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DEVELOPMENT AND CHARACTERIZATION OF AN OPTIMIZED NOVEL DRINK FROM THREE VARIETIES OF SPROUTED QUINOA

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ABSTRACT

Sprouted products are a food alternative that contribute to improving human nutrition. Quinoa has a large amount of natural antioxidants. The dry and hard grains when they undergo a germination process change to tender and slightly acidic sprouts that contain amino acids, minerals, vitamins, enzymes that help digestion and antioxidants. Furthermore, sprouted quinoa has a high protein content and a low concentration of saponins. Previous studies have shown that sprouted quinoa has shown an increase in protein, calcium and ascorbic acid content. Quinoa sprouts improve the organoleptic characteristics of quinoa grains; few studies have used sprouted quinoa in the preparation of beverages. The objective of this study was to prepare a beverage based on sprouted quinoa using a simplex lattice mix design to determine the optimal formula. Three varieties of sprouted quinoa were used: white (Salcedo INIA), red (INIA-415 Pasankalla), and black (INIA 420-Negra Collana). The quinoa was incubated at 30°C in the dark for 48 hours at a relative humidity of 98%. Ten treatments with different proportions of the three types of sprouted quinoa were used. The antioxidant capacity and consumer satisfaction of the ten treatments were evaluated. The ABTS method was used to measure the antioxidant capacity of each treatment. The optimal drink mix was composed of 81.67% sprouted black quinoa, 18.33% sprouted white quinoa, and 0% sprouted red quinoa. Furthermore, the consumer acceptability results were similar across all treatments ($p>0.05$). A nutritional analysis revealed significant differences ($p<0.05$) between the optimized drink and the control treatment. The microbiological analysis demonstrated that the formulated drink met the required sanitary norms for aerobic mesophiles, coliforms, molds, yeasts, and absence of Salmonella. The quinoa beverage made from three varieties of germinated quinoa represents a novel alternative to the current drinkable products marketed in Peru due to its nutritional content, antioxidants, and ease of preparation.

Key words: Sprouts, *Chenopodium quinoa*, ABTS, Design-expert, Mixture design, antioxidant capacity, acceptability

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INTRODUCTION

Quinoa (*Chenopodium quinoa* Willd) belongs to the *Amarantaceae* family and is considered an Andean grain cultivated in the Andes region spanning Peru and Bolivia. Its adaptability to diverse environments, ranging from sea level to 4000 m above sea level, is attributed to its rusticity and ability to withstand different conditions. Quinoa exhibits a high protein content, ranging from 13.81% to 21.90%, and its nutritional composition varies depending on the native variety. All of them contain essential amino acids, vitamins, micronutrients, phytosterols, and flavonoids [1]. Due to these nutritional properties and its multiple uses, but also for considering it as an alternative to solve the serious nutrition problems human.[2]. Moreover, quinoa seeds are renowned for their abundance of natural antioxidant compounds. The antioxidant capacity of quinoa has been predominantly observed in red and black varieties [3,4]. Notably, certain studies have indicated an increase in antioxidant capacity after sprouting, particularly in black quinoa [5].

Germination transforms dry and hard grains into tender alkaline sprouts, which are abundant in amino acids, digestive enzymes, vitamins, minerals [6], antioxidants, a significant amount of fiber, and active enzymes [7]. Furthermore, sprouted quinoa exhibits a high protein content and a low concentration of saponin [8, 9]. According to Bravo [10], sprouted quinoa showcases a slight increase in protein content (from 12.94 to 13.09 mg%), calcium (from 85.0 to 405.44 mg%), and ascorbic acid (from 0.74 to 6.20 mg%). Overall, the process of germination enhances the organoleptic properties of quinoa grains, making them more palatable.

Germination enhances the levels of health-promoting compounds in quinoa, thereby offering opportunities for the development of more nutritious and healthier food products [11]. The utilization of process and mixing factors within the same design facilitates the development of these health-conscious foods. In a mixture experiment, various mixtures are selected, incorporating different proportions of their ingredients [12]. Mixture design is employed in the development and optimization of food-based products, where the evaluated characteristics typically rely on the proportions of individual ingredients present in the formulations [13].

Due to concerns about lactose, fat, and cholesterol, plant-based foods are gradually gaining acceptance and becoming part of many individuals' diets. Lifestyle changes also contribute to the reduced consumption of milk, as many young people in this generation prefer alternative options that are both beneficial and easier to consume [14]. Hence, the primary objective of this study was to determine the optimal mixture for creating a beverage based on three varieties of

sprouted quinoa: "white" (Salcedo INIA), "red" (INIA-415 Pasankalla), and "black" (INIA 420-Negra Collana). This was achieved through a mixture design approach utilizing design-expert® software version 11.

MATERIALS AND METHODS

Raw material and ingredients

The drink was prepared from the liquid mixture of three sprouted quinoa varieties: Salcedo INIA (SWQ), INIA-415 Pasankalla (SRQ) and INIA 420-Collana Negra (SBQ). The quinoa grain, of each variety, was supplied by the company Andes Alimentos y Bebidas S.A.C in Peru. The ingredients used were Frutarom brand vanilla flavoring powder, Frutarom brand potassium sorbate, sugar, and CMC (carboxymethyl cellulose) stabilizer.

Physical characterization of the raw material

The granulometric analysis of the three quinoa varieties was conducted following the guidelines outlined in the Peruvian technical standard for quinoa 205.062:2014 [15]. The analysis involved employing a series of sieves with three distinct diameters, namely 1.31mm, 1.18mm, and 1.0mm. These sieves were positioned vertically on a Raftmann ML 712-4 brand vibrator and subjected to vibrations for a duration of 5 minutes.

Germination procedure

The germination process was conducted following the method described by Paucar Menacho *et al.* (2018) with certain modifications. Quinoa seeds (200 g for each variety) were immersed in a 0.1% sodium hypochlorite solution (1:5, w/v) at room temperature for 30 minutes [11]. Subsequently, the water was drained, and the seeds were thoroughly rinsed with distilled water until the residual hypochlorite was completely removed and a neutral pH was achieved. The quinoa seeds were then soaked in distilled water (1:5, w/v) for an additional 6 hours, with intermittent shaking every 30 minutes. Afterward, the hydrated seeds were placed in sterile metal trays on moist filter paper, resulting in three separate trays for each variety. These trays were placed inside an incubator (JSB Model.220 brand) for germination under dark conditions at 30 ºC for 48 hours. To maintain a relative humidity of 98%, water was sprayed for 15 minutes at 12-hour intervals. The grains were manually aerated every 5 hours, followed by rinsing with distilled water. Finally, the samples were stored at 18ºC for future use.

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Preparation of the drink

The procedure outlined by Pineli [16] was adopted for this study with certain modifications. The beverage preparation took place at the pilot plant located in the laboratory of Andes Alimentos y Bebidas S.A.C. in Lima, Peru. The process commenced with the crushing of the germinated quinoa, with each variety handled separately. A Philips HR3652 blender, providing 1400 Watts of power and operating at 35000 RPM, was employed for this purpose, with a blending duration of one minute. A ratio (1:2) 1 of quinoa and 2 of purified water, at room temperature was used during this process. The resulting crushed product underwent filtration utilizing cotton gauze to obtain a homogeneous liquid, while discarding the residue. Only the filtered liquid was retained for further processing. Finally, the filtered liquid was flavored with vanilla and sweetened with sucrose, followed by undergoing a thermal pasteurization process in an AISI 304 quality stainless steel kettle at a temperature of 80 °C for a duration of 20 minutes [17].

Drink formulation

The determination of the optimal formulation was achieved by employing a simplex lattice mixture experimental design. This design was utilized to evaluate the impact of the various treatments on the dependent variables, namely antioxidant capacity and sensory acceptability. A total of 10 mixtures were formulated, incorporating different proportions of the filtrate obtained from each variety of germinated quinoa (refer to Table 1). The estimation of the optimal formula was carried out by analyzing the mixture design data and utilizing response variable optimization techniques for both antioxidant capacity and sensory acceptability.

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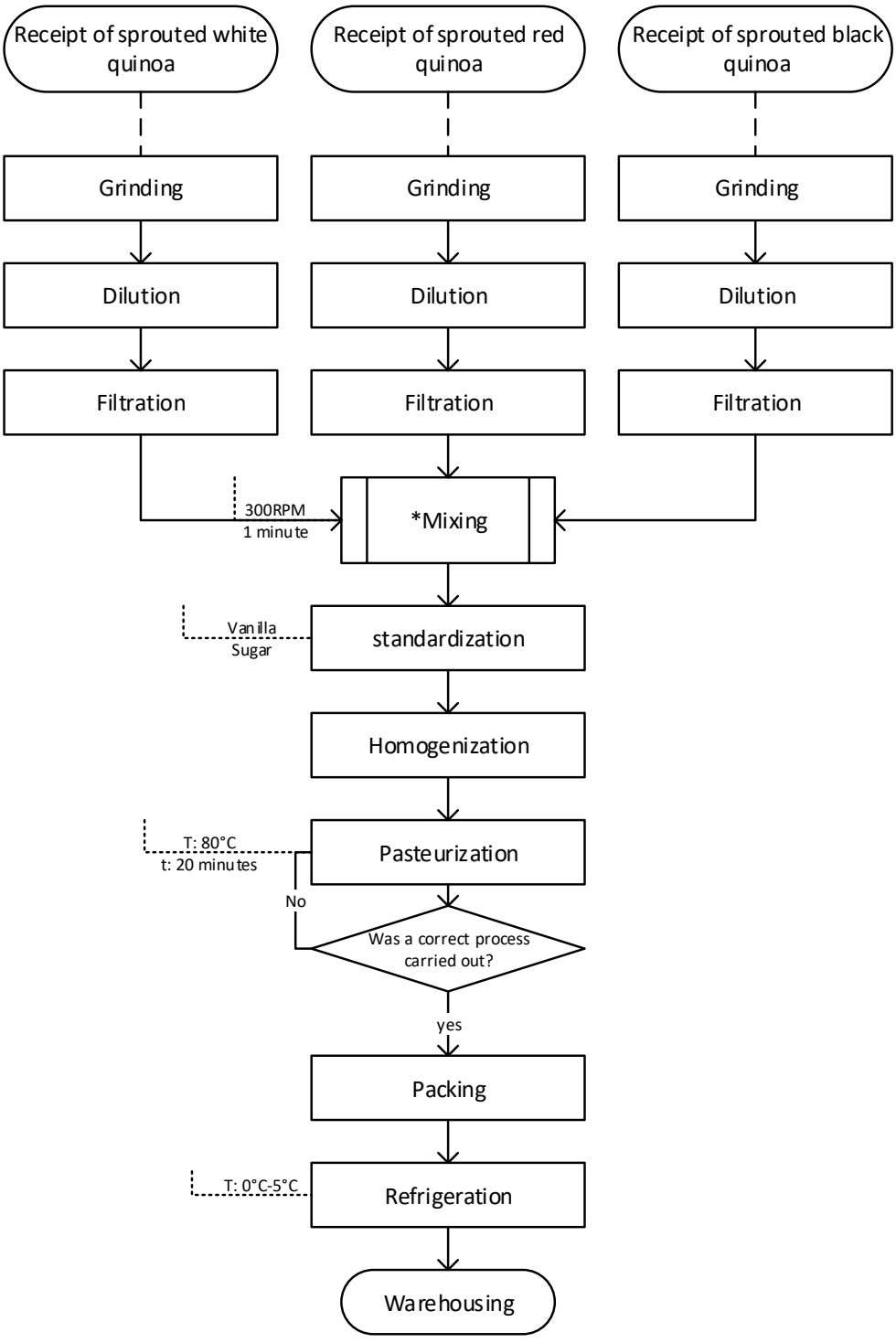

Figure 1: Workflow of the sprouted quinoa drink development

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Physicochemical and microbiological analysis of the drink

The pH measurements of the treatments were conducted in triplicate using a Biolab model PG38W digital potentiometer. The soluble solids (Brix degrees) were measured using an ATC brand refractometer, specifically the GM-RHW032 model. The analysis of major nutritional compounds was performed in triplicate as well. The protein content was determined using the AOAC 920.152 Kjeldahl method (2009), while the ash content was assessed through the AOAC 940.26 method (1994) The fat content was determined using the AOAC 905.02 method (1973) and the carbohydrate content was determined by the difference method MS-INN (Collazos 1993).

For the determination of mesophilic aerobes, the was utilized for the detection of E. coli. Finally, the official AOAC Method 989.13 (2016) was applied for the detection of Salmonella.

Antioxidant capacity evaluation using the ABTS method

The evaluation of antioxidant capacity was performed using the modified ABTS (2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid)) method, adapted from the Floegel method [18]. A Zuzi 4255 brand spectrophotometer (model 4201/20, Navarra, Spain), was employed for the measurements. For the assay, 15.52 mg of ABTS reagent was mixed with 4 mL of distilled water. Subsequently, 2.64 mg of potassium persulfate was added to the solution, and the reaction was allowed to proceed for 16 hours at room temperature in an amber bottle. Additionally, 2.5 g of each drink treatment and 12.5 mL of absolute ethanol were weighed. The absorbance was measured at 754 nm using a spectrophotometer. The absorbances were recorded after a 10-minute reaction time for each treatment. A standard curve was constructed using Trolox (Sigma-Aldrich) as an antioxidant at concentrations ranging from 0 to 25 µM/mL. The results were expressed as µM Trolox equivalents per mL (µM TEAC/mL). All samples were analyzed in triplicate.

Organoleptic acceptability

The sensory acceptability test for the 10 treatments derived from the mixture design was conducted using a balanced incomplete block design (DBIB). The DBIB was characterized by the following parameters: t (number of treatments or samples) = 10; k (number of block treatments) = 4; b (number of blocks or judges) = 60; r (number of repetitions per sample) = 24; N (total number of experimental units) = 240. Each formulation was assigned a unique three-digit random code, and participants were given a random order in which to consume the samples. The samples were served at room temperature, and participants were instructed to

drink water between each sample to cleanse their palate and neutralize any potential aftertaste.

The consumer panel consisted of 60 participants, who were students and administrative staff of the Faculty of Pharmacy and Biochemistry at the National University of San Marcos. The participants had a mean age of 27.5 years, with an age range of 18-58. The gender distribution among the participants was 56.7% men and 43.3% women.

The test utilized a three-point verbal hedonic scale, where participants could indicate their preference as (1) “dislike” neither like nor dislike”, or (3) “like” [19].

Experimental design and statistical analysis

To examine the impact of different proportions of three varieties of sprouted quinoa on the antioxidant activity and acceptability of a quinoa-based beverage, a simplex lattice mixture design was employed. The design incorporated three components: SWQ (sprouted white quinoa), SRQ (sprouted red quinoa), and SBQ (sprouted black quinoa), (Table 1). The experimental design and the corresponding quantities of each independent variable are presented in Table 1. To optimize the formulation, the combination of factors that yielded the most favorable response was determined. A quadratic model was fitted to express the responses (Y) as a function of the independent variables:

$$Y = \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 12X1X2 + \beta 13X1X2 + \beta 23X2X3$$

In the context of the study, the response variable is represented by Y, while X1, X2, and X3 correspond to SWQ, SRQ, and SBQ respectively. The regression coefficients (β) were calculated using multiple regression analysis based on the experimental data. The suitability of the models developed for the variables investigated in the mixture design was assessed using several statistical indicators, including the coefficient of determination (R2), adjusted coefficient of determination (R2-adj), F-value, and P-value obtained from the analysis of variance (ANOVA). The Design Expert program (version 10, Stat-Ease Inc., Minneopolis, MN, USA) was employed for these analyses. The validation of the obtained models was performed by comparing the predicted values with the experimental values obtained for different responses under optimal conditions.

The analytical results were presented as the mean values accompanied by the standard deviation, based on triplicate measurements. Data analysis was carried out using Minitab software (v.18, Minitab MLL, USA). To assess significant

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differences in the mean values, analysis of variance (ANOVA) was conducted. Once the assumptions of data normalization and homogeneity of variances were confirmed, a Tukey multiple comparison test was employed. Treatments with P values less than 0.05 were considered statistically significant. The acceptability test was subjected to statistical analysis using the Durbin test and multiple comparisons, with a significance level of $P < 0.05$.

RESULTS AND DISCUSSION

Physical characterization of the raw material

The granulometric analysis of table 2 indicates the percentage of mesh retention for each variety of quinoa, for black quinoa it was considered as small grain quality due to the resulting retention in mesh 14 of 1.31mm grain thickness, being 50.45% of the total: for white quinoa, 81.95% was retained, considered as medium quality and finally; red quinoa was classified as large grain quality since the retention percentage was 91.44% (greater than 85% retained in mesh 14 of 1.31 mm grain thickness).

Germination of the three quinoa varieties

The germination percentages for white, red, and black quinoa were 96%, 91%, and 87% respectively. The radicle growth after 48 hours of germination was observed to be in the range of 0.6-0.8 cm for white quinoa, 1.7-1.8 cm for red quinoa, and 1.7-1.8 cm for black quinoa.

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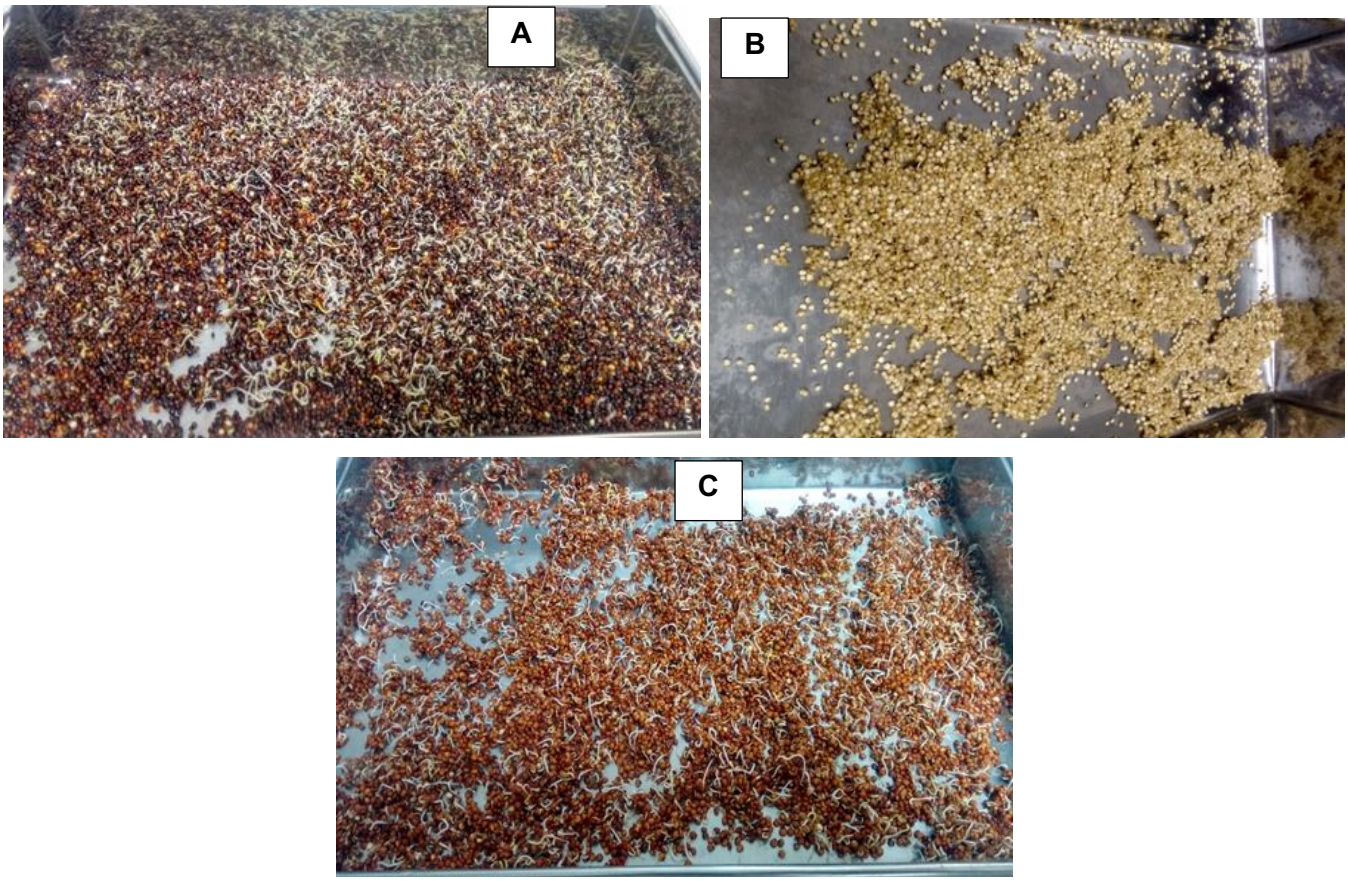

Figure 2: Three varieties of quinoa
(A) Sprouted white quinoa;
(B) Sprouted red quinoa;
(C) Sprouted black quinoa

Determination of the pH and soluble solids of the germinated quinoa drink
The pH measurements for each treatment are presented in Table 3. The average pH values for the 10 treatments were calculated, and no significant differences were observed among them. The analysis of soluble solids, measured using an ATC GM-RHW032 refractometer following the AOAC 983.17 method (2005) yielded results ranging from 1.2 to 1.45 ºBrix for the 10 treatments.

Effect of sprouting on antioxidant capacity
Treatments comprising various compositions based on the design of experiments (DOE) were prepared using ungerminated components (control treatments) and germinated components to compare them and evaluate the impact of germination on antioxidant capacity.

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Among the ten control treatments consisting of non-germinated quinoa drinks, lower antioxidant activity was observed in T7 (5.99 µM TEAC/mL) with a formulation of 33.33% white quinoa (WQ), 33.33% red quinoa (RQ), and 33.33% black quinoa (BQ). Among the ten treatments with quinoa sprout drinks, the lowest antioxidant activity was observed in treatment 1 (100% black quinoa, QB) with 15.91 µM TEAC/mL, while the highest activity was recorded in treatment 9 (16.67% QB, 66.66% RQ, 16.67% BQ) with 21.60 µM TEAC/mL.

Based on TEAC and ABTS values, the sprouted quinoa drink demonstrated significant antioxidant activity, making it a potential substitute for commercially available carbonated beverages that contain fructose, sucrose, and various colorants which pose risks to human health and can lead to depressive symptoms [20]. Additionally, this product's organic formulation without additives, colorings, or preservatives adds to its beneficial attributes. The antioxidant capacity of this drink also surpasses that of many artificial commercial beverages, as indicated in the study conducted by Floegel *et al.* [18].

The heat treatment applied to the drink had an impact on its reducing properties, potentially resulting from the loss of natural antioxidants [21] and the generation of new oxidative compounds during the early stages of the reaction, depending on the specific combinations of temperature and duration. This depletion in the overall antioxidant properties of the drink could explain the decrease in antioxidant compounds observed in the final product. Scientific literature indicates that quinoa without any thermal processing exhibits high values of trolox equivalents (µM/100g), which is supported by studies such as the one conducted by Dini *et al.* [22], where boiling resulted in a loss of antioxidant capacity in quinoa seeds. Additionally, Palermo [23] reported a nearly 50% reduction in phenolic compounds due to firing.

The formulation with the highest antioxidant capacity was found to be treatment T9 (21.60 µM ET/ml), which can be attributed to the presence of black and red quinoa varieties containing higher levels of anthocyanins, flavonoids, and lycopene. Conversely, treatment T1 (15.91 µM ET/ml), which solely consisted of white quinoa exhibiting yellow coloration, exhibited the lowest antioxidant capacity, potentially indicating the presence of xanthophylls as indicated by Zambrano's research in 2013 [24].

Formulations T3 and T5, prepared with 100% sprouted white quinoa and a mixture of 50% sprouted black quinoa and 50% sprouted white quinoa, respectively, demonstrated the highest acceptability. This could be attributed to the pleasant

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semi-sweet flavor contributed by the white quinoa and the black variety Collana, as indicated in Table 3.

Organoleptic acceptability of the sprouted quinoa drink

Figure 3 presents the average acceptability values for the ten treatments included in the mix design. Durbin's test revealed significant differences ($p<0.05$) among all ten treatments. Specifically, treatments T1-T5, T4-T5, and T3-T4 showed significant differences ($p<0.05$) when subjected to the multiple comparisons test. The treatment that received the highest score was T5 (SWQ:SBQ - 50%:50%), with mean and standard deviation scores of 3.0 and 1.02, respectively. According to the sensory scale utilized, treatment T5 was rated as "I like it". On the other hand, treatment T4 (SWQ:SRQ - 50%:50%) obtained the lowest score, with mean and standard deviation values of 2.0 and 0.81, respectively. This indicates that, on average, the panel rated treatment T4 as 'neither like nor dislike'. The remaining treatments fell within the range of ratings between "neither like nor dislike" and "like".

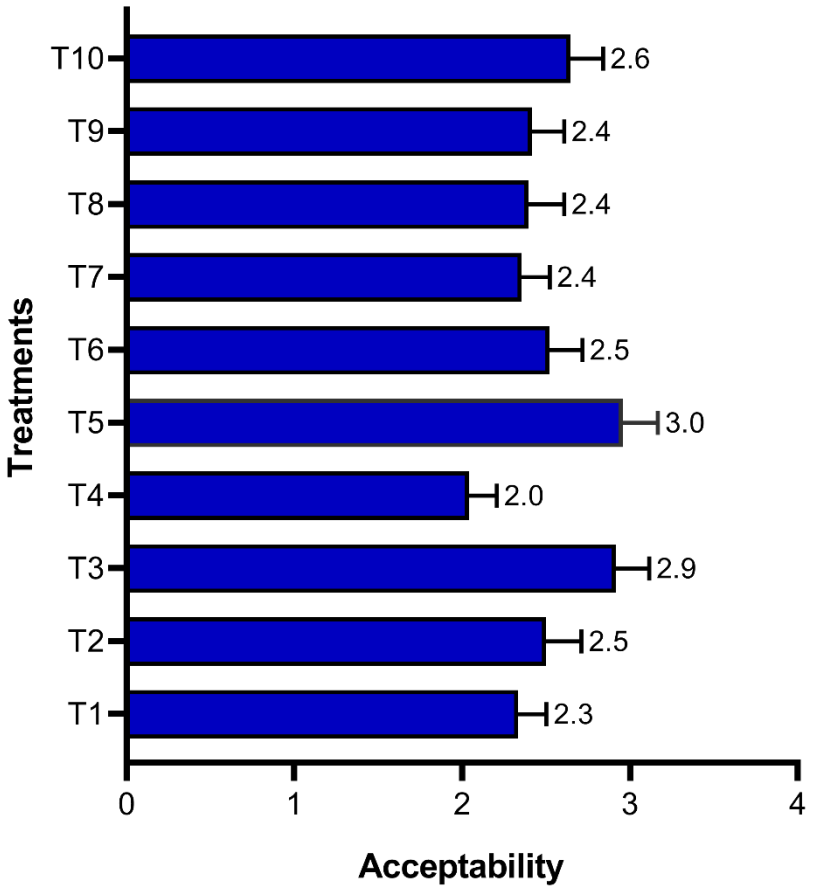

Figure 3: Acceptability scores of the sprouted quinoa drink

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Model fit and optimal formulation

The analysis of variance (ANOVA) yielded a quadratic model for the acceptability variable. The obtained values for R2 and adjusted R2 were 0.9723 and 0.9549, respectively, indicating a high level of fit of the predictive model. The coefficient of variation was determined to be 2.47%, further supporting the model's quality. Moreover, the model demonstrated significance with a p-value of less than 0.0001 and an F value of 56.09, further affirming its reliability. The predictive model for acceptability is as follows:

$$Y = 0.56 * SWQ + 0.60 * SRQ + 0.69 * SBQ - 0.003714 * SWQ * SRQ + 0.002647 * SWQ * SBQ - 0.0021 * SRQ * SBQ$$

Where:

Y: Acceptability

All the terms of the quadratic equation exhibited a significant influence on the sensory acceptability score ($P < 0.05$) of the sprouted quinoa beverage. This indicates that each component of the beverage (SWQ, SRQ, and SBQ) plays a role in influencing the acceptability of the drink based on different varieties of quinoa sprouts.

In contrast, the regression model obtained for the antioxidant capacity content in the sprouted quinoa-based drink did not demonstrate significance in relation to the proportions of the studied components in the mix design. Although the coefficient of determination for the model was 0.8013 (R2 = 0.8013), indicating a relatively high value, the adjusted coefficient of determination was below 0.75 (adjusted R2 = 0.4834). According to Paucar-Menacho *et al.* [11] only R^2 values greater than 0.75 indicate the goodness of fit of the models [11]. The low value obtained for the adjusted R^2 suggests that the generated model was inadequate in predicting the variation of the experimental data for the proportions of germinated quinoa studied. The coefficient of variation was determined to be 6.54. Moreover, the model did not exhibit significance, with a P-value of 0.1617 and an F value of 2.52. None of the model terms were found to be significant ($P > 0.05$).

The optimization process using mix design revealed that the optimal proportions for maximizing acceptability in the sprouted quinoa drink were determined to be 18.333% SWQ, 0% SRQ, and 81.6667% SBQ. The desirability value for this optimal mixture was calculated as 1.00, indicating a highly desirable outcome (Figure 5).

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The acceptability of the sprouted quinoa drink exhibited a significant response according to the R2 model, with a value close to 1. This signifies that there is a noticeable difference in acceptability among the 10 treatments of the germinated quinoa drink. Consequently, the program utilized only the results from these treatments for the final optimization of the product.

Figure 4 depicts the contour plot illustrating the impact of the mixtures of the three sprouted quinoa varieties (SWQ, SRQ, and SBQ) on the consumer acceptability of the beverage. The drink formulated with these three varieties of germinated quinoa demonstrated the highest levels of acceptability.

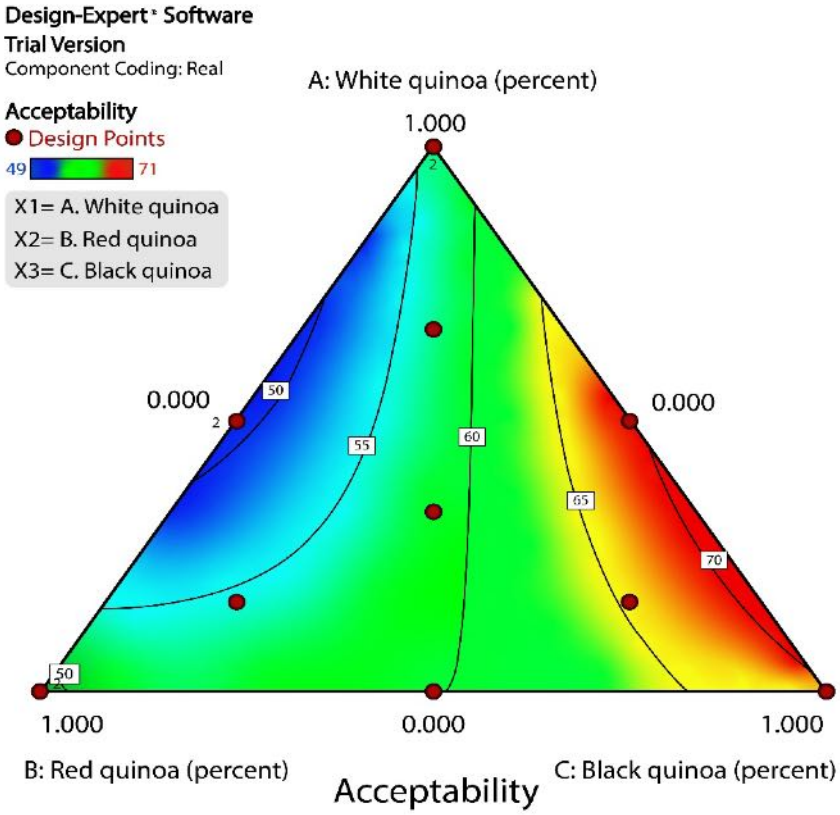

Figure 4: Contour plot of acceptability

Microbiological analysis

The results for mesophilic aerobes, molds, yeasts, and coliforms showed levels below 10 CFU/g in all cases (Table 4). Additionally, Salmonella sp. was absent in all tests. This outcome is significant for ensuring the stability of the beverage on the shelf and its overall quality.

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The microbiological analyses were conducted in accordance with the microbiological criteria for beverages described in R.M 591-2008-Minsa-27-06-2008 (Sanitary Standard for Microbiological Criteria, Diario el Peruano, 2008). The obtained results were positive, indicating the absence of microbial growth in the analyzed samples, and they met the permissible limits for consumption.

Mixture design

The final mixture design was employed to optimize the composition of the sprouted quinoa drink. The collected data were subsequently input into the Design-expert program 11 for analysis. The results revealed a non-significant model with an R2 value less than 1 for the antioxidant capacity, indicating that the model did not adequately explain the variations in this parameter. However, a significant model with an R2 value close to 1 was obtained for the acceptability of the drink, indicating that the model provided a good fit to the data (Table 5).

Utilizing the Design-expert program 11, the optimal formulation for the sprouted quinoa drink was determined. It consists of 18.333% white quinoa, 0% red quinoa, and 81.667% black quinoa. This formulation was identified as the most favorable composition based on the analysis conducted.

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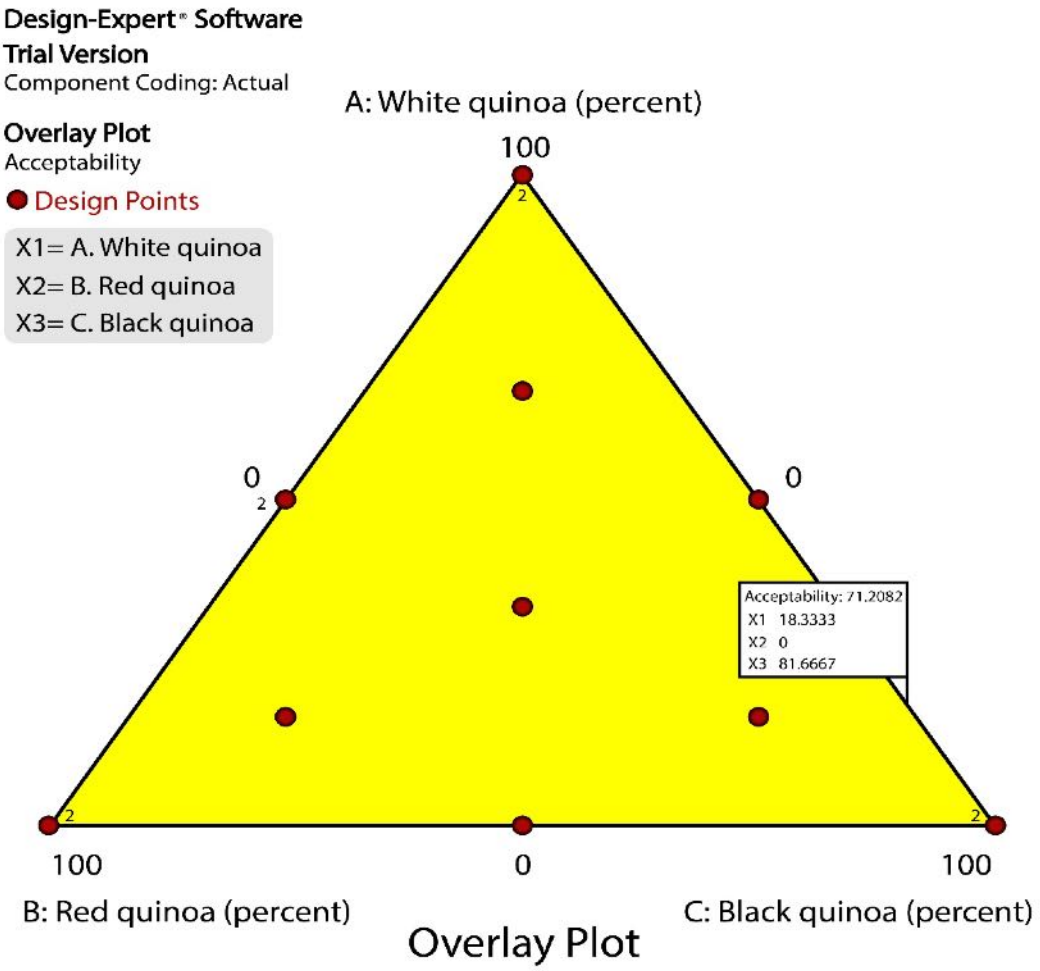

Figure 5: Optimal formulation of the sprouted quinoa drink

One of the limitations encountered in the preparation of the sprouted quinoa drink using the three quinoa varieties was the occurrence of instability issues, such as phase separation, precipitation, and lump formation. This phenomenon was attributed to starch gelatinization, as highlighted by Biduska *et al.* [25] in his previous research. To address this challenge, Pérez B *et al.* [26] employed heat sterilization, which not only improved the appearance of the drink but also prevented phase separation. However, it is worth noting that this process has some drawbacks, including a potential decrease in product pH by 0.3 to 0.5 units and the caramelization of sugars. In the developed product, the pH of the final drink was measured after the thermal process was conducted.
Moreover, it should be noted that quinoa-based sprouted drinks are not currently available in the market. Therefore, they represent a viable and promising alternative to artificial beverages that lack substantial health benefits.

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CONCLUSION, AND RECOMMENDATIONS FOR DEVELOPMENT

The process of elaborating the beverage using three varieties of germinated quinoa has provided us with new insights into the technological requirements for cereal germination. This process has been successful in terms of enhancing the nutritional properties of the drink.

The sensory evaluation of the ten formulated treatments revealed that the 5th formulation (T5: WQ:BQ - 50%:50%) exhibited the highest level of acceptability. Treatment number 9 (WQ: 16.67%, RQ: 66.66%, and BQ: 16.67%) demonstrated the best antioxidant capacity with a value of 21.60 uMEt/Ml.

By employing the mixture design program Design-expert 11, it was determined that the optimal formulation consists of 18.333% white quinoa, 0% red quinoa, and 81.6667% black quinoa.

Likewise, the characteristic flavor of sprouted quinoa drinks and the formation of sediments can be reduced through the use of hydrocolloids that guarantee the stability of the drink and therefore better acceptance. It is recommended to evaluate the stability of the product during storage to determine its shelf life.

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Table 1: Proportions of different varieties of sprouted quinoa according to the simplex lattice Mixture Design

Treatments	SWQ (%)	SRQ (%)	SBQ (%)
T1	100	0	0
T2	0	100	0
T3	0	0	100
T4	50	50	0
T5	50	0	50
T6	0	50	50
T7	33.33	33.33	33.33
T8	66.66	16.67	16.67
T9	16.67	66.66	16.67
T10	16.67	16.67	66.66

Legend: SWQ= Sprouted white quinoa; SRQ= Sprouted red quinoa; SBQ=Sprouted black quinoa

Table 2: Percent retention of quinoa varieties' mash in mesh of different dimensions

		% Detained		
Mesh	Size	Black quinoa	White quinoa	Red quinoa
14	1.31 mm	50.45	81.95	91.44
16	1.18 mm	43.26	12.15	8.01
18	1.0 mm	4.41	3.89	0.43
Small	<1.0 mm	1.88	2.01	0.12
Grain quality		Small	Medium	Large

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Table 3: Values of antioxidant capacities, pH values and soluble solids in sprouted and non-sprouted quinoa drinks

Treatment	Quinoa drinks -Antioxidant capacity (uMet/ml)			
	non-sprouted	sprouted	Sprouted *	
			(pH)	°Brix
T1	6.68 ± 0.2	15.91 ± 0.55	6.15	1.45
T2	9.64 ± 0.1	17.38 ± 0.4	6.39	1.3
T3	8.38 ± 0.23	16.76 ± 0.51	6.34	1.25
T4	7.33 ± 0.05	16.24 0.28	6.36	1.2
T5	7.18 ± 0.22	16.16 ± 0.58	6.37	1.3
T6	7.76 ± 0.51	18.97 ± 0.6	6.35	1.3
T7	5.99 ± 0.8	16.11 ± 0.51	6.39	1.3
T8	7.29 ± 0.3	16.22 ± 0.27	6.36	1.3
T9	9.17 ± 0.33	21.6 ± 0.41	6.35	1.3
T10	7.73 ± 0.26	17.17 ± 0.12	6.35	1.3

(*) average

Table 4: Microbiological results of the optimized drink based on sprouted quinoa

Microorganism	Unit	Maximun limit	Count
Aerobic mesophilic microorganisms	UFC/g	10^2	<10
Molds	UFC/g	10	<10
Yeast	UFC/g	10	<10
Escherichia coli	UFC/g	<2.2	<10
Salmonella sp.	/in 25g	absence	absence

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Table 5: Combination Matrix of Mixture design

Treatments	Components							
	X_1	WQ (%)	X_2	RQ (%)	X_3	BQ (%)	Antioxidant capacity UM ET/ml	Acceptability
T_1	1	100	0	0	0	0	15.91	56
T_2	0	0	1	100	0	0	17.38	60
T_3	0	0	0	0	1	100	16.76	70
T_4	1/2	50	1/2	50	0	0	16.24	49
T_5	1/2	50	0	0	1/2	50	16.16	71
T_6	0	0	1/2	50	1/2	50	18.97	60.5
T_7	1/3	33.33	1/3	33.33	1/3	33.33	16.11	56.5
T_8	2/3	66.66	1/6	16.67	1/6	16.67	16.22	57.5
T_9	1/6	16.67	2/3	66.66	1/6	16.67	21.60	58
T10	1/6	16.67	1/6	16.6;7	2/3	66.66	17.71	63.5

Legend: WQ: White quinoa; RQ: Red quinoa; BQ: Black quinoa

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Table 6: Nutritional content of the Optimized Drink made of sprouted and non-sprouted quinoa

	Quinoa	
	Non-sprouted	**Sprouted**
Crude Proteins	1.54±0.007[a]	1.93±0.014[b]
Carbohydrates	9.79±0.007[a]	4.63±0.042[b]
Fat (crude lipids)	0.42±0.007[a]	0.59±0.028[b]
Moisture content	87.70±0.042[a]	92.83±0.007[b]
Total ash	0.38±0.028[a]	0.20±0.028[b]

The means that do not share a letter are significantly different, level of significance α = 0.05

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