulk is desired. According to a study low Bulk Density powders are desirable in powders. This is because the lower the Bulk density value, the higher the amount of flour particles that canstay together and thus increasing the energy content that could be derived from such food product. Reconstitution index is to establish the ease of dispersibility in the IZD. Dispersibility determines the tendency of powders to move apart from water molecules and reveals its hydrophobic action.

Table 1 Results of functional properties for samples of instant zobo drink (IZD)

Parameters	Sample 414 (Red variety IZD)	Sample 424 (Purple variety IZD)
Bulk Density	1.09 g/cm^3 (±0.70)a	1.16 g/cm^3 (±0.7)b
Wettability	1.38 Sec (±0.70)a	1.22 Sec (±0.70)a
Reconstitution Index	72.00% (±0.71)a	68.00%(±0.71)a
Water absorption	6.00% (±0.05)a	5.10% (±0.05)a

Values are mean of triplicate determinations ±SD values within a row with the same letter are not significantly different and those with different superscript along the row are significantly different ($P < 0.05$).

Table 2 Results of the total plate count of the samples of prepared IZD

Samples Code	Microbial cell loads (cfu/g)	Converted Value (log10cfu–g)
414	< 1.0 x 101	1.00 (±0.01)a
424	< 1.0 x 101	1.00 (±0.01)a

Values are mean of triplicate determinations ±SD values within a row with the same letter are not significantly different ($P < 0.05$).

Results for microbiological analysis

This part of the study presents and discusses the results of the microbiological status conducted on the samples of IZD. Tables 3&4 present the results of the microbiological status conducted on samples of IZD prepared (Sample 414) and (Sample 424) methods, respectively.

Table 3 Results of the yeasts/moulds cells count of the samples of ISD

Samples Code	Microbial cell loads (cfu/g)	Converted Value (log10cfu–g)
414	< 1.0 x 101	1.00 (±0.01)a
424	< 1.0 x 101	1.00 (±0.01)a

Values are mean of triplicate determinations ±SD values within a row with the same letter are not significantly different ($P < 0.05$).

Table 4 Result of t-test for both samples of the IZD prepared from the red and purple calyces

Sensory attributes	Cal. Values	Tab. Value	Conclusion
Color	0.419	2.262	NSD
Flavor	-0.291	2.262	NSD
Taste (mouth feel)	-0.728	2.262	NSD
Sweetness	0.291	2.262	NSD
Overall acceptability	0.488	2.262	NSD

Keyword: No significant difference.

Results of Yeast and Moulds status conducted on samples of IZD prepared from the Purple variety (Sample 414) and Red variety (Sample 424). The results of the microbiological analysis of both samples of IZD show count ofless than ten (10) cells counts indicating the impact of preparation of IZD under strict hygienic condition, as well as the fact that IZD is a dry food product indicating the effect of the concentration, evaporation and spray-drying methods that the Zobo concentrate was subjected to. Furthermore, the samples of the IZD being high acidic food products will hardly support the growth, harboring and proliferation of cells of Yeasts and Moulds. Hence, results of microbial analyses predict thatthe IZD samples are microbiologically safe for human use and consumption. In addition, IZD containing Malic acid, as a highly water soluble acid, can interact with pH to inhibit the growth ofYeasts, Moulds and bacteria supporting the theory of the fact that anti-microbial effect of Malic acid is due to a lowering of the pH value.[20] Also, both samples of the IZD are acidic foods that were processed by the method before being packaged into the glazed and amber-colored paper packaged; and it is expected that ready-to-eat foods should not contain pathogens in them with the exception of Moulds, Yeasts and a few bacteria that are acid-tolerant that may likely grow and proliferate over period of time.[20] Hence, this study established that microbial cells that were detected from the two samples of the IZD (Tables 2 and 3) are within the satisfactory (10^3cfu/g) and marginal (10^3 to $<10^5$cfu/g) microbial limit for Ready-To-Eat foods owing to the fact that they fall within Log one (< 1.0 x 10^1cfu/g (±0.01) ($P < 0.05$).

Results of sensory evaluation

This part of the study presents and discusses the results of the sensory evaluation of Instant Zobo Drink (IZD). Table 4 presents the results of the sensory evaluation conducted on samples of prepared IZD samples. The result of the sensory evaluation (Table 4) suggests that there is no significant difference in all the sensory parameters of both IZD prepared from both varieties of Sorrel calyces, color, flavor, taste (mouth-feel), sweetness and overall acceptability ($P < 0.05$). This is owing to the fact that the T-calculated is less than the T-tabulated indicating that there is a significance difference between the two samples. Thus in this study, both samples of IZD have similar sensory attributes ($P < 0.05$) and this could be attributed to the fact that both samples were prepared from the same recipe formulation. Hence, this study opined that variety of Sorrel calyx does not affect the sensory properties of the IZD prepared; and this infers that both Purple and Red varieties of the Sorrel calyces, Hibiscus sabdariffa variety sabdariffa, can be used in the preparation of IZD ($P < 0.05$).

Conclusion

In summary, this research demonstrates that both Red and Purple varieties of Sorrel calyces were used to prepare the two samples of IZD by concentration, evaporation and spray-drying; and the results of sensory, microbial and physico-chemical analyses indicated that IZD can be prepared from the both varieties of Sorrel calyces successfully for human use andconsumption. And both samples of IZD prepared were accepted by the sensory panelists and microbiologically safe for human consumption within the period of this study. Hence, this study suggests that concentration, evaporation and spray-drying is recommendable for the preparation of IZD.

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Conflicts of interest

All the authors designed and performed the study after detailed discussion and communication with one another; also the three authors prepared and approved the draft and final manuscripts. And there was no conflicting/competing interest associated with this research.

Special Notification

This developed product (i.e. Instant Zobo drink) is on the process of patenting; hence no person or group of persons is allowed to use the Production Procedure used for this study. However, any interesting persons or group can contact the principal researcher/author via his Gmail address: smfuntua@gmail.com.

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