Original Research Article

DEVELOPMENT OF PINEAPPLE BASED-BEVERAGE UTILIZING WHEY AND BANANA PSEUDOSTEM EXTRACT

ABSTRACT

Aims: Nutritional benefits of whey with fiber enriched banana pseudo stem extract, pineapple pulp and ginger were exploited in the present study by developing a whey beverage. This work aimed to facilitate economic utilization of whey and banana pseudo stem in a profitable manner, which not only increases nutritive value of product but also reduces pollution due to efficient utilization of whey and banana pseudo stem.

Study design: This research was experimental and performed in a laboratory.

Place and Duration of Study: This study was conducted at College of Dairy Science and Technology, KVASU, Pookode, Kerala, India, between the period of March 2022 and September 2022.

Methodolgy: The whey drink was prepared by adding pineapple juice, ginger extract and banana pseudo stem extract to the whey obtained during paneer production. The minimum and maximum levels of incorporation of each ingredient were selected based on the preliminary sensory evaluation. Further, optimization of the whey drink was carried out using Central Composite Rotatable Design (CCRD) of Response Surface Methodology (RSM), by taking the levels of pineapple juice, ginger extract and sugar as variables. In the next phase, the optimized product was evaluated for its sensory and physico-chemical parameters.

Results: The optimum formulation of whey drink given by RSM to achieve the predicted maximum response values were 32.5% pineapple juice, 0.875% ginger extract and 8% sugar. The whey drink was found to have 92.3% moisture, 0.6% ash, 1.77% protein, 0.32% acidity, 4.5% pH, 10% total solids, 12% total soluble solids ,8.5% radical scavenging activity,0.12% fiber and 6.3% ascorbic acid.

Conclusion: The study successfully developed a nutritious whey beverage incorporating banana pseudo stem extract, pineapple pulp, and ginger, optimizing its formulation to enhance both its economic viability and nutritional value while minimizing waste.

Keywords: whey, pseudo stem, pineapple, ginger

1. INTRODUCTION

Whey is the liquid waste that is left over after making casein, chhana, paneer, and cheese. It is a waste product of the dairy business that wasn't thought to be important in the past and was either fed to animals or thrown away. About 145 million tonnes of whey are made around the world every year, so it makes sense to look for new ways to use it (Macwan *et al*., 2006). Fresh liquid whey from cheese production comprises 94.2 percent water and 50 percent total solids, containing 0.8 percent whey proteins, 0.5 percent minerals, 0.1 percent fat, and 4.3 percent lactose. (Minj *et al.,* 2020). Pareek *et al*. (2014) made an effort to replace the empty calories in soft drinks by incorporating whey into a carbonated beverage that was made using orange juice. The selection of orange juice was based on the fact that its color is comparable to that of other soft drinks. The addition of whey protein is a fantastic solution for beverage manufacturers who are wanting to incorporate essential nutrients into their product. As a consequence of this, the creation of such a value-added product has the potential to create a new market for whey in the form of a product that is more nutritious. (Seethalakshmi & Shankar,2009)

The banana plant's pseudo-stem is a byproduct that has the potential to produce economic products such as food for human use. Phosphorus (P), potassium (K), sodium (Na), calcium (Ca), magnesium (Mg), and phosphorus (P) are all essential for maintaining a healthy body, and banana pseudostem flour (BPF) includes quite a few of these essential elements (Ho *et al.,* 2015). Swarnalakshmi*et al.* (2019) formulated a lemongrass-based isotonic beverage using banana pseudo stem and mint extracts, addressing the requirements of a healthy lifestyle through an economical and nutritious food option while reducing the underutilization of banana pseudostem.

Pineapple juice is rich in Vitamin C, which serves as an antioxidant that enhances iron absorption and combats bacterial and viral illnesses. Pineapples contain several essential minerals, notably manganese, a trace mineral vital for bone formation and the synthesis and activation of certain enzymes. Copper is an additional trace mineral present in pineapples. It facilitates iron absorption and regulates blood pressure and heart rate. (Hossain *et al.,* 2015). Ginger is a spicy, aromatic household spice with potential antioxidant capabilities (Stoilova ,2007).

During the process of planning and formulating new scientific investigations, the response surface methodology is utilized. The processing parameters are optimized using scientific means, and a new product can be generated through the utilization of the response surface approach. Through the use of the RSM technique, statistical parameters are analyzed, and the relevance of the model can also be validated. (Bradley, 2007)

Therefore, the current study aimed to formulate a pineapple-based whey beverage incorporating pseudostem and ginger extracts to enhance its nutritional content and enhance the consumption of whey and pseudostem

2. MATERIAL AND METHODS

2.1 Preparation whey drink

The procedure followed during paneer preparation is as according to Divya *et al.,* (2014), with slight modifications. The standard milk is heated to 90□C, and then cooled to 80□C. The 20ml lemon juice is added to milk with vigorous stirring initially followed by gentle stirring till the completion of coagulation. Then coagulant added milk was left undisturbed for 5 minutes. Afterwards, the clear whey was separated through muslin cloth and the whey was used for further work**.**

The pineapple juice was extracted by the juicer and filtered for clear juice. The banana pseudo stem extract was elicited by a mixer and filtered according to (Shiva *et al.,* 2018). The banana pseudo stem was sliced into small pieces, washed and crushed using a mixer and grinder. The juice was extracted by squeezing and filtered through doublefold muslin cloth. The filtered extract was further used. Fresh and matured ginger is washed, blanched at 60ºC for 30 minutes to eliminate microorganisms, peeled, shredded, ground into a paste, and then the extracts are obtained by hand squashing and filtering through muslin cloth.

The prepared whey is combined with 90 percent of its volume, and freshly prepared pseudo stem extract is added at 10 percent. This mixture is then placed in a beaker and allowed to sit overnight to facilitate segmentation. The ingredients for the development of whey drink were evaluated at different levels in the preliminary trials.

2.1.1 Selection of levels of pineapple juice

In the preliminary trials, whey- pseudostem beverages were incorporated with different concentrations of pineapple juice to the levels of 25% (T1), 30%(T2), 35%(T3) and 40% (T4). Then whey beverage is subjected for sensory analysis. The sensory scores were statistically analysed using Kruskal wallis test.

2.1.2 Selection of levels of ginger extract

In the preliminary trials, whey- pseudostem beverages were incorporated with different concentrations of ginger extract to the levels of 0.25% (T1), 0.5%(T2), 0.75%(T3) and 1% (T4). Then whey beverage is subjected for sensory analysis. The sensory scores were statistically analysed using Kruskal wallis test.

2.1.3 Selection of levels of Sugar

In the preliminary trials, whey-pseudostem beverages were incorporated with different concentrations of sugar to the levels of 6% (T1), 8%(T2), 10%(T3) and 12% (T4). Then whey beverage is subjected for sensory analysis. The sensory scores were statistically analysed using Kruskal wallis test.

2.2. Experimental design

The Central Composite Rotatable Design (CCRD) of Response Surface Methodology (Design Expert Software Version 13) was used for the optimization of banana pseudo stem incorporated whey drink. The ranges for experimental parameters were selected based on preliminary trials of sensory evaluation. The process variables considered for the optimization were levels of pineapple juice, ginger extract and sugar. The response to variation in process parameters are measured in terms of color and appearance, flavor, sweetness, consistency and overall acceptability. Experimental design was applied after selection of ranges. 13 experiments were performed according to a second order central composite rotatable design with three independent variables and five levels of each variable to examine the response pattern. The central point of the experiment was repeated five times to calculate the reproducibility of the method. The optimized blend was used in further studies.

The adequacy of developed models was determined using F values, lack-of fit test, R^2 (coefficient of determination), Coefficient of variation (CV), PRESS and adequate precision ratio (APR). Three-dimensional response surfaces are generated using Design Expert - version 9.0. The numerical and graphical optimization was also performed by the same software.

2.3 Physicochemical analysis of whey drink

The proximate and chemical analyses of samples were carried out using standard procedures as follows: The total solids content, acidity and moisture of whey-based fruit beverages was determined by a method described in 1S: 1479 (1960). Lactose content was determined by Lane Eynon method as per IS: SP: 18, Part XII (1981). The protein content was determined by Micro Kjeldahl method (AOAC, 2008). Ash content was measured using a 10g sample, which was incinerated in a muffle furnace at 550°C for a duration of 4 hours, followed by cooling at room temperature (25°C). The residual ash was measured, and the ash content was determined (AOAC, 2008). Total soluble solids in degree brix were determined using a refractometer. Dietary fiber content was estimated according to method given in AOAC (2008). Free radical scavenging activity of the whey based fruit beverage was determined by 1,1-diphenyl-2-picryl-hydrazyl (DPPH) assay according to the procedure reported in an earlier study (Tepe, 2008).

3. RESULTS AND DISCUSSION

3.1 Selection of minimum and maximum levels of ingredients used for the development of whey drink

3.1.1. Selection of levels of pineapple juice

The Kruskal-Wallis H value of 18.02, 23.2, 17.4, 0.54 and 19.5 were observed for sensory attributes like color and appearance, flavor, sweetness, consistency and overall acceptability of pineapple juice (Table 1). There was significant difference between the samples ($P < .01$). As our aim was to select the minimum and maximum levels of addition of pineapple juice. T2 and T3 were selected on the basis of sensory scores.

3.1.2 Selection of levels of ginger extract

The Kruskal-Wallis H value of 0.54, 23.2, 17.4,0.54 and 19.5 were observed for sensory attributes like color and appearance, flavor, sweetness, consistency and overall acceptability of ginger extract (Table 1). There was significant difference between the samples ($P < .01$). As our aim was to select the minimum and maximum levels of addition of ginger extract. T3 and T4 were selected on the basis of sensory scores.

3.1.3Selection of levels of sugar

The Kruskal-Wallis H value of 0.48, 17.88, 23.08, 0.35 and 16.77 were observed for sensory attributes like color and appearance, flavor, sweetness, consistency and overall acceptability of pineapple juice (Table 1). As our aim was to select the minimum and maximum levels of addition of sugar. T2 and T3 were selected on the basis of sensory scores.

Table 1. Preliminary sensory analysis for selection of levels of pineapple juice, ginger extract and sugar.

Levels of pineapple juice					
Parameter	**T1**	**T2**	**T3**	**T4**	**Kruskal-Wallis H**
Colour and appearance	7.7±0.400	8.1±0.654	8.5±0.340	8.3±0.345	18.02**
Flavour	7.4±0.654	8.0±0.122	8.4±0.320	8.4±0.432	23.2**
Sweetness	7.8±0.626	8.1±0.560	8.5±0.203	8.3±0.460	17.4**
Consistency	8.1±0.543	8.0±0.342	8.00±0.377	8.00±0.132	0.54^{ns}
Overall Acceptability	7.9±0.654	8.3±0.132	8.5±0.333	8.2±0.155	19.5**
Levels of ginger extract					
Colour and appearance	7.9±1.00	8.1±0.244	7.9±0.310	7.9±0.130	0.54^{ns}
Flavour	7.4±0.244	7.6±0.127	8.3±0.540	6.5±0.416	23.2**
Sweetness	7.2±0.122	7.9±0.500	8.2±0.200	7.5±0.400	17.4**
Consistency	7.5±0.787	7.7±0.200	7.7±0.200	7.8±0.542	0.54^{ns}
Overall Acceptability	7.5±0.258	8.5±0.178	7.7±0.400	7.2±0.322	19.5**
Levels of sugar					
Colour and appearance	8.2±0.244	8.2 ± 0.374	8.3±0.509	8.2±509	0.48^{ns}
Flavour	7.7±0.331	8.1±0.254	8.3±0.244	8.3±0.187	17.88**
Sweetness	7.9±0.100	8.2±0.122	8.5±0.187	8.3±0.100	23.08**

Consistency	8.0±0.316	8.1±0.300	8.1±0.509	8.0±0.509	0.35^{ns}
Overall acceptability	7.7±0.200	7.8±0.254	8.5±0.200	8.3±0.100	16.77**

**- Significant at one percent level (*P*<.01), ns-non significant, Figures are the mean ± standard error of sensory scores by five permanent judges in six replications

3.2. Optimization of pineapple juice, sugar and ginger extract by Response Surface Methodology (RSM).

Optimisation was done using a five level of three factor Central Composite RotatoryDesign (CCRD). When the minimum and maximum levels were fed to the RSM, the output showing coded and actual levels of the four factors (design factors) (Table 2) and the central composite rotatable design of four factors consisting 20 runs with different combinations were obtained (Table 3). The sensory scores valuesfor the different combinations obtained as a result of the proposed experimental design are summarized in Table 3 given below.

3.2.1.Diagnostic Check of the Quadratic Model

The quadratic models for sensory attributes such as flavor, body and texture, consistency, sweetness and overall acceptability were obtained through continuous regression analysis. The partial coefficients of regression of linear, quadratic and interaction terms for each model and their R^2 values are shown in Table 4.The model F value was found to be significant *(P*< .05) and lack of fit was found to be non-significant for all sensory attributes.

3.2.1.1. Effect on flavor

The scores of flavors obtained from sensory analysis and the partial coefficients are summarized in Table 3 and Table 4 respectively. The study found a significant flavor effect on the design, with a coefficient of determination (R^2) of 0.92 and a precision of 10.6750. A response surface equation was generated to predict flavor changes with different levels of pineapple juice(A), ginger extract(B), and sugar(C).

Flavour = 8.4792 + -0.0269593 * A + 0.0808779 * B + 0.120152 * C + 0.075 * AB – 0.000* AC -0.000 * BC -0.232248 * A^2 -0.161537 * B^2 -0.161537 * C^2

3.2.1.2. Effect on color and appearance

The scores for color and appearance are summarized in Table 3 and Table 4 contains the partial regression coefficients. The study found a significant impact of pineapple juice, ginger extract, and sugar on color and appearance, with a coefficient of determination (R^2) of 0.96 and a precision of 14.8852. The response surface equation was generated to predict changes in color and appearance with different levels of these substances.

Colour and Appearance = 8.13296 - 0.041604 * A + 0.0662333 * B + 0.0685633 * C + 0.05 * AB - 0.025 * AC - 0.025 * BC - 0.203783 * A^2 - 0.168428 * B^2 - 0.115395 * C^2

3.2.1.3. Effect on consistency

The scores obtained for consistency of banana pseudostem incorporated whey drink are given in Table 3 and the partial coefficients are given in Table 4. The study found a significant effect in consistency on the design, with a coefficient of determination (R^2) of 0.94 and a precision of 12.5751. A response surface equation was generated to predict consistency changes with different levels of pineapple juice(A), ginger extract(B), and sugar(C).

Consistency = 8.14941 - 0.041604 * A + 0.0662333 * B + 0.0562486 * C + 0.05 * AB - 0.025 * AC - 0.025 * BC - 0.137581 * A^2 - 0.102226 * B^2 - 0.0668705 * C^2

3.2.1.4. Effect on sweetness

The scores of sweetness obtained from sensory analysis and the partial coefficients are summarized in Table3 and Table 4 respectively. The study found a significant effect in sweetness on the design, with a coefficient of determination (R^2) of 0.95 and a precision of 11.4454. A response surface equation was generated to predict changes in sweetness with different levels of pineapple juice(A), ginger extract(B), and sugar(C).

Sweetness = 8.13194 + 0.20569 * A - 0.0369439 * B + 0.215674 * C + 0.00 * AB + 0.15 * AC + 0.025 * BC - 0.285506 * A^2 - 0.303183 * B^2 - 0.285506 * C^2

3.2.1.5. Effect on overall acceptability

The scores for overall acceptability are summarized in Table3 and the partial coefficients are given in Table 4. The study found a significant effect in overall acceptability on the design, with a coefficient of determination (R^2) of 0.93 and a precision of 10.7338. A

response surface equation was generated to predict changes in overall acceptability with different levels of pineapple juice(A), ginger extract(B), and sugar(C).

Overall Acceptance = 8.18 -0.0270* A +0.0393*B+0.1348*C +0.0750*AB-0.0250*AC-0.0250* BC-0.2360*A^2-0.1476*B^2-0.1653*C^2.

Table 2.The coded and actual levels of Pineapple, Ginger and Sugar

Coded level Factor	**Lower limit**	**Factorial point**	**Centre coordinate**	**Factorial point**	**Upper limit**
	-2	-1	0	+1	+2
Pineapple (%)	30	31.25	32.5	33.75	35
Ginger (%)	0.75	0.8125	0.875	0.9375	1
Sugar (%)	6	7	8	9	10

Table 3. The Central Composite Rotatable design for the three factors and their responses

Run	**Factors**			**Responses**				
	Factor 1	**Factor 2**	**Factor 3**	Response 1	Response 2	Response 3	Response 4	Response 5
	Pineapple (%)	**Ginger (%)**	**Sugar (%)**	Flavour	Colour	Consistency	Sweetness	Overall Acceptability
1	32.5	0.875	8	8.5	8.2	8.1	8.3	8.2
2	32.5	0.875	11.3636	8.2	7.9	8	7.7	7.9
3	32.5	0.875	8	8.5	8.2	8.1	8.3	8.2
4	32.5	0.875	8	8.6	8.2	8.1	7.9	8.3
5	30	0.75	10	8.1	7.8	8	7.1	7.9
6	35	0.75	10	7.9	7.6	7.8	7.8	7.7
7	32.5	0.875	8	8.3	8	8.2	8	8
8	32.5	1.08522	8	8.1	7.8	8	7.1	7.8
9	30	0.75	6	7.9	7.6	7.8	7	7.6
10	35	1	10	8.2	7.7	7.9	7.9	7.8
11	28.2955	0.875	8	7.8	7.6	7.8	7	7.5

12	32.5	0.664776	8	7.8	7.5	7.7	7.4	7.6
13	30	1	10	8.1	7.8	8	7.1	7.8
14	32.5	0.875	8	8.4	8.1	8.2	8	8.1
15	35	1	6	8	7.7	7.9	7.1	7.7
16	35	0.75	6	7.7	7.4	7.6	7.2	7.4
17	32.5	0.875	8	8.6	8.1	8.2	8.3	8.3
18	32.5	0.875	4.63641	7.7	7.7	7.9	6.9	7.4
19	30	1	6	7.9	7.6	7.8	7	7.5
20	36.7045	0.875	8	7.7	7.5	7.7	7.6	7.4

Table 4. Regression coefficients and ANOVA of fitted quadratic model for sensory characteristics of whey drink incorporated with pseudo stem extract.

Partial Coefficients	Sensory characteristics				
	Flavor	**Color and appearance**	**consistency**	**sweetness**	**Overall acceptability**
Intercept	8.4792	8.13296	8.14941	8.13194	8.17977
A- Pineapple	-0.0269593^{ns}	-0.041604**	-0.04160**	0.20569**	-0.0269593^{ns}
B- Ginger	0.0808779**	0.0662333**	0.066233**	-0.0369439^{ns}	0.039273^{ns}
C- Sugar	0.12015**	0.068563**	0.056248**	0.21567**	0.134797**
AB	0.075*	0.05*	0.05**	4.782E-16^{ns}	0.075*
AC	-2.728E-16^{ns}	-0.025^{ns}	-0.025^{ns}	0.15**	-0.025^{ns}
BC	-3.974E-16^{ns}	-0.025^{ns}	-0.025^{ns}	-0.025^{ns}	-0.025^{ns}
A2	-0.23224**	-0.20378**	-0.13758**	-0.28550**	-0.23597**
B2	-0.16153**	-0.16842**	-0.10222**	-0.30318**	-0.1475**
C2	-0.16153**	-0.11539**	-0.066870**	-0.28550**	-0.16526**

Lack of fit	0.8921^{ns}	0.3805^{ns}	1.29^{ns}	0.2843^{ns}	0.7285^{ns}
Model F value	14.01*	28.83*	18.58*	22.38*	15.16*
R^2	0.92	0.96	0.94	0.95	0.93
Adeq. Press	10.6750	14.8852	12.5751	11.4454	10.7338

**- Significant at one percent level (*P*<.01),*- Significant at five percent level (*P*<.05), ns-non significant,

3.2.2. Optimized Solutions and Their Validation

The criteria for optimization and solutions generated by Response Surface Methodology are summarized in Tables 5 and Table 6 respectively. The levels of pineapple juice ginger extract and sugar were kept in range. The sensory scores were kept maximum during the optimization process (Table 5).

Table 6 shows the suggested solution for preparation of banana pseudostem incorporated whey drink. The predicted values for all the ingredients are tabulated in Table 6. It was also noted that the solution had a high desirability value of 0.9.

3.2.3. Verification of Optimum Formulations

The optimized product was evaluated for sensory attributes and the data along with the predicted values of responses are depicted in Table 7. The results were subjected to statistical analysis using t test (assuming equal variance) with the corresponding predicted value. It was found that the observed values were not significantly different from the predicted values with respect to all attributes.

Table 5. Constraints and criteria for optimization of whey drink incorporated with pseudo stem

Constraint	Goal	Lower limit	Upper limit
Pineapple (%)	In range	30	35
Ginger (%)	In range	0.75	1

Sugar (%)	In range	6	10
Flavour	Maximize	7.7	8.6
Colour and appearance	Maximize	7.4	8.2
consistency	Maximize	7.6	8.2
sweetness	Maximize	6.9	8.3
Overall acceptability	Maximize	7.4	8.3

Table 6. Solutions obtained after response surface analysis

Solution No	Pineapple (%)	Ginger (%)	Sugar (%)	Desirability
1.	32.5	0.875	8	0.9

Table 7. Verification of the optimum formulation

Attributes	Predicted value	Observed value	t value
Flavor	8.52	8.5±0.045	0.42 ^{ns}
Consistency	8.34	8.3±0.043	0.54 ^{ns}
Color and appearance	8.52	8.5±.076	0.47 ^{ns}
sweetness	8.23	8.2±0.032	0.53 ^{ns}
Overall acceptability	8.54	8.5±0.065	0.65 ^{ns}

ns-non significant.

3.3. Physicochemical analysis of optimized whey drink

Banana pseudostem incorporated whey drink was optimized using RSM and the resultant product was subjected for analysis of its physicochemical parameters. The results are summarized in table 8.

Moisture content in food products significantly influences physical attributes like consistency, color, texture, and weight, as well as shelf life, freshness, quality, and resistance to bacterial contamination. The whey beverage's moisture content was found to be 92.3% which was in accordance with the findings of Alane *et al.* (2017) in studies on preparation and storage stability of whey-based mango herbal beverage.

Ash content measures total inorganic substances in food. Ash content in whey was 0.6%. Bhavsagar*et al.* (2010) examined chhana whey-based pineapple-flavored beverages. This beverage had ash of 0.44, 0.60, 0.76, and 0.78% after adding 5, 10, and 15% pineapple pulp to chhana whey.

Total solids are a measure of the dissolved combined content of all inorganic and organic substances present in a liquid in a molecular, ionized, or microgranular suspended form. The total solids of whey beverage are 10 per cent.

Total soluble solids (TSS) is a way to find out how dense all soluble solids are (how much mass there is in a given amount). The total amount of soluble solids in whey drink is 12%. In their study, Baljeet *et al.* (2013) found that newly made beverage samples had similar TSS levels of 13.97, 13.77, and 13.73.

Fiber constitutes a crucial element of the banana pseudostem. The fiber level, which accounts for numerous health benefits, is 2.1% in the whey beverage. The protein content of whey beverage was about 1.77% and acidity of 0.32%.

The radical scavenging activity (RSA) of the whey was observed to be 8.5%. According to a study by Krishnaiah *et al.* (2011), pineapple extracts exhibited significant radical scavenging activities, attributed to the presence of flavonoids and phenolic acids. Sharma *et al.* (2018) recorded RSAs between 7-12% in whey-based beverages enhanced with plant extracts, highlighting the effectiveness of these combinations in creating health-promoting beverages.

The ascorbic acid content of whey beverage was found out to be 6.3%. The result seems obvious because the pineapple fruit is considered as a good source of vitamin C which is determined as total ascorbic acid content (Lu *et al.,* 2014).

Table 8. Physicochemical analysis of optimized whey drink.

Parameter	Whey drink
Moisture (%)	92.3
Ash (%)	0.6
Total solids (%)	10
Total soluble solids (%)	12
Crude fibre (%)	2.1
Protein (%)	1.77
Acidity (%)	0.32
Radical Scavenging Activity (%)	8.5
Ascorbic acid (%)	6.3

4. CONCLUSION

In conclusion, the research successfully proved the potential of integrating banana pseudo stem extract, pineapple pulp, and ginger into a whey beverage in order to create a beverage that is high in nutrients. The process of optimization using RSM resulted in the formulation of a beverage that not only improves the nutritional profile of the beverage but also encourages the economic utilization of whey and banana pseudo stem, which in turn contributes to the reduction of waste. The results emphasize the feasibility of this innovative method in the development of health-oriented products that simultaneously address environmental concerns.

5. REFERENCES

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