

(RESEARCH ARTICLE)



Healthy foods for human consumption produced with amaranth, chia and quinoa seeds and precooked soybean

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Abstract

The purpose of this report is to improve and make higher benefits on human diet through the consumption of seeds having high nutritional values. Different combinations of amaranth, chia and quinoa seeds and precooked soybean were used to elaborate a new sweet food. Mixed seeds (flour) and soybean whit peanut, sugar or stevia, glucose, hydrogenated oil and natural essence were prepared and tasted by people of both sex and age range from 1 to 78 years old. Previously nutritional composition was analyzed in the different samples. Sweet foods samples were given to persons to evaluate the acceptance and preference of them compared with two market candies of similar composition. The association analysis was performed using t-test and Analysis of Variance (ANOVA) with Bonferroni's multiple comparisons for quantitative variables and chi square test for qualitative variables. From all the samples having a standard protein content (more than 10% each), have a higher acceptance those composed by amaranth, chia and quinoa, including more acceptance by women. The same result was obtained respect the preference. The production for human consumption of this new sweet food would imply a better use of vegetable proteins as a complement of the diet animal proteins and improve the health preventive advantages.

Keywords: Amaranth; Chia; Human food; Quinoa; Soy

1. Introduction

Amaranth and quinoa are pseudo cereals seeds with high starch content, not so chia seeds (herbaceous plant) with low content of carbohydrates and high content of essential fatty acids like omega-3 type. These seeds contain vegetable proteins and essential amino acids, amaranth possess mainly a large lysine content as well as chia and quinoa; all seeds contain threonine, tryptophan, histidine, isoleucine, leucine, methionine, phenylalanine and valine. Soybean is an oleaginous that contains almost 40% of proteins and essential amino acids too. In addition, these seeds do not contain gluten protein founded in grasses such as wheat, oats, barley and rye, so their consumption is suitable for people with intolerance to it (celiac). The high content of lysine in amaranth allows it an excellent amino acid complementation with maize and rice proteins for its consumption by celiac people.

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These seeds also contain abundant fiber, micronutrients such as minerals and vitamins, other bioactive compounds such as saponins and anti-nutrients whose effects are reduced by cooking, phenolic compounds (antioxidants), phytosterols, etc.

Chemical composition of these seeds makes them to be a great nutritional value for human consumption and also a therapeutic value for the disease's prevention. According to the American Institute for Cancer Research, diets including soy protein not only help fight heart disease and reduce harmful LDL cholesterol while raising good HDL cholesterol levels, they can also help to prevent osteoporosis and cancers such as colon, breast and prostate. They constitute an excellent resource to be used in the production of functional and/or nutraceutical foods to improve the human health [1- 8].

In preliminary studies we analyzed samples of sweet foods for human consumption produced with soybean or amaranth seeds. They were subjected to chemical composition analysis and biological tests with experimental animal (white laboratory rats), to determine their respective nutritional values. Subsequently, we analyzed the acceptance and preference degree in human consumption of sweet foods made with precooked soybean and others made with an industrial waste called "okara" of high protein content, product obtained in the liquid food preparation process soybean [9- 12]. We also studied the poultry feeding with diet containing okara as an alternative protein source, obtaining higher values in egg pose by animals [13].

In the present work amaranth (*Amaranthus caudatus*), chia (*Salvia hispanica L.*), white quinoa (*Chenopodium quinoa Willd.*) seeds and precooked soybean (*Glycine max L.*) were used in preparation of sweet foods for human consumption. Taking into account the great nutritional value of these seeds, one of our main objectives is to create a food habit in the population and promote the consumption of foods made with them. For this reason and as the second main objective, it will also be necessary to provide a new formulation and advice about the obtaining procedures and optimizing of the elaboration processes, to companies that produce and market food at regional, national and international position.

The processed sweet foods were subjected to tasting tests by people (judges) of both sexes and priority age in children. The acceptance and preference of these foods compared to other sweet foods with similar composition and commercial sale was determined.

2. Material and methods

Samples were prepared with amaranth, chia and quinoa seeds and precooked soybean in different combinations and concentration percentages. Sample number one with 12.0% amaranth, 4.0% of chia and 4.0% of quinoa (total seeds 20.0%). Sample number two with 20.0% of precooked soybean, 7.5% of chia and 7.5% of quinoa (total 35.0%) and sample number three with 20.0% of amaranth, 10.0% of chia and 10.0% of quinoa (total seeds 40.0%). Each seeds sample was ground and mixed with peanut butter (~25%) and sugar (~25%) until get a homogeneous mixture. Then hydrogenated oil (~8%), glucose syrup (~7%) and a little vanilla natural essence were added to each sample and mixed again.

A fourth sample was prepared with ground seeds of chia (25.0%) and quinoa (25.0%) as the main mixture components (total seeds 50.0%), no sugar and/or glucose syrup was added. To obtain the sweet taste commercial stevia (with water content, steviol glycoside sweetener 5.000mg/100g, sucralose, potassium sorbate and sodium benzoate as preservatives and citric acid as acidulant) was used. Stevia was added by dripping and sweet taste test was determined. As described above it was added peanut butter (35.0%), hydrogenated oil (15.0%) and a little vanilla natural essence to the sample and mixed until get a homogeneous paste.

The chemical (nutritional) composition of the samples was performed by methods from the Association of Official Analytical Chemists [14, 15, 16].

People (judges) of both sexes and preferably in children age was selected to taste the different elaborated mixtures. They were interviewed in order to make tasting tests on the samples. The judge's opinion was requested with regard to acceptance and preference of each samples using the following scale: 3 (good); 2 (regular); 1 (bad). For the fourth samples, one more acceptance parameter was determined: 4 (very good); 3 (good); 2 (regular); 1 (bad).

Judges were required the preference of each sample compared to commercial sale candies with similar composition to the sample in survey. It was also required the judges to choose each sample according to their preference: 1 (more acceptance) to 3 (smaller acceptance).

A descriptive analysis of the variables was performed presenting percentages, mean and 95% confidence interval. The association analysis was performed using t-test and ANOVA (Analysis of Variance) with Bonferroni's multiple comparisons for quantitative variables and chi square test for qualitative variables. The level of significance considered was 5%. All analyzes were performed with Stata/CI (Confidence Interval) 15 software [17].

3. Results and discussion

Table 1 shows the chemical composition of elaborated samples containing up to 50% totally of seeds mixtures; using the three ground seeds types and soybean (flours) in different proportions with protein composition between 11.5% and 17.0%. Vitriu et al. from our research group were working in chickpeas flour production, carrying out a flow sheet chart to obtain flour at industrial level [18]. Generally, all the samples obtained a good acceptance by the judges, however the preference study of samples revealed significant differences according to the concentrations of the other components of the food; for example, the sugar content is a determining factor as well as the flour mixture purity.

Table 1 Composition of samples by 100g portions each. The protein content of samples varies between 11.5% in sample number 1 to 17.0% in sample number 4

Samples Chemical Composition (by 100g portion each)								
	Sample 1 % DV		Sample 2 % DV		Sample 3 % DV		Sample 4 % DV	
Protein	11.5g	16	12.9g	17	13.6g	18	17.0g	23
Total Fat	19.6g	35	19.0g	34.5	29.0g	53	38.0g	69
Saturated Fatty Acids	6.1g	27	5.9g	26	5.2g	23	4.9g	22
Carbohydrates	51.0g	16	39.0g	13	46.0g	15	31.0g	10
Dietary Fiber	1.2g	4.8	1.4g	5.6	13.0g	52	10.0g	40
Sodium	10mg	0.43	10mg	0.43	12mg	0.52	93mg	4
Energy							534 Kcal	27

%DV: Percent Daily Value; g: grams; mg: milligrams; Kcal: kilocalories

The four samples of sweet food with different compositions were analyzed by judges as shown in Figure 1 (age of participants) and Table 2 (sex distribution of participants). Sample 1 was tasted by 78 people with an average age of 11 years old with Confidence Interval (CI)_{95%}= (9-13) years, minimum age 1 year old - maximum 57 years old, median of 9 and a Percentile (P)75 of 11 years old.

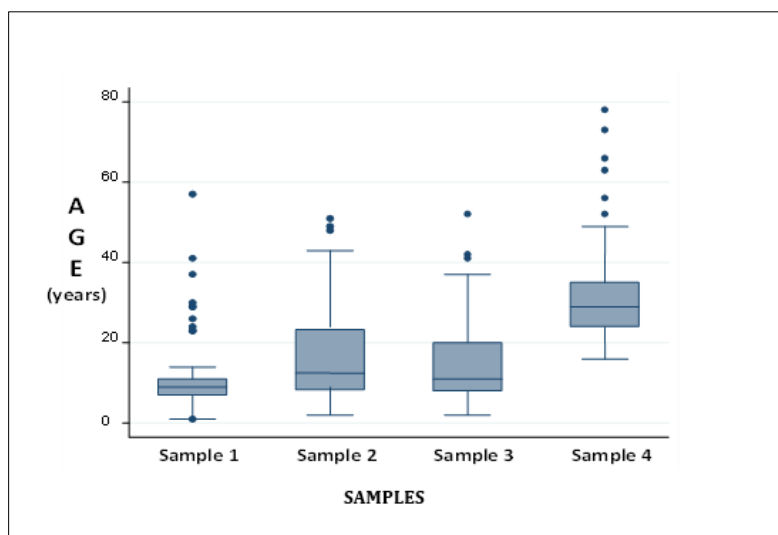


Figure 1 The diagram of judge's age according to the sample's types tasted

Sample 2 was tasted by 90 people with an average age of 18 years old with CI_{95%}= (15-20) years, minimum age 2 years old - maximum 51, a median of 12.5 and a P75 of 24 years old. Sample 3 by 69 people with an average age of 15 years old with CI_{95%}= (12-17) years, minimum age 2 years old - maximum of 52 years old, median of 11 and a P75 of 20 years old. Sample 4 by 41 people with a mean age of 33 years old with CI_{95%}= (28-40) years, minimum age 16 years old - maximum of 78 years old, median of 29 and a P75 of 35 years old. The people's age of sample 4 was significantly higher than the others (ANOVA with Bonferroni's multiple comparisons, p <0.0001).

Regarding the sex of the participants table 2 shows that in the groups of samples 1 to 3 women predominate and men in sample 4 although there are no significant differences in the distribution of sex according to sample (chi square test, p=0.109).

Table 2 The Judges sex distribution in the four samples studied

Sample	Male	Female	Total Number of Judges (100%)
1	32 (41%)	46 (59%)	78
2	30 (33%)	60 (67%)	90
3	28 (41%)	41 (59%)	69
4	23 (56%)	18 (44%)	41

Figure 2 shows that the highest number of participants in samples 1, 2 and 4 consider it "good" (74%, 67% and 66% respectively), followed by "regular" for samples 3 and 4 (38% and 27% respectively) and "poor" for sample 1 (18%). The highest number of participants who tasted sample 3 considers it "regular 38%", "bad 33%" and "good 29%". There are sufficient evidences to ensure that acceptance of the new sweet food is significantly different depending of the analyzed sample (chi square test p<0.0001).

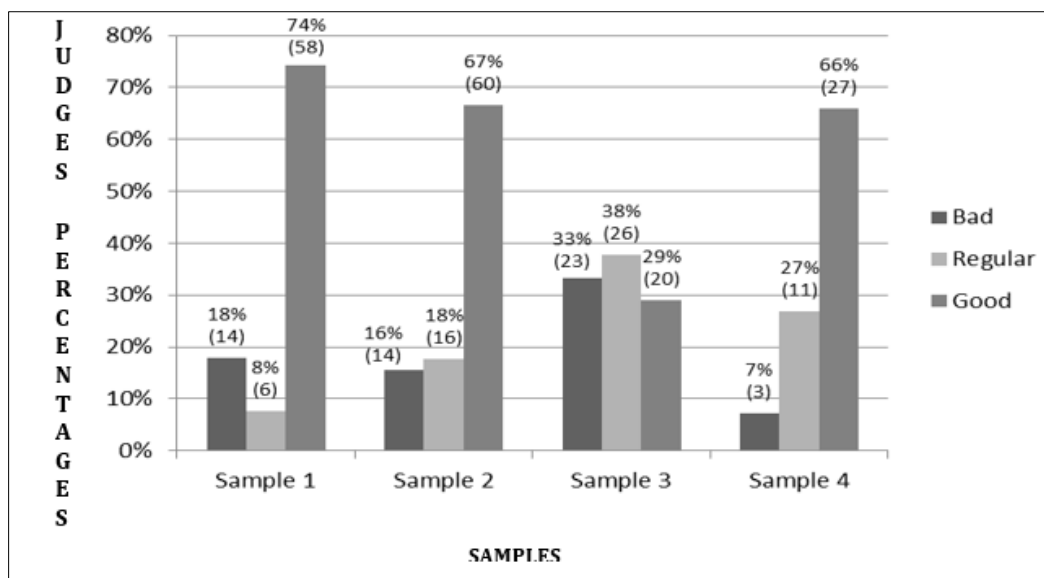


Figure 2 Judges distribution according the acceptance degree on evaluated samples (in parentheses number of judges)

Figure 3 graphs shows: the only case with significant differences in the acceptance of the new sweet food between men and women is the sample 2, where there are a significantly higher number of good acceptances among women, while regular acceptance is significantly higher among males.

Figure 4 shows: 1) 47% of the judges who tasted sample 1 place it in the first place of preference compared to the other two trademark candies, 38% of judges chose sample 1 in second place and 14% in third place. 2) Taking into account of the judges who tasted sample 2, the highest percentage (43%) chose it in second place, followed by those who chose it in first place (37%) and third place 20%. 3) From the judges who tasted samples 3 and 4, the highest number of people

chose both samples in third place of preference (58% and 59% respectively), in second place 36% and 34% respectively and 6% and 7% respectively chose the samples 3 and 4 in first place.

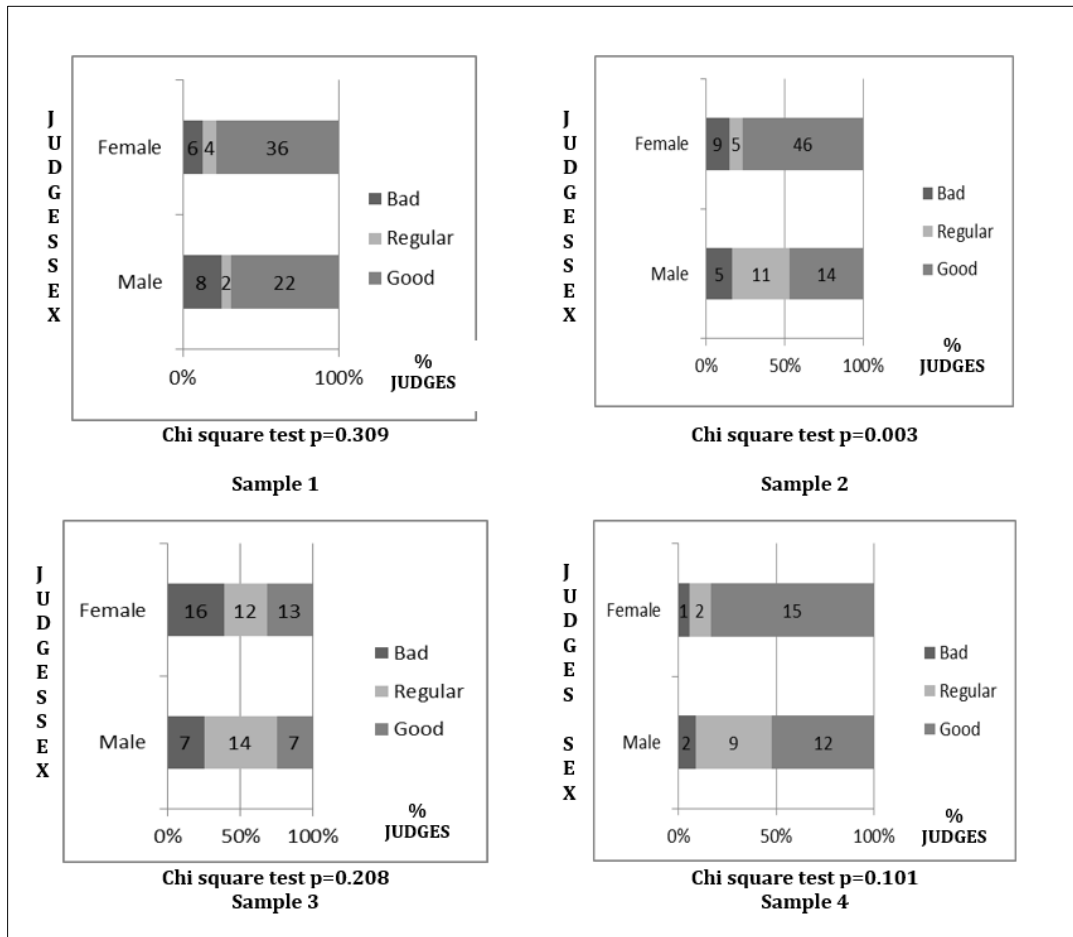


Figure 3 The acceptance distribution of sweet foods according to each sample and judges sex

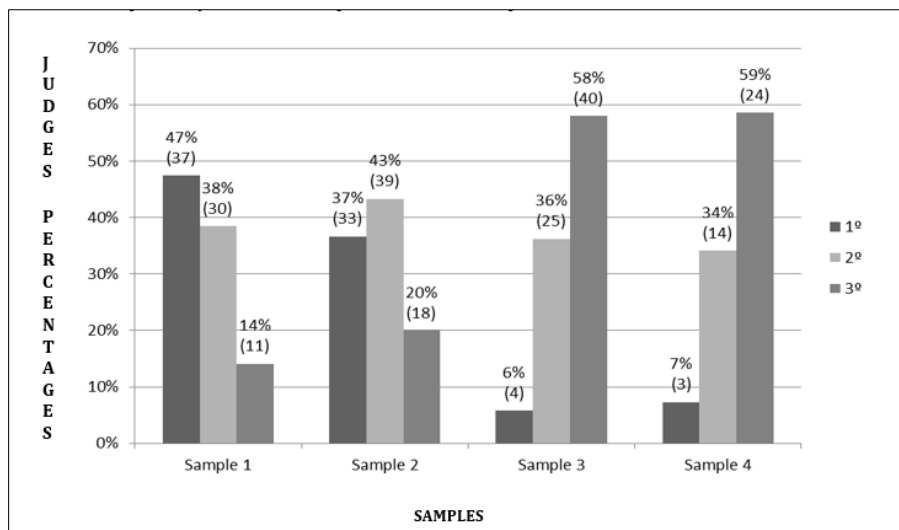


Figure 4 Judges distribution according to their preference on evaluated samples (in parentheses number of judges)

These results sufficiently evidence that the order of preference of the judges is different depending on the sample being analyzed (chi square test, $p < 0.0001$).

4. Conclusion

- All the samples manufactured of this new sweet food contain proteins of good nutritional quality in standard percentages higher than 10%. These kinds of proteins are of vegetable origin and may be part of the human diet as complementary sources for the animal proteins.
- The sex judges selected to taste samples for the acceptance and preferences tests of this new sweet food was 42.8% males and 57.2% females, with ages between 1 and 78 years old. These values represent a similar percentage for both sex and cover a wide age range statistically analyzed.
- Mainly the lower combination of amaranth, chia and quinoa seeds has bigger judge acceptance degree as show figure 2, sample 1 compared with samples 2 and 4. Sample 1 with content 4% chia-quinoa each and 12% amaranth; sample 2 with content 7.5% chia-quinoa each and precooked soybean totally 35%, sample 4 with content 25% chia-quinoa each, they have 74%, 67% y 66% respectively good acceptance. The lower total seed percentage combination (sample 1 with no more than 20% total seeds) has more acceptance degree. The same results were obtained by us when we working with a derivate of soy named okara [11].
- Sample's sweetness has no different influence in judge taste depending if sugar-glucose syrup or stevia is used to manufacture the samples.
- The amaranth (12%) and chia-quinoa combination 7.5% each (sample 2), has higher acceptance by women (51.1%) than men (15.6%).
- The amaranth (12%) and chia-quinoa combination 4% each (sample1) has higher preferences (47%) compared with two others market sweets of similar composition.
- The production for human consumption of this new sweet food would imply a better use of vegetable proteins as a complement of the diet animal proteins and improve the health preventive advantages.
- The industrial manufactures of this new sweet food and sale it as a candy would increase the profitability of the production factories and also increase the profit of the seeds farms producers.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

We are a multidisciplinary research group of professors from an argentine national university; we don't have any conflict of interest. We are working in food technology subject subsidized mainly by the national government of Argentina, with the purpose of contributing to the development of high nutritional value foods for the benefit of the population.

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