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A new approach to formulate an innovative cream pudding with flaxseed-based beverage

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Abstract – The aim of this study was to enhance the added value of flaxseed through double innovative aspects of its use and its introduction into the consumption of Tunisian consumers. The first part of this work was based on a survey of a consumer group of 306 persons in order to investigate the perception and acceptance of Tunisian consumers with regard to new uses of flaxseed in their diet. Secondly, two extraction protocols have been tested to obtain a vegetable beverage from flaxseeds. The physicochemical composition (dry matter, ash and protein contents), as well as pH, color parameters (L*a*b*) and extraction yield of both flaxseed beverages were determined. The richest beverage, in terms of dry matter, ash and protein contents, was used to formulate a cream pudding. The innovative cream with flaxseed-based beverage was assessed through its physicochemical characteristics (dry matter, ash and protein contents, and aw) and its sensory evaluation. The results showed that such a new approach to formulate an innovative cream pudding with flaxseed-based beverage was a viable alternative and that consumers were aware of the fact that flaxseeds and its food derivatives are a source of healthy nutrients. The cream pudding has an interesting nutritional composition and was sensory acceptable with no major organoleptic impairment.

Keywords: vegetable extract, innovation, formulation, quality, consumer.

1. Introduction

Global demand for flaxseeds is increasingly dominated by industrial uses. Indeed, flaxseeds are making great progress in global food supply and demand, for food and feed markets, due to the unique properties of this crop. Flaxseeds are cultivated in many parts of world for fiber, oil, as well as for medicinal purposes and also as a nutritional product (Kajla et al., 2015). In fact, flaxseed crop is mainly transformed into oil and also intended for animal feed because of its richness in alpha linolenic fatty acid (Cloutier et al., 2012). Although lower than demand for animal feed, human demand for flaxseed has been increased because of consumer awareness about the various health benefits of this crop and its nutritional value (Eyres, 2015). However, even it is a crop with a unique nutrient profile, particularly omega-3 fatty acid, lignans, and fiber (Goyal et al., 2014), flaxseed is undervalorised in human diet crop.

The population of vegetarians worldwide is growing. In this context, flaxseed is an important source of α-linolenic acid in the diet of vegetarian people (Kaur et al., 2018). Therefore, it may serve as an alternate for supplying fatty acid to populations that do not have large access to animal food origin such as seafoods (El-Beltagi et al., 2007). Moreover, products of animal origin are considered increasingly unhealthy. Plant-based products are considered to provide benefits beyond basic nutrition and may reduce the risk of certain diseases (Pinto et al., 2012). This is why consumers have recently turned to a plant-based diet that includes cereals, legumes, seeds, nuts, fruits and vegetables for a healthier lifestyle (Janssen et al., 2016; Sebastiani et al., 2019). In this context, there is a great interest in milk substitutes, for example, which are of vegetable origin and because of their high nutritional values and their positive health effects (Valencia-Flores et al., 2013). In fact, vegetable beverage are naturally rich in minerals (sodium, potassium, magnesium and phosphorus), and in polyunsaturated fatty acids, antioxidants, such as flavonoids, and in vitamins (Aydar et al., 2020). According to the same authors, these vegetable beverages may also reduce the risk of cardiovascular disease, cancer, atherosclerosis and diabetes. Regarding their confirmed nutritional benefits, plant-based beverages constitute thus a key ingredient in the diet of certain underdeveloped countries and those who are suffering from malnutrition. Also, plant-based beverage has an interesting economic potential. Among the most well-known plant-based beverage in the world are the almond, the soy, the coconut and the oat beverages. Several other plants and oilseeds are undervalorised in this field, among them flaxseed.

In this work, a double innovative approach of the use of flaxseeds in human nutrition has been used. Firstly, through the extraction of a vegetable beverage from flaxseeds, and secondly through the innovative valorization of this flaxseed-based beverage into a cream pudding (cream dessert). In order to well justify this choice, a consumer perception test was applied prior to the extraction of the flaxseed beverage in order to investigate the consumption profile of cream puddings/desserts, and also the flaxseed consumption profile among Tunisian consumers. The acceptance and decisions of Tunisian consumers on buying the innovative cream pudding with flaxseed-based beverage was also investigated. Subsequently, the extraction of the flaxseed beverage was made according to a protocol developed by our research team (Research Unit PATIO, INAT). To our knowledge, the extraction of a flaxseed beverage and its subsequent valorization have never been published in the literature. It should be noted that cream pudding or cream dessert from plant-based beverages do not exist on the Tunisian market and are not known by Tunisian consumers.
Moreover, to the best of our knowledge, no previous research studies have involved such a combined consumer perception test and a technological approach to investigate the extraction of a flaxseed-based beverage and its further valorization into a cream pudding.

2. Material and methods

2.1. Consumer perception test

A consumer survey was conducted in the greater Tunis region with a panel of 306 consumers who were randomly selected. A questionnaire was used to collect information on consumer profile data, Tunisian's cream pudding consumption habits, their perception and their degree of acceptance of an innovative pudding product, including their choices, their requirements and their needs. Information on flaxseed and buying decisions of the innovative cream pudding formulated with flaxseed-based beverage were also investigated. The collected data were processed and statistically analyzed using SAS 9.2 software.

2.2. Plant material

Flaxseeds (*Linum usitatissimum* L.) have been purchased from a local market in Tunis. The whole seeds were manually cleaned to remove dust and foreign matter and stored in a glass box at 25°C, away from moisture and light. Flaxseeds have been ground using a grinder (Moulinex LM34, France) whenever grinded raw material was required for experimental using.

2.3. Extraction protocol of the flaxseed-based beverage

Two protocols of flaxseed beverage extraction were tested in this work. The first one consisted on soaking 20 g of whole flaxseeds in 400 ml distilled water at 25°C during 6 hours. The second extraction protocol consisted on adding 20 g of ground flaxseeds to 400 ml of distilled water. The mixture was soaked at 25°C during 6 hours. For both protocols, samples were mixed for 3 minutes using a blender (KENWOOD BLP10A1WH, France) at speed 2. The mixture samples were then filtered through a muslin cloth to obtain the vegetable beverage.

2.4. Cream pudding formulation

The innovative cream pudding was formulated with the best flaxseed beverage (according to its dry matter, ash and protein contents) extracted from the two protocols tested. The cream pudding was prepared as follows: to 500 mL of flaxseed beverage, 2 tablespoons of sugar, 2 tablespoons of corn starch and 5 g of pasteurized powder egg yolks were added. The mixture was well homogenized in a blender (KENWOOD BLP10A1WH, France) at speed 2 and then cooked at 60°C during 15 minutes on a hot plate (HSMN series, Tunisia) while stirring until the cream thickens. Once ready, the cream pudding was poured into glass containers and left to cool at room temperature.

2.5. Characterization of flaxseed beverage and cream pudding

Flaxseed beverages were characterized as follows: dry matter, ash and protein content (Nx6.25) were determined according AOAC methods (1995, 1998, and 1997, respectively). pH was measured according to NT 53-30 (1984) with a digital pH meter (Orion Star, thermo Fisher scientific, USA). Color parameters determination of flaxseed beverages was performed in the CIE L*a*b* system using a chromameter (Minolta CR-300, Japon). The extraction yield (%) was estimated as the volume of the obtained extract (ml) from the amount of whole or ground flaxseeds used (20 g).
The analyses carried out on the cream pudding were the dry matter, ash and protein contents. They were conducted according to the same protocols as for the flaxseed beverages. The water activity of the cream pudding was measured using an a_w-meter (Rotronic Hygrolab 2, Suisse).

A sensory assessment was also performed on the cream pudding. An hedonic evaluation, trough an acceptance test, was conducted with an untrained panel of 50 assessors of different ages (Watts et al., 1991). The panelists, who claimed to be frequent consumers of cream dessert/pudding, were asked to rate each of the following sensory attributes: color, flavor, texture, taste, and overall acceptability, using a ten-point scale (1 = extremely dislike to 10 = extremely like).

2.6. Statistical analysis

All analyses were conducted in triplicate and data were reported as mean values ± standard deviation (SD). An ANOVA analysis was performed and the mean comparisons were carried out using Lsmeans procedure. Statistical analysis was performed at 95% confidence level using the SAS (version 9.2. SAS Institute) software package.

3. Results and discussion

3.1. Consumer perception on cream pudding consumption and on the new cream pudding formulated with flaxseed-based beverage

The 306 respondents' characteristics on consumption profile of cream pudding and flaxseed are reported in **Table 1**. 87.1% of the consumers were women. A first significant age group was distinguished between 21-35 years (67.8%), followed by a second group between 35-55 years (27.7%). The majority of the respondents (97.7%) had more than 3 years university degree. Almost half of the respondents (45.5%) were government employee. Worker (17.4%) and student (18%) respondents were quasi equivalent. However, the minority of the respondents has either a liberal function or was unemployed.

Table 1. Characteristics of the respondents

Characteristics	Data (%)
1. Gender	
Female	87.1
Male	12.9
2. Age	
20 or less	3.1
21 - 35	67.8
35 - 55	27.7
Over 55	1.4
3. Education	
Middle and High school	2.1
University degree	97.7
4. Occupation	
Student	18
Liberal function	8.5
Government employee	45.5
Worker	17.4
Unemployed	10.6

The respondents' consumption profile of cream pudding is reported in **Table 2**. The majority of the respondents consumed this product, to almost an equal extent, one time per week (31.8%) or depending on the occasion (35.1%). 16.2% consumed cream pudding 3-4 times a week. Such a consumption profile revealed the Tunisian habits who typically consume sweet dishes from time to time. This consumption pattern was confirmed by the majority of the respondents (68.7%) who consumed cream pudding especially for its sweet taste, and also for pleasure (23.1%). The highest consumption form of cream pudding by the respondents was the industrial product (71.9%), may be because it has become increasingly available in the market with a varied range of products and a reasonable price. The homemade cream pudding was also consumed (20%), but in general much more during religious holidays or the holy month of fasting (Ramadhan) when it was traditionally prepared. Only 8.1% of the respondents consumed artisanal cream pudding that was sold in fine food stores.

Table 2. Consumption profile of cream pudding

Characteristics	Data (%)
Frequency of eating	
Daily	3.7
3-4 times/week	16.2
1 time/week	31.8
1 time/month	13.2
Depends on the occasion	35.1
Reason for consumption	
Taste	68.7
Pleasure	23.1
Habit	4.5
Nutritional benefits	2.2
Consumption form	
Industrial product	71.9
Artisanal product	8.1
Homemade product	20

Regarding respondents' awareness of the benefits of flaxseed (**Table 3**), most of them (62.5%) were aware of the nutritional benefits and virtues of flaxseeds, which is in line with its high use in food consumption (80.2%). The majority of the 306 people who answered the questionnaire (81%) accepted the idea of a new flaxseed-based beverage cream pudding and agreed to buy this new product (83.4%), essentially because it is either natural (69.8%) or dietetic (24.6%).

The consumer survey results showed that the new cream pudding formulated with flaxseed-based beverage was approved by consumers (**Table 3**) which is encouraging in terms of the development of this plant-based food. Hence, the health benefits and nutritional added value of flaxseed and its derivative products, i.e. it's based beverage and cream pudding, well justified the second part of this research work. The flaxseed-based beverage and its derivative cream pudding were assessed to characterize their physicochemical composition. A sensory evaluation was also conducted on the cream pudding.

Table 3. Flaxseed consumption profile, acceptance and decisions on buying the innovative cream pudding formulated with flaxseed-based beverage

Characteristics	Data (%)
Awareness of the benefits of flaxseed	
Yes	62.5
No	37.5
Nature of flaxseed use	
Food consumption	80.2
Others	19.8
Acceptance of flaxseed-based beverage cream pudding	
Acceptance	
Neutral	81
Non-acceptance	17
Flaxseed-based beverage cream pudding attributes preference	2
Natural	69.8
Dietetic	24.6
Lactose free	5.6
Decisions on buying flaxseed-based beverage cream pudding	
Buy	83.4
Not sure	15
Not buy	1.6

3.2. Flaxseed beverage characterization

The proximate composition of flaxseed beverages and their physical characteristics are reported in **Table 4**. Flaxseed beverage extracted from ground flaxseeds has a dry content almost 5 times higher than that of beverage extracted from unground flaxseeds. This result was expected since the grinding operation, preceded by soaking, allowed the release of the encapsulated soluble substances inside the cells (Wardhani et al., 2008). This fact explained the significant increase in the dry content of the beverage extracted from ground flaxseeds.

Similarly, the ash content of the beverage extracted from ground flaxseeds was 1.5 times higher than that of the beverage extracted from whole flaxseeds. This result was also expected since the grinding operation, preceded by soaking, may increase the surface area of exchange and thus the diffusion of water-soluble molecules in the medium. Thus, it can make possible the release, among soluble substances, of minerals but

also vitamins, amino acids, pigments, carbohydrates and other water-soluble substances, which may infiltrate and dissolve in water (Wardhani et al., 2008).

A similar trend was observed for the total protein content of the beverage extracted from the ground flaxseeds which had a protein content 4 times higher than that of the beverage extracted from whole flaxseeds, for the same soaking time. These results may be explained by the study of Guéguen et al. (2016) who mentioned that the fractionation of the vegetable material can generate changes in the native structure of molecules. Grinding can change the proteins structure and increase their solubility (become more accessible). The high protein content recorded in the beverage extracted from ground flaxseeds, compared to the one from whole flaxseeds, could be also explained by the fact that grinding has altered the structure of flaxseed coat and thus leaded to a decrease of mucilage (which is present in the flaxseed coat) and therefore allowed a better protein extraction as reported by Kaushik et al. (2016), and Marambe and Wanasundara (2017). Moreover, the high protein content may confer to flaxseed beverage an interesting nutritional and economic potential to compete with other well-known vegetable beverages, that may have lower protein contents, such as soy beverage (8.71%, Kundu et al., 2018), almond beverage (1.7%, Bernat et al., 2015), sesame beverage (2.97% , Sethi et al., 2016) and Hazelnut beverage (4.17%, Atalar, 2019).

According to **Table 4**, flaxseed beverage was characterized by a more acidic pH for the sample extracted from whole flaxseeds (6.56) compared to the beverage extracted from ground flaxseeds (6.78). It should be noted that these pH values would be technologically interesting since they are in the same pH range of cow's milk (6.6 to 6.8). Moreover, the pH values of flaxseed beverages (**Table 4**), which were close to neutrality, are comparable to the pH of almond beverage (6.67) (Makinde and Adebile, 2018), coconut beverage (6.60) (Lu et al., 2019) and Hazelnut beverage (6.57) (Gul et al., 2018). It is interesting to note that microbial activity and microbial inactivation are moreover affected by enzyme activity and by pH.

The beverage extracted from grinded flaxseeds was darker (L* = 74.94) than the sample extracted from whole flaxseeds (**Table 4**). This could be explained by a greater contact surface of the ground flaxseed coat (outer layer of brown color) with the extraction solution, which can lead to an important extraction of brownish pigments from the flaxseeds previously grinded. This result was confirmed by a higher red index a* (1.99) and a lower yellow index b* (14.55) in the beverage extracted from ground flaxseeds than in the sample extracted from whole seeds. In addition, beverage extracted from ground flaxseeds is darker when compared to sesame beverage (L* = 86.81, a* = -1.161) (Ahmadian Kouchaksaraei et al., 2014) and to almond milk (L* = 85.38, a* = -1.02) (Dhakal et al., 2016).

The extraction yield was slightly improved for extract from ground flaxseeds compared to one from whole seeds (**Table 4**). This is consistent with the obtained extract from ground flaxseeds that was rich in total dry content from a quantitative and a qualitative point of view. Therefore, it is the beverage that will be used for the formulation of the cream pudding based on this vegetable extract. Nevertheless, the extraction yields recorded, as well as the dry matter, ash and protein contents, were globally considered low in relation to the average composition of flaxseeds (Kaewmanee et al., 2014; Kaushik et al., 2017). These low extraction yields could be explained by the aqueous extraction technique used, which should be optimized to have a higher yield and a richer composition of the flaxseed-based beverage.

Table 4. Physico-chemical characterization of beverages from whole or ground flaxseeds.

Parameter	Whole flaxseeds	Ground flaxseeds
Dry matter (DM) content (%)	1.09 ± 0.56^{a}	5.32 ± 0.06^{b}
Ash content (g/100 g DM)	3.45 ± 0,00^{a}	5.11 ± 0.00^{b}
Protein content (g/100 g DM)	5.77 ± 0.69^{a}	22.92 ± 1.20^{b}
pH	6.56 ± 0.05^{a}	6.78 ± 0.01^{b}
L*	81.36 ± 0.63^{a}	74.94 ± 0.63^{b}
a*	-0.35 ± 0.22^{a}	1.99 ± 0.04^{b}
b*	15.27 ± 0.12^{a}	14.55 ± 0.15^{b}
Extraction yield (%)	76.34 ± 0.22^{a}	77.93 ± 0.12^{b}

Means within lines (whole versus grounded flaxseeds) followed by different letters are significantly different ($P \leq 0.05$).

3.3. Characterization of the cream pudding formulated with flaxseed-based beverage

3.3.1. Physicochemical characterization

Table 5 presents the mean values for the physicochemical characterization of the cream pudding formulated with flaxseed-based beverage from ground seeds. The cream sample has a dry matter content of 18.56%. The major component of this total dry content was proteins (10.16 g/100g DM). This cream pudding was also characterized by a relatively high ash content, which indicated a potential interesting mineral content. Thus, by difference, the lipid and carbohydrate contents of this cream pudding will not be high, which would

confirm once again its nutritional potential. This was consistent with the expectations of Tunisian consumers, since according to their responses in **Table 3**, they expressed their attributes preference concerning this innovative cream pudding, based on flaxseed beverage, as a natural product, and also as a dietetic product. Moreover, the innovative cream pudding formulated with flaxseed-based beverage was characterized by a low a_w (0.9) (**Table 5**). Such an a_w value is interesting to prevent the development of bacteria and yeast and molds, which affect food safety and quality. This law Aw value may be explained by the presence of sugar in the cream pudding formulation, which is an hygroscopic ingredient able to bind water through its hydroxyl groups, and thus, is able to retain moisture, leading to a lower water activity value. The second parameter that it may be responsible of this law Aw in the cream pudding was its richness of fibers. In fact, the presence of such components increased water retention by mucilaginous matter present in flaxseeds (Hussain et al., 2006).

Table 5. Physicochemical characterization of the cream pudding formulated with flaxseed-based beverage

Parameter	Mean value
Dry matter (DM) content (%)	18.56 ± 0.02
Ash content (g/100 g DM)	3.88 ± 0.12
Protein content (g/100 g DM)	10.16 ± 0.34
Aw	0.90±0.02

3.3.2. Sensory characterization

Figure 1 shows the hedonic scores of the cream pudding. All attributes of this sensory test had high scores except for color. The lowest score of the cream sample color (4.12) would be due to the brownish coloration of the flaxseed beverage extracted from grinded seeds, as evidenced by the results of **Table 1**. However, Tunisian consumers are more accustomed to consuming milk-based cream dessert, such creams based on milk and/or dairy products. In fact, milk gives to cream dessert/pudding a much lighter and even a whitish color, especially when these creams do not contain egg yolk in their formula. The scores recorded for the other attributes of the cream pudding formulated with flaxseed beverage (**Figure 1**), i.e. flavor, taste, texture and overall acceptability, well showed the appreciation and the acceptance of this formulation by consumers. Indeed, these results are very encouraging and may testify to the competitive potential of this cream pudding compared to other conventional cream dessert, whether artisanal or industrial.

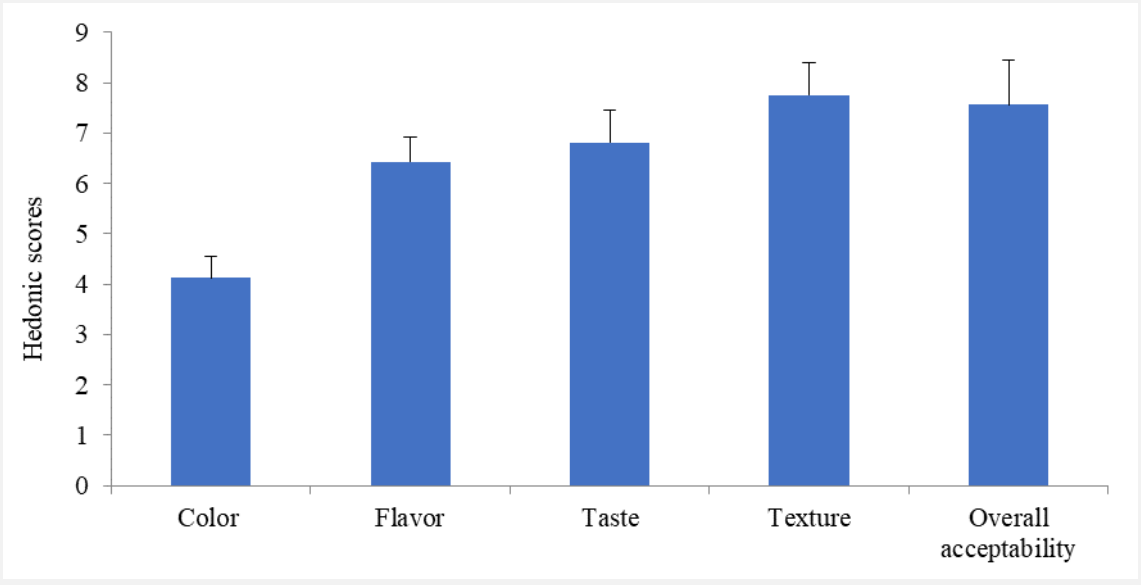

Figure 1. Hedonic scores of the cream pudding

4. Conclusion

This research work was firstly focused on a consumer survey to apprehend the degree of acceptance of an innovative cream pudding with flaxseed-based beverage and the perception of its introduction on the Tunisian market. The results of the consumer survey were encouraging and support the idea of a new use of flaxseed. The extraction of a vegetable beverage from flaxseed was successfully conducted and an extraction protocol has been proposed for the first time for this kind of crop. Flaxseed beverage exhibited good nutritional composition and physicochemical characteristics. The formulation of an innovative cream

pudding based on this flaxseed beverage was also successfully elaborated with interesting physicochemical and sensory characteristics. Moreover, considering the economic aspects of flaxseed (i.e. available, and has a reasonable price), as well as its nutritional added value, this new cream pudding based on flaxseed beverage may be considered as an alternative to dairy cream dessert.

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