Fermented Drink of Whey Enriched with Different Portions of Tarwi (Lupinus Mutabilis)

Wilber Quispe[1], Carol Ocaña[2], Ciro Rodriguez[1], Doris Esenarro[1], and Jennifer Arteaga[3]
[1] Specialized Institute for Ecosystems and Natural Resources Research (INSTI), UNFV, Lima, Peru
[2] Federico Villarreal University Lima, Lima, Peru
[3] Peruvian University of Ciencias Aplicadas (UPC), Lima, Peru
Email: wqprado_09@hotmail.com, ocrocana@unfv.edu.pe, crodriguez@unfv.edu.pe, desenarro@unfv.edu.pe and U20151C024@upc.edu.pe

Abstract—The objective of the present investigation is to obtain an optimal formulation for the elaboration of a fermented beverage from whey enriched with tarwi. The research was carried out in the laboratories of biochemistry, processes, and microbiology of the Professional School of Agroindustrial Engineering of the National University Federico Villarreal (UNFV). The Taguchi methodology was used in the formulation and optimization process, which allowed us to work with three control factors: fresh milk (LF), whey (LC) and tarwi flour (HT), with two levels of work and four runs Experimental The formulations to which sensory acceptability analysis (AS) determined by taste, color and smell were obtained. The F4 formulation (50% LC, 40% LF, and 5% HT) obtained the highest score with an AS (4.49) equivalent to "Moderately liked," Signal to Noise ratio (13,045). The factor with the most significant influence in the elaboration of the fermented whey drink enriched with tarwi depending on the sensory acceptability determined by the S / R was fresh milk (1.78). The addition of tarwi flour does affect the sensory acceptability of the product according to the S / R and the response surface method, and they determine that the higher the amount of tarwi flour shows lower acceptabilty of the product.

Index Terms—formulation, fermented beverage, Tarwi, biochemistry, microbiology

I. Introduction

Whey means a more or less cloudy, acidic, and slightly viscous greenish-yellow liquid resulting from the draining of the curd, and which practically lacks almost no fat and albuminoids, its main richness is the somewhat substantial amount of lactose and traces of albumin. This lactose includes about half of the ashes and up to a quarter of milk proteins [1], which allows the growth and multiplication of lactic acid bacteria [2].

The whey is one of the most representative residues of the dairy industry and one of the most severe pollutants that exist at the environmental level [3]. For many years it has been categorized as a waste and polluting agent, which is usually discarded by the dairy industry [4].

Manuscript received January 1, 2021; revised May 8, 2021.

Given the problem, whey or its components is used as an ingredient in a yogurt-type drink, and it can be developed in two ways: unfermented milk and fermented products because of being rich in phosphorus, calcium and lactic acid [5].

It is estimated that from 10 liters of cow's milk can produce 1 to 2 kg of cheese and an average of 8 to 9 kg of whey, which represents about 85 - 90% of the volume of milk, which contains about 55% of its nutrients [6].

Fresh milk is the component that allows the beverage to generate lactic fermentation and obtain the consistency characteristic. Tarwi is an Andean cereal, and whole grains are nutritious; Its protein is rich in lysine and has a high-fat content. Its protein content is even higher than soy [7].

To date, there are various investigations in fermented beverages from whey, but the most relevant is the research conducted on the influence of partial replacement of whey and quinoa flour, each with three levels; whey (40, 50 and 60%) and quinoa flour (2, 3 and 4%) on the organoleptic and physicochemical properties of a substituted yogurt, with nine treatments with three repetitions, obtaining as a result that the partial replacement of whey and flour Quinoa influences the organoleptic and physicochemical properties of substituted yogurt. Besides, the optimal percentage of 48.8% whey and 2.0% quinoa flour was determined by mathematical models [8].

II. Method

A. Supplies, Materials and Equipment

The raw material was required: fresh milk, whey, precooked tarwi flour, lyophilized cultures, and additives (stabilizer, fruit pulp, etc.). Likewise, scales, test tubes, thermometers, Erlenmeyer glasses, pot, spoons, bowls, containers, refrigerator, techno port incubator with focus, and potentiometers were used.

B. Instruments for Data Collection and Data Processing

The hedonic test or questionnaire was taken from an investigation whose validation contains a Cronbach's alpha 0.895. The test was conducted with a 5-point

doi: 10.18178/ijfe.7.1.1-6

hedonic scale of 1 to 5 (1 = unacceptable and 5 = excellent). [9]. The tasting of the samples was carried out with 80 untrained judges previously trained in the technique to be used in the sensory evaluation, the judges were the regular students. The period of execution of the interviews was one week and the following programs were used to process the data: Minitab version 16, Microsoft Office Excel 2013 and IBM SPSS Statistics 24.

C. Experimental Design

Acceptability through the Taguchi Method: Three independent variables were identified: Whey (LC), Fresh milk (LF), and tarwi flour (HT), with two levels of work (Table I) and the dependent variable is the formulation (F). The indicators to be analyzed are sensory acceptance (AS), signal to noise (S / R), and delta.

TABLE I. LEVELS CONSIDEREDIN THE TAGUCHI EXPERIMENTAL DESIGN

Control factors	Levels	
	1	2
Whey	40 %	50 %
Fresh Milk	30 %	40 %
Tarwi Flour	5 %	10 %

The Taguchi method presented 4 formulations in Table II. The analysis is based on sensory acceptability (AS) and noise signal (S / R).

TABLE II. EXPERIMENTAL FORMULATIONS WITH TAGUCHI DESIGN

Design Point	LC	LF	HT
F1	1	1	1
F2	1	2	2
F3	2	1	2
F4	2	2	1

The preparation of the fermented beverage was started by subjecting the fresh milk to heat treatment at a temperature of 80 °C for 30 minutes and the whey at a temperature of 65 °C for a period of 15 minutes. See in Fig. 1.

Figure 1. First treatment.

The whey, milk and pre-cooked tarwi flour were homogenized. The mixture was cooled to a temperature of 42-45 °C. It was inoculated with the selected cultures, and incubated for 4 hours maintaining a constant temperature of 42 °C. See in Fig. 2.

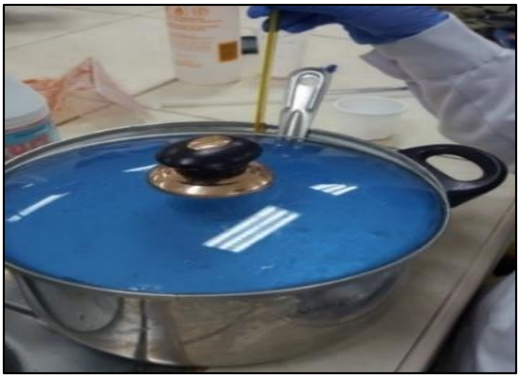

Figure 2. Incubation and control of T °C.

It was cooled to 15 °C and the addition of additives was made with the technical specifications for the preparation of the desired product. See in Fig. 3.

Figure 3. Adding additives

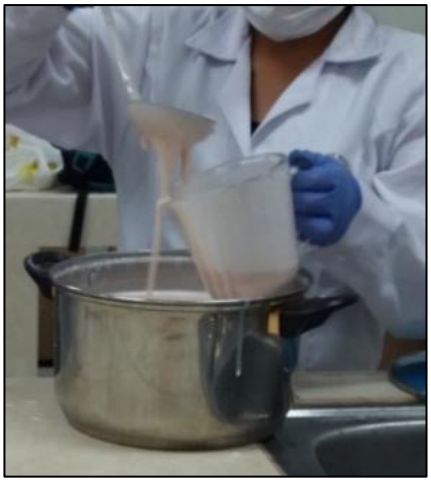

Figure 4 Packaging.

The drink was packed both in bottles of 1L capacity. The tight seal was secured with the lid and then placed in a cold chamber at a temperature between 4-6 °C. See in Fig. 4.

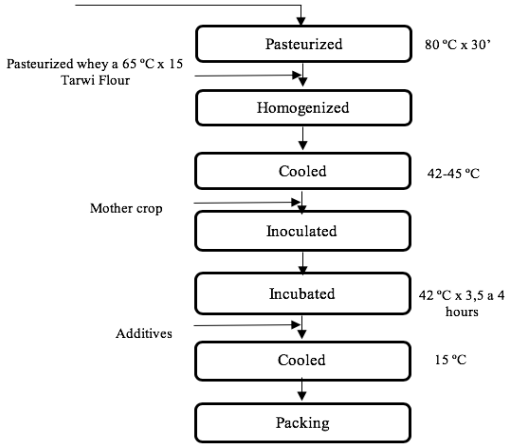

Figure 5. Pasteurized sequence

The sensory acceptability equation (AS) was defined by the panel of experts as the sum of taste, color and smell. For each of these, the relative influence percentages were determined.

$$AS = 0.45\ flavor + 0.3\ color + 0.25\ smell \quad (1)$$

A variance analysis was performed on the data and the normality test was applied for comparison between formulations. For acceptability, the non-parametric statistical test of Kruskal-Wallis was applied.

III. Results

The analysis of p-value concerning the Kolmogorov-Smirnov statistic to analyze the homogeneity of the variances indicates that the formulations differ from a normal distribution and would be considered non-parametric data.

Sensory analysis of the formulations shows that the fermented beverage that had the highest acceptance was the F4 formulation (Table III). The one with the lowest acceptance was the F3 formulation, and this fermented beverage contained a higher proportion of tarwiflour.

TABLE III. AVERAGE RANGES OF THE KRUSKAL- WALLIS TEST

Formulations		N	Average Range
Sensory acceptability	F1	80	120.37
	F2	80	210.45
	F3	80	40.63
	F4	80	270.55
	Total	320	

TABLE IV. TEST STATISTICIANS A,B.

	Sensory acceptability
Chi-square	393,220
gl	3
Sig. asintotic	,000

a. Kruskal Wallis Test
b. Grouping variable: Formulations

The TableIV shows the p-value 0.000 lower than the level of significance (0.05), therefore we say that there is a significant difference between the different formulations evaluated.

A. Optimal Formulation

Table V shows the average results of AS and Noise Signal (S / R). The analysis shows that the best formulation of independent variables corresponded to F4 with an average AS score equal to 4.49 equivalent to "Moderately Like" and an S / R-value of 13.045 using the "Greater is better" model.

TABLE V. AVERAGE AS AND S/ R VALUES OF THE EXPERIMENTAL FORMULATIONS

	LC	LF	HT	AS	S/R
F1	1	1	1	3,08	9,771
F2	1	2	2	4,10	12,256
F3	2	1	2	3,97	11,976
F4	2	2	1	4,49*	13,045

* Average of one repetition, work levels: 1 = lower and 2 = higher

Table VI shows the differences in magnitude (delta). With this statistic, it was determined in this study that both LF and LC were the independent variables with the greatest impact on AS, with delta values of 1.78 and 1.50 respectively, results corresponding to the maximum levels of work.

TABLE VI. AVERAGE AS AND S/ R VALUES OF THE EXPERIMENTAL FORMULATIONS

	Control factors	1	2	Delta	Classification
F1	LC	11,01	12,51	1,50	2
F2	LF	10,87	12,65	1,78	1
F3	HT	11,41	12,12	0,71	3

* Average of one repetition, work levels: 1 = lower and 2 = higher

In Fig. 5 it is determined that the factors that show the most significant influence on the acceptability of the product is demonstrated by fresh milk with a higher index at level 1 (30%) followed by the whey showing a lower dependence on the acceptability of the product with a higher index at level 2 (50%).

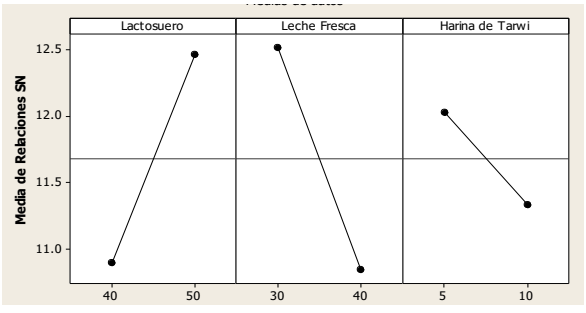

Figure 6 Effects of the S/R ratio (greater is better).

Fig. 7 and Fig 8 show that sensory acceptance is characterized by the lower concentration of tarwi flour

(5%) and higher percentage of whey (50%). Where the acceptability is 4.49 indicating a degree of positive acceptance.

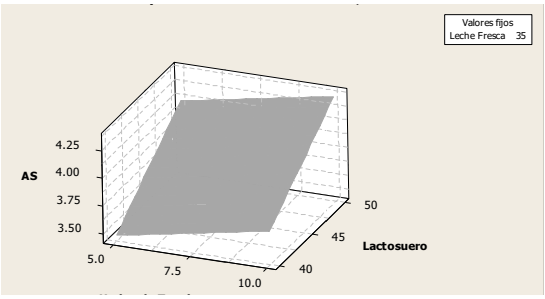

Figure 7. Response surface of sensory acceptability.

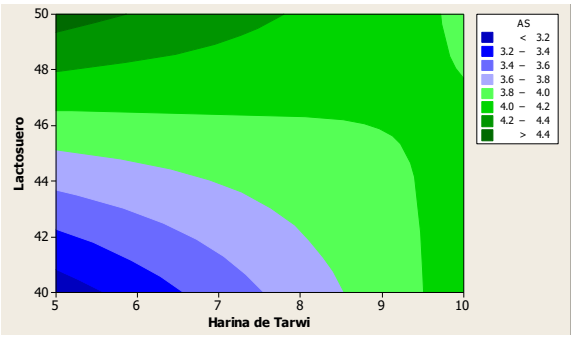

Figure 8. Contour plot of sensory acceptability.

IV. Discussion

The described results allow us to confirm that a fermented beverage can be obtained from the whey and enrich it with the addition of tarwi flour. This is consistent with the conclusions indicated by various studies regarding the production of fermented beverages from whey, a byproduct of cheese making, and that the fermentative activity of lactic acid bacteria can be guaranteed, even when the whey was used as raw material [2], [9], [10].

In addition to this, Tarwi has a high concentration of lysine, which has a high protein content; these are unusual characteristics in plant foods [11]. Therefore, it results in different consumption proposals.

In the Proximal Analysis evaluated in other studies [12], about proteins the values found are within those of reference [13].

Importance of studying the adequate percentage of whey and tarwi flour is embedded in studies of the general acceptability of optimal bread when between 4 and 9% of tarwi flour and 8 and 12% of quinoa flour is substituted [14] and the use of fresh cheese whey in the preparation of a fermented beverage with the addition of passion fruit pulp [15]. For example, in the present study, between 40-50% whey and 5-10% tarwi flour were used, obtaining the highest sensory acceptability (4.49) when using 50% whey and 5% of the flour of tarwi.

The influence of the addition of tarwi flour in the fermented whey drink is related to that indicated by several studies that reveal that a percentage greater than 48.8% whey and a percentage less than 2% tarwi flour they cause the fermented drink to have lower acceptability [8], [12].

However, the results obtained in this study indicate that the addition of 5% tarwi flour does not generate adverse effects on the acceptability of the product since it showed an average acceptability of 4.49 interpreted as "moderately liked," and that also with a higher percentage than 48.8% of whey, greater acceptability is obtained.

It was agreed with other authors, who produced two mixtures that incorporate different concentrations (YSPT1; 70% milk powder + 30% tarwi flour), (YSPT2; 80% milk powder + 20% tarwi flour). Sensory characteristics, such as smell, taste, and acceptability, did not show any statistically significant difference [16]. Finally, another study obtained as a result in the sensory analysis performed on extruded snacks (quinoa flour, sweet potato flour, and tarwi flour) coated with a 50° Brix honey solution, determined that there is no significant difference between the level to please the 16 formulations [17].

TABLE VII. Proximal Analysis of QB, QN and T (g/100)

Component	QB*	QN**	T***
Moisture	10,67±0,8	10,17±0,5	6,48±0,21
Ash	2,37±0,01	3,26±0,34	3,61±0,01
Crude Fat	5,7±0,4	7,7±0,36	19,5±0,6
Protein	15,02± 0,24	14,4±0,28	48,0±0,58
Fiber	3,1±0,11	6.5±0,3	6,0±0,21
Total Carbohydrates	63,06	57,97	16,41
*QB: Royal whitequinoa ** QN: Royal black quinoa *** T: Tarwi			

Data expressed with the mean ±SD of three repetitions

CONFLICT OF INTERESTS

This research was carried out as a contribution to the knowledge, society and academic purposes contributes to the knowledge of the development of new perfume essences, "The authors declare that we have no conflicts of interest".

AUTHOR CONTRIBUTIONS

A carried out the research design; AB select the materials to experience, AC carried out the design of the CD Experimentation development and data analysis. We carried out the exploratory field study, the authors' contribution is reflected in all the research approved in its final version.

REFERENCES

[1] R. Encinas, "Preparation of a Lactoserum-based drink with the addition of fruit from the region", Bachelor's thesis, National University of the Peruvian Amazon, Peru, 2014.

[2] O. M. Miranda, P. L. Fonseca, I. Ponce, C. Cedeño, L. S. Rivero and L. M. Vázquez, "Preparation of a fermented beverage from whey that incorporates lactobacillus acidophilus and streptococcu thermophiles", Cuban Journal of Food and Nutrition, vol. 24, no. 1, pp. 7-16, 2014

[3] C. A. E. Inda, "Performance optimization and safety assurance in the cheese industry", OAS – Organization of American States, Mexico, p.160, 2000.

[4] R. Blanquicet, C. Flórez, Y. González, E. Meza, and J. Rodríguez, "Synthesis and properties of chitosan/lactoserum-based films polymers: Science and technology", Asoc. Brasileira de Polímeros São Paulo, vol. 25, no. 1, pp. 58-69, Brasil, 2015.

[5] J. Callejas, F. Prieto, V. Reyes, Y. Marmolejo, and M. Méndez, "Physicochemical characterization of a whey: phosphorus recovery potential", University of Guanajuato, Mexico, vol. 22, no 1, pp. 111-18, 2012

[6] K. Cury, M. Arteaga, G. Martínez, D. Luján, and A. Durango, "Evaluation of the fermentation of the acid whey (whole and deproteinized) using lactobacillus casei, Colombian Biotechnology Magazine, National University of Colombia Bogota, Colombia, vol. 16, no. 1, pp. 137-145, 2014.

[7] G. Suca and C. Suca, "Potential of tarwi (Lupinus mutabilis Sweet) as a future protein source and advances in its agro-industrial development", Rev. Per. Quím, vol. 18, no. 2, pp. 55-71, 2015.

[8] L. Pichihua, M. Sichez, and C. Julio, "Influence of the partial replacement of whey and quinoa flour (Chenopodium quinoa willd) on the organoleptic and physicochemical properties of substituted yogurt (Tesis de bachiller)" National University José María Arguedas, Andahuaylas, Peru, 2016.

[9] T. Ozcan, L. Yilmaz-Ersan, A. Akpinar-Bayizit, B. Delikanli, and A. Barat, "Survival of lactobacillus spp. in fruit based fermented dairy beverages", International Journal of Food Engineering, vol. 1, no. 1, pp. 44-49, June 2015.

[10] M. M. L. Uribe, S. Valencia, A. J. U. H. Monzón, and J. E. P. Suescún, "Fermented fresh cheese whey drink inoculated with Lactobacillus casei", National Faculty of Agronomy Magazine Medellin, vol. 61, no. 1, pp. 4409-4421, 2008.

[11] N. Güenes-Vera, O. Arciniega-Ruiz, and G. Dávila-Ortiz, "Structural analysis of the Lupinus mutabilis seed, its flour, concentrate and isolate as well as their behavior when mixed with wheat flour," Lebensmittel-Wissenschaft & Technologie, vol. 37, pp. 283-290, 2004

[12] F. Endara and A. Francisco, "Preparation of a drink from cheese whey and skim milk with mango flavor", Bachelor's thesis, Pan American Agricultural School, 2002.

[13] R. Gross, E. V. Baer, F. Koch, R. Marquard, L. Trugo, and M. Wink, "Chemical composition of a new variety of the Andean lupin (Lupines mutabilis cv. Inti) whit low alkaloid content" Journal of Food Composition and Analysis, vol. 1, pp. 353-361, 1988.

[14] M. Díaz , "Optimization of the breadmaking process by replacing wheat flour (Triticum aestivum) with tarwi flour (Lupinus mutabilis) and quinoa flour (Chenopodium quinoa)", Bachelor's thesis, National University of Trujillo, Peru, 2015.

[15] N. Navia, G. Nina, E. Mena, and L. Salcedo, "Enzymatic hydrolysis in quinoa and tarwi flour by α -amylase effect", Biotechnology in the Agricultural and Agroindustrial Sector, vol. 17, no.1, pp. 64-73, 2019

[16] C. Benjamín, M. Renán, C. Fabricio, J. Ana, E. Fernando, C. Frank, and H. Jorge, "Probiotic elaborated from the seeds of Lupinus mutabilis sweet (chocho o tarwi)" Peruvian Medical Act, vol. 25, pp. 210-215, 2008.

[17] K. Pérez, C. E. Peñafiel, and V. Delgado, "High-protein snack: an extruded from quinoa (Chenopodium quinoa Willd.), tarwi (Lupinus mutabilis Sweet), and sweet potato (Ipomoea batatas, L.) Scientia Agropecuaria, vol. 8, pp. 377-388, 2017

[18] P. Williams, "Formulation and elaboration of two soft drinks based on sweet whey of fresh cheese and fruit flavor", Bachelor's thesis, Pan American Agricultural School, Zamorano, Honduras, 2002.

Wilber Quispe,
Andahuaylas 1981 Agronomist, graduated from the National University José María Arguedas, master in environmental engineering, with extensive experience in beekeeping, university professor, doctoral student in environmental engineering.
Contribution: Experimentation development and data analysis.

Doris Esenarro
Cusco, 1968 system engineer and bachelor of architecture of the National University Federico Villarreal, Lima, Peru, professor of Faculty of Environmental Engineering of the University Federico Villarreal, professor of the Graduate School EUPG. The research topics are focused on the environmental pollution generated by vehicles, sustainable ecotourism constructions and renewable technologies.
Contribution: Data analysis technologies.

Carol Ocaña
Lima, bachelor of engineering in agro industry, graduated from the National University Federico Villarreal, works in a food processing company
Research with food and non-food products.
Contribution: Data processing

Ciro Rodriguez
Lima, 1961, industrial engineer of the National University Federico Villarreal, Lima, Peru 1990.
He has worked in the National Registry of since 2003 is associate professor of the Faculty of Computer and Electronic Engineering of the University Federico Villarreal, professor of the Graduate School EUPG and the School of Software Engineering of the National University Mayor de San Marcos.
Contribution: supervision of the methodology used

Jennifer Arteaga
Research student at the Peruvian university of applied sciences and international trade management by the exporter's association.
Contributions: Processing data.