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A Preliminary Study on the Incorporation of Quinoa Flour in Organic Pumpkin Creams: Effect on the Physicochemical Properties †

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Abstract: COVID-19 pandemic strengthened food trends to consume healthier food products. Creams are a good option to produce healthy and tasty foods. Quinoa is an ingredient with a high potential in creams due to its nutritional and techno-functional properties. The aim of this work was to evaluate the influence of the addition of organic quinoa flour (at three concentrations: 0, 3, and 6%) in organic pumpkin creams on their physicochemical properties during the storage time. These organic creams were elaborated according to the industrial procedures. pH, water activity (Aw), and colour (CIELAB) parameters were evaluated during storage time (0, 30, and 60 days). Quinoa flour addition increased the pH. Aw was not affected by quinoa addition. Lightness (L*) increased with the increase in quinoa concentration, on the contrary, redness (a*) and yellowness (b*) decreased. All the physicochemical parameters evaluated (pH, Aw, and colour coordinates) were stable during the storage time. The addition of quinoa flour to organic pumpkin creams is an interesting option to develop healthy new food products.

Keywords: pumpkin; organic foods; quinoa; coproducts; healthy foods; creams

1. Introduction

The COVID-19 pandemic is one of the "great events" of the 21st century, it is well known for the great economic, social, and health repercussions, among others, that it has caused at a global level. The food industry is no stranger to this new situation and during this period it has not stopped working, not only in food processing, increasing the already high levels of hygiene and safety in food processing plants, offering more food. insurance, applying corporate social responsibility (helping with the contribution of food to food banks, soup kitchens, delivery of sanitary material, etc.), to improve the well-being of the population, but also in development and innovation [1]. For the development of new products, there are different strategies to do so. One of them and of recent implementation is the 5Star foods methodology (healthy, safe, tasty, sustainable, and socially accepted) [2,3], where food is considered in a comprehensive way, adding value to food by considering not only its nutritional and/or technological aspect.

The consumer associate fruits and vegetables consumption that are "good for health". This is due to the great work that has been done in the school and academic environment, as well as campaigns such as "5 a day" (www.5aldia. org) and the mixture of colours in fruits and vegetables in the food, among others. Pumpkin stands out for being rich in vitamins A, C and E, in potassium, calcium, fibre, phosphorus, magnesium and for being low in calories and is well appreciated for its properties.

If we talk specifically about COVID-19, with what is known, at this time, the easiest prepared foods to heat and thereby eliminate the potential "virus" that might exist in the food are soups and creams. The water content makes them easily heated in microwave ovens, which makes them "perfect" for many consumers, as it is an easy way to consume vegetables without worrying about handling many raw foods. Its texture, colour, and flavour contribute to its acceptance by all types of consumers, from children to the elderly. It is also an excellent way to consume dietary fibre, mineral vitamins, and other bioactive compounds with healthy properties. Further. Soups and creams can be used both in conventional food and for vegan and vegetarian food. For these last two types of food, the nutritional quality of the same can be improved by incorporating amaranth and/or quinoa (both pseudocereals) in the formulation.

Organic quinoa flour has also been used to make different types of food, with great commercial success, among which stand out, conventional bakery, confectionery and pastries and to develop new products for celiacs. The use of quinoa reach to meat products, especially cooked-cured meat products [4], where the gelatinization of the starch plays an essential role in the production of the product.

The aim of this work was to evaluate the influence of the addition of organic quinoa flour (at 3 concentrations: 0, 3, and 6%) in organic pumpkin creams on their physicochemical properties during the storage time.

2. Materials and Methods

As a preliminary study and for industrial purposes, "easy to measure" parameters were evaluated: pH, water activity (Aw) and objective colour measurements (CIELAB colour space). These parameters were analysed during 0, 30 and at 60 days, as conventional shelf-life. In addition, these parameters were analysed for organic quinoa (*Chenopodium quinoa W.*) flour.

Organic pumpkin cream elaboration process: The composition and elaboration process of DCS was carried out according to the industrial procedure. All ingredient were organics and locally purchased. Three different industrial formulations of pumpkin creams were made. C1 for the pumpkin cream made with a control formulation (without quinoa), C2 for the pumpkin cream to which 40 g of organic quinoa flour (3%) was added with respect to the control formulation and C3 for the pumpkin cream with the addition of 80 g of organic quinoa flour (6%) compared to the control formulation. All samples were elaborated at industrial scale in SURINVER facilities.

CIELAB (1976) colour parameters: Lightness (L*), red/green (+/−) co-ordinate (a)*, yellow/blue (+/−) co-ordinate (b*) were measured using a spectrophotocolorimeter Minolta CM Minolta CM-700 (Minolta Camera Co., Osaka, Japan), using D_{65} as illuminant and 10° as standard observer. Colour differences (ΔE*) were calculated as: $\Delta E^* = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$, where ΔL* = (L*sample − L*control); Δa* = (a*sample − a*control); Δb* = (b*sample − b*control), where control was control sample (0% added of organic pumpkin cream at time 0). Guidelines for colour evaluation was followed [5] and Sanchez-Zapata et al. recommendations [6].

The pH was measured directly using a Hach puncture electrode probe (5233) connected to a pH-meter (model SensIONTM + pH3, Hach-Lange S.L.U., Vésenaz, Switzerland). The measurement was taken three times, changing the place of electrode insertion. The water activity (Aw) was measured at 25 °C using an electric hygrometer NOVASINA TH200 (Novasina; Axair Ltd., Pfaeffikon, Switzerland).

All sample analysis were measured by triplicate, except for colour measurements which 9 measurements, from each sample, were made.

The experimental design was according with IPOA-5Stars methodology (healthy, safety, tasty, sustainable and social accepted foods [2].

A Multifactor ANOVA was used to evaluated the influence of quinoa concentration (0, 3 and 6%) and storage time (levels: 0, 30, 2 and 60 days). When differences between levels were found, the Tukey´s test was applied.

3. Results

In Table 1 can be observer the results of "ready to measure" industrial analysis (pH, Aw, CIELAB colour parameters) in organic pumpkin cream added with different organic quinoa flour concentration (0, 3 and 6%) during 60 days of storage time.

Table 1. Mean and standard deviation of pH, water activity (Aw), and CIELAB colour parameters (L*: lightness; a*: red/green co-ordinate (+/−); b*: yellow/blue co-ordinate (+/−) of an organic pumpkin cream (OPC) added with several organic quinoa flour concentration (0, 3 and 6%) during the storage time (0, 30, 60 days).

Time (days)	Parameter	OPC (0%)	OPC (3%)	OPC (6%)
0	**pH**	4.69 ± 0.01 ^{A,a}	4.90 ± 0.01 ^{B,a}	5.00 ± 0.01 ^{C,a}
	Aw	0.967 ± 0.003 ^{A,a}	0.968 ± 0.002 ^{A,a}	0.969 ± 0.002 ^{A,a}
	L*	56.61 ± 0.54 ^{A,a}	59.04 ± 0.43 ^{B,a}	61.40 ± 0.40 ^{C,a}
	a*	10.80 ± 0.11 ^{A,a}	10.05 ± 0.13 ^{B,a}	9.58 ± 0.14 ^{C,a}
	b*	40.79 ± 0.54 ^{A,a}	39.66 ± 0.42 ^{B,a}	37.53 ± 0.32 ^{C,a}
	ΔE*	-	1.54 ± 0.2	5.32 ± 0.4
30	**pH**	4.67 ± 0.02 ^{A,a}	4,85 ± 0.01 ^{B,b}	4.98 ± 0.01 ^{C,a}
	Aw	0.970 ± 0.001 ^{A,a}	0.971 ± 0.002 ^{A,b}	0.972 ± 0.001 ^{A,a,b}
	L*	54.44 ± 0.56 ^{A,b}	57.96 ± 0.99 ^{B,b}	59.89 ± 0.59 ^{C,b}
	a*	10.21 ± 0.11 ^{A,b}	9.82 ± 0.16 ^{B,b}	9.14 ± 0.13 ^{C,b}
	b*	37.87 ± 0.49 ^{A,b}	37.67 ± 0.74 ^{A,b,c}	35.01 ± 0.43 ^{B,b}
	ΔE*	7.02 ± 0.3	0.92 ± 0.02	1.15 ± 0.02
60	**pH**	4.73 ± 0.01 ^{A,b}	4.91 ± 0.02 ^{B,a}	5.03 ± 0.01 ^{C,b}
	Aw	0.973 ± 0.001 ^{A,b}	0,973 ± 0.001 ^{A,b,c}	0.974 ± 0.001 ^{A,c}
	L*	55.21 ± 0.28 ^{A,c}	59.92 ± 0.93 ^{B,a}	61.11 ± 0.49 ^{C,a}
	a*	9.90 ± 0.09 ^{A,c}	9.88 ± 0.11 ^{A,b}	9.34 ± 0.02B ^{c}
	b*	37.94 ± 0.28 ^{A,b}	38.91 ± 0.91 ^{A,a,b}	35.77 ± 0.28 ^{B,b}
	ΔE*	6.01 ± 0.09	4.34 ± 0.03	2.55 ± 0.04

$^{a–c}$ Similar values in the same column indicates not significant differences ($p > 0.05$). $^{A–C}$ Similar values in the same row indicates not significant differences ($p > 0.05$).

When the pH was analysed, it can be observed that on average, the addition of organic quinoa flour increased the pH values of the samples. The increase was greater at higher concentration. This may be due to the fact, that quinoa flour has a higher pH (6.01 ± 0.09) than that of organic pumpkin cream. A similar behaviour was found with the addition of the same organic quinoa flour to other foods [7]. When analysing the storage time factor, the Tukey test detected significant differences ($p < 0.05$) for the time 30 days of storage time, in which lower pH values were presented in all samples. In all samples under study (storage time and organic quinoa concentration) the pH was not lower than 4.5, thus this parameter cannot be considered as a safety criterion.

The results showed in Table 1 indicate that, for the water activity (Aw), the incorporation of organic quinoa flour did not modify the values of this parameter ($p > 0.05$) for all concentrations under study. Even though the organic quinoa flour values were 0.437 ± 0.003. However, when analysing the storage time, the Aw values increased in all the studied samples ($p < 0.05$), this could be due to the fact that during the elaboration of the organic pumpkin cream the gelatinized starches and/or other polysaccharides present in the product, underwent syneresis and released water from its structure.

When CIELAB colour co-ordinate Lightness (L*) was analysed, the effect of the addition of organic quinoa flour into the organic pumpkin cream (OPC) can be seen in Table 1. Its effect was to increase its values, that is, the addition of quinoa, regardless of the added concentration, made the organic pumpkin creams lighter. This aspect would be expected, since the value of this coordinate in organic quinoa flour is L * = 89.32 ± 0.21. However, if the inclusion of any of the added quinoa flour concentrations did not represent a huge increase therefore, its function on colour is rather scarce and it would be included in the matrix of the OPC matrix. This phenomenon has also been seen in other types of emulsified products, where the starches addition, prior to or during the gelatinization process, increases the value of this colour co-ordinate. However, in pasta and other similar products this behaviour was the opposite, in which, the addition of quinoa flour decreases this coordinate (L*) and increase a* and b* [9]. When storage time was analysed for each of the concentrations of organic quinoa flour, it can be seen that there are no significant differences ($p > 0.05$) between the samples at time zero and at time 60 days of storage time, while they are lower ($p < 0.05$) between them and 30 days. However, it is mentioned that differences of 1 unit (as occurs in several of the samples) would lack any visual and practical use for colour purposes.

Statistical analysis applied to a* colour co-ordinate (red colour component when a* is positive), the results showed that the addition of organic quinoa flour in OPC, decreased (Table 1). The addition causes in this coordinate, small differences ($p < 0.05$) that would lack of practical sense, since they are practically less than 1 units [8] for both, quinoa flour concentration and storage time. It is interesting to note that the addition of quinoa flour would not cause a subtractive effect on this coordinate, that is, it should produce a more pronounced decrease in the OPC values since its value is 0.40 ± 0.03. This indicates that OPC would include quinoa in its ultrastructure (food matrix), preventing the quinoa subtractive effect took place [9]. As was mentioned above, this behaviour is in opposite with pasta and other related foods [9].

When analysing the effect of the addition of organic quinoa flour (at different concentrations) upon OPC during storage time (Table 1), upon b* (yellow colour component when b* is positive). it can be seen that the addition of quinoa flour decreased its value by increasing the concentration of this flour. Although the value of the quinoa flour was 14.15 ± 0.35, its effect is not so pronounced in the OPC. In other words, as the others colour co-ordinates, the matrix formed in the OPC would reduce the effect of the incorporation of this flour. Similar behaviours occur in foods that form emulsions or suspensions since once the ultra-structure of the product was established; the individual effects of the ingredients disappear. It should be noted that during the storage time the values of this coordinate decreased [10]. In this case must be taken into account that the other pigments from other ingredients, such as pumpkin, can fade during storage time.

4. Conclusions

This work is a practical application in an industrial scale for the use of "ready to measure" parameters to evaluate important properties that can decide the reformulation or acceptation of the product to scale up to make a local consumer test. In a practical point of view organic quinoa flour increased pH, did not affect water activity of the organic pumpkin cream and, the OPC matrix masked any colour effect that quinoa flour could have in this product.

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