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Research Article

Potential Use of Quinoa for Yoghurt Preparation

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ABSTRACT
Yoghurt is one of the classical products of milk made by fermentation process to convert milk into yoghurt. It also converts valuable components of milk into more desirable and easily digestible constituents. It contains many bioactive peptides and it is suitable for all age groups and lactose intolerant people. Quinoa is an excellent gluten free cereal with maximum availability of protein and many essential minerals and vitamins. Antioxidants in quinoa protect against the varieties of chronic diseases. With these properties it's a good choice to incorporate in yoghurt. This study is designed to develop new and innovative cereal based dairy product. In this study yoghurt will be manufactured by using quinoa at different concentrations (0.5%, 1.0%, 1.5% and 2.0%) and resultant product will be stored at 6-8℃ and will be evaluate for different physiochemical analysis, microbial, textural, functional and sensory profile. Result shows protein % range was found 3.546 at T0 and 7.113 at T1. Fat % results are in range of 3.500 at T0 and 7.633 at T1. pH range was found 4.400 at T0 and 4.576 at T1. Mold count was found 0.67cfu at T0 and 0.33cfu at T4. After whole testing influence of quinoa on all concentrations were good on all aspects.

Keywords: yoghurt, prebiotic, quinoa, syneresis

1. INTRODUCTION

Milk is a pure white fluid that is secreted by the mammary glands of mature female mammals. It is used for nourishing their young until they are grown up to 3 years. Milk is a dense source of micro and macronutrient, developing countries the food of poor people's normally lack variety and ingestion of animal source food is limited there milk and milk products plays key role in human nutrition's. It's commonly a dynamic component in especially formulated foods and therapeutic nourishing of malnourish child's (Black *et al*., 2008).

Dairy and dairy food products are highly nutritious and important role in income generation and food security. In developing countries dairy industry is a direct source of income and provides employment to the poor's and has a sustainable contribution in poverty reduction (Burchi *et al.*, 2011).

In World, the fourth major milk producing country is Pakistan. In Pakistan 59.759 million tones milk production in 2018-19, by which 48.185 million tones is used for human consumption. Milk used for humans is derived by subtracting 20% (5% in calving and 15% wastages in transportation). World milk production (85%) comes from

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cows followed by goats, sheep's, buffaloes, donkeys and mares. worldwide milk production nearly 600 million tones every year (Economic Survey of Pakistan. 2018-19).

Yoghurt possesses various therapeutic properties and reported to be very nutritious milk product (Sarkar *et al*., 2008). It is one of the earliest examples of food processing to improve shelf life of milk products (Maillat *et al.*, 2013). In world many types of yoghurt are produced like Greek yoghurt, almond yoghurt, sheep milk yoghurt, Australian yoghurt, goat milk yoghurt, soy yoghurt, traditional unstrained yoghurt, coconut yoghurt, Skyr, Aka icelandic yoghurt and drinkable yoghurt and kefir. Yoghurt is the product of the effects of bacteria, enzyme and acid on milk fat and protein (Ayub *et al*., 2006).

Quinoa has a grain such type of potential which can compete the market of dairy substitute. Quinoa declared as "one of most ancient cops of humanity" by FAO, and that's crop has a latent for NASA's Controlled Ecological Life Support System (Arendt and Zannini, 2013). In natural conditions, the seeds have a coating, which have bitter taste saponins, make them unpalatable. Quinoa is a gluten-free having high concentration of protein and many essential minerals and vitamins. Quinoa in Jewish community leavened grains is used as a staple food (Melinda Lund *et al.*, 2013).

Quinoa contains an amino acid lysine, which is not found in other cereals, so that content makes it unique. Quinoa contains have high amount of fiber and polyunsaturated fatty acids, which is helpful to treat hypercholesterolemia, obesity and cardiovascular disorders. Quinoas contain antioxidant content which is helpful in curing degenerative diseases. Gluten intolerance peoples consume quinoa regularly due to absence of gluten. Breads, pasta, salad and cookies are used in healthy and daily diets (Zevallos, 2014).

In food industry, quinoas are useful and prevent chemical additives in food (Carciochi, 2014). Quinoa hulls contains 40-45% saponins, that's saponins have pharmacological and nutritional benefits. Saponins have antifungal activity which damage fungal membrane. Saponins have many pharmacological and biological properties, includes cytotoxic, antitumor, hemolytic, anti-inflammatory and immune modulatory impact. It's have pharmaceutical properties and used as plant drug and folk medicines for centuries (Moses, 2014).

This study is designed with the following objects.

i) To develop new and innovative product.
ii) To improve nutritional profile of yoghurt.
iii) To check the acceptability of quinoa enriched yoghurt.

2. Material and methods

2.1. Procurement of raw material

The research was done at Department of Food Science and Technology, MNS-University of Agriculture Multan. Raw cow (breed Sahiwal) milk was obtained from dairy farm situated near to MNS- University of Agriculture, Multan, Pakistan and Quinoa was taken from department of Agronomy, MNS-University of Agriculture, Multan. Culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* was bought from the local dealer of Chris Hensen Pvt. Ltd.

2.2. Treatment plan

According to our treatment plan T_0 was consider as control yoghurt and no quinoa was use for its preparation. T_1, T_2, T_3, T_4 were quinoa yoghurt made with quinoa flour in 0.5%, 1.0%, 1.5% and 2.0% quinoa flour concentration respectively.

2.3. Yoghurt manufacturing process

Milk was pasteurize at 65°C for 30 minutes in water bath and cooled to 37°C before inoculation. A quinoa flour supplement was added according to our

treatment plan and incubation was done at 37°C for 4 hours. Incubation time was set till proper gel formation. Quinoa yoghurt was stored at 4-8°C for 28 days.

2.4. Proximate composition of quinoa yoghurt

Quinoa yoghurt was analyzed for proximate structure of pH with pH meter, fat by Gerber butyro meter method, and acidity by standards solution of NaOH using titration method, protein with Kjeldhal method at 0 day, 7th day, 14th day, 21st day and 28th day of storages according's to the standards protocol described by AOAC, (2000).

2.5. Rheological and texture analysis of quinoa yoghurt

The water holding capacity, syneresis, viscosity and texture study of quinoa yoghurt was analyzed by the protocols described in Sing and Muthukumarapan, (2008), Amatayakul *et al*., (2006), McGrew, (2007) and Mousavi, (2019) respectively.

2.6. Microbial and mineral analysis

Microbiological analysis mold count, total plate count and macro minerals of quinoa yoghurt were analyze according to standards protocols of AOAC, (2002) and protocol described by Kirk and Sawyer (1991) respectively.

2.7. Sensory evaluation

Quinoa yoghurt was assessed for its sensory parameters on hedonic scales (1-9) as prepared by Meilgaard, (1999).

2.8. Statistical analysis

The data acquired was subjected to statistical analysis CRD as via steel *et al.* (1997).

3. Results and Discussion

3.1. Physiochemical analysis of quinoa yoghurt

Physiochemical analysis of quinoa yoghurt was done at storage periods of 0 day, 7th day, 14th day, 21st day and 28th day. pH is the main factor that defines shelf life of quinoa yoghurt. This parameter is also a sign for the rise in number of lactic acid bacteria (Al-Kadamany *et al.*, 2002).

The result of pH of quinoa yoghurt was in ranges from 4.23 and 4.746. The highest values of pH were found at T_4 on 0 day and value of pH for T_0 was found 4.400 at 0 day. These results links with the study of Kamaruzzaman and Rehman, (2002). The enzymatic and biochemical degradations of biochemical components that cause decrease in pH.

The values of fat is 3.500 at T_0 and 7.700 at T_4 at 0 day and 2.076 at T_0 and 5.800 at T_4 on 28th day. The result of fat percentages is in according to the result of Bano *et al.*, (2011). The values of protein are 3.546 at T_0 and 8.673 at T_4 on 0 day and 2.610 at T_0 and 6.680 at T_4 on 28th day. The results of this study are in closeness with the results of Serra *et al*. (2009). The results about physicochemical analysis of quinoa yoghurt are stated in table 1.

Table 1: Physicochemical analysis of quinoa yoghurt

Treatments	pH		Fat%		Protein %		Acidity%	
	0 day	28th Day	0 day	28th Day	0 day	28th Day	0 day	28th Day
T_0	4.400	4.233	3.500	2.076	3.546	2.610	4.350	3.936
T_1	4.576	4.453	7.633	5.800	7.113	5.606	4.550	3.803
T_2	4.633	4.520	7.633	5.800	7.550	5.946	4.750	3.960
T_3	4.703	4.563	7.466	5.766	7.930	6.243	4.916	4.130
T_4	4.746	4.570	7.700	5.800	8.673	6.880	5.066	4.290

3.2. Viscosity

Yoghurt thickness is known as viscosity. Yoghurt viscosity increase with in the treatments and storage periods. Viscosity varies on milk type which is being used (solid content higher then viscosity will be higher). The values of viscosity is 2.070 at T_0 and 6.650 at T_4 on 0 day and 7.710 at T_0 and 14.507 at T_4 on 28th day of storage. Results shows increase in viscosity. The result is according to Eissa *et al.* (2011); Ayar *et al.* (2005); and Le *et al.* (2011). The result is given in table 2.

Table 2: Mold count and functional analysis of quinoa yoghurt

Treatments	Mold Count (cfu/g)		Viscosity		Syneresis		WHC (%)	
	0 day	28th Day	0 day	28th Day	0 day	28th Day	0 day	28th Day
T_0	0.67	2.79	2.070	7.710	29.627	73.760	29.867	27.750
T_1	0.67	2.07	2.950	9.513	29.817	73.997	29.827	27.497
T_2	0.33	1.68	4.107	11.630	29.827	73.827	29.823	27.310
T_3	0.67	1.06	5.443	13.360	27.433	73.860	29.800	27.037
T_4	0.33	2.22	6.650	14.507	28.393	73.937	29.767	26.590

3.3. Syneresis

A process in which whey separates out from the gel that's known as syneresis. During storage deficiency of yoghurt occurs due to binding of water molecules by quinoa. Syneresis increased in normal yoghurt with time while in case of quinoa yoghurt it also increases. The values of syneresis is 29.627 at T_0 and 28.393 at T_4 on 0 day and 73.760 at T_0 and 73.937 at T_4 on 28th day of storage. There are numerous factors that increases the syneresis of yoghurt. The increase in creation of acids by lactic acid bacteria increase the titratable acidity also cause the increase in values of syneresis Al-Kadamany *et al.*, (2002); Chye *et al.*, (2012). The result of this study regarding syneresis is according to Salvador and Fiszman (2004).

3.4. Water holding capacity

It's the ability of water to be a part of curd by the incorporation of different ingredients like quinoa flour that interact with quinoa flour and fix with water. The values of water holding capacity is 29.867 at T_0 and 29.767 at T_4 at 0 day and 27.750 at T_0 and 26.590 at T_4 on 28th day of storage. Water holding capacity decreases due to increase in acidity level in quinoa yoghurt. Sakandar *et al*. (2014) shows same results of this study.

3.5. Mold count of quinoa yoghurt

Microorganisms which are exist in multicellular and unicellular form and are not be able to see from naked eye, these organisms are found everywhere. In food commodities these are found in millions and they must destroy the food before eating and processing. Increase in storage period microorganism's quantity also increases. These microorganisms decrease the shelf life of dairy products. Dairy products have sufficient amount of water and good source of nutrients that favors the microorganism's growth. To avoid the entry of these microorganisms, dairy products are manufactured in hygienic conditions (Ekici *et al*., 2019). The values of mold count is 0.67 cfu/g at T_0 and 0.33 cfu/g at T_4 on 0 day and 2.79 cfu/g at T_0 and 2.22 cfu/g at T_4 on 28th day of storage. Initial quality of milk highly influence on decrease and increase of mold count of end product and quinoa yoghurt shelf life. Milk production in unhygienic environment then end product quality will be low. Refrigeration temperature highly influences the growth of microbes in yoghurt. Refrigeration temperature decreases the growth of mold also decreases (Souza *et al*., 2003).

3.6. Acidity

Acidity in yoghurt is expressed as production of lactic acid percentage. After the result of fermentation process lactose convert into lactic acid, with the addition of quinoa flour acidity of yoghurt decreases because the nature of quinoa flour is not to be acidic. The values of acidity is 4.350 at T_0 and 5.066 at T_4 on 0 day and 3.936 at T_0 and 4.290 at T_4 on 28th day of storage. Result of this study shows there is decrease in acidity with the increase in quinoa level and also with increase in storage periods. Decrease in activity of microorganism's lactic acid bacteria causes the decrease in lactic acid production that increases pH resultant decrease in acidity with storage periods (Andic *et al*., 2013).

3.7. Mineral analysis of quinoa yoghurt

Milk is a perfect diet which provides essential mineral elements to provide nutrition to our body. Hundreds of minerals elements are presents in milk. Essential minerals are calcium, sodium, potassium, iodine and manganese. Milk products are also enriched with mineral elements. In human nutrition, these minerals are important part of our food. For human, minerals have nutritional, functional and biochemical benefits. In human body, minerals work as an enzyme to speed up the chemical reaction (Cashman, 2002).

The values of sodium is 417.02 at T_0 and 417.13 at T_4 on 0 day and 421.99 at T_0 and 425.08 at T_4 on 28th day of storage. The values of calcium is 68.011 at T_0 and 68.243 at T_4 on 0 day and 72.677 at T_0 and 76.421 at T_4 on 28th day of storage. The values of potassium is 71.002 at T_0 and 71.009 at T_4 on 0 day and 75.348 at T_0 and 79.564 at T_4 on 28th day of storage. Mineral content increase in day storage in quinoa yoghurt due to breakdown of protein structure and decrease in moisture contents. Minerals contents increase during storage period due to breakdown of yoghurt other components into basic components.

3.8. Texture profile analysis

Texture is a significant quality standard of quinoa yoghurt. Texture of quinoa yoghurt is good quality therefore consumer acceptance increased. Texture is the mixture of different factors includes cohesiveness, springiness, gumminess, hardness and chewiness. There are number of factors that influence the value specially the texture of yoghurt (Lucey, 2004). The quinoa yoghurt samples were analyzed for texture analysis of springiness (mm), hardness (kg), chewiness, gumminess and cohesiveness. Texture profile of quinoa yoghurt is the resultant of various factors and these factors include composition of yoghurt, composition of milk, i.e. fat level of yoghurt, protein quantity of yoghurt, moisture content of yoghurt, total solids, conditions and ripening time by enzyme (Lucey *et al*., 2003).

3.9. Hardness

In different treatments at intervals there is a clear difference in quinoa yoghurt hardness. Maximum value of hardness was found 8.95 kg at T_3 and minimum value was 6.84 kg at T_0. According to Delgado *et al*., (2011) there is a positive correlation in moisture contents and hardness. During storage moisture content decrease and hardness of yoghurt increase. Protein contents increase hardness of yoghurt also increased (Koca and Metin, 2004). Results are according to Dongare *et al*., (2019) paneer at 4°C shows same results. Hardness of fresh yoghurt is closer to our study (Eroglu *et al*., 2016).

3.10. Cohesiveness

In different treatments at intervals there is a clear difference in quinoa yoghurt cohesiveness. Maximum value of hardness was found 0.54 N at T_3 and minimum value was 0.36 N at T_0. Cohesiveness depends upon the yoghurt chemical composition. Yoghurt

dry matter has direct relationship of cohesiveness. Protein contents increase then dry matter % also increased thus cohesiveness of quinoa yoghurt sample also increased (Koca and Metin, 2004). According to Romeih *et al*., (2002) fat has important characteristics on smoothness and texture of quinoa yoghurt. There is an inverse relationship between cohesiveness and fat contents in yoghurt samples as decrease the fat contents increase the cohesiveness of quinoa yoghurt (Eroglu *et al*., 2016). According to Dongare *et al*., (2019) results of this study are much closer to our study.

3.11. Chewiness

In different treatments at intervals there is a clear difference in quinoa yoghurt chewiness. Maximum value of chewiness was found 0.51 N cm at T_3 and minimum value was 0.35 N cm at T_0. Chewiness is the energy or force require for mouth feel sensation before swallowing (Haung *et al*., 2007). Chewiness depends upon different parameters like yoghurt type, ripening period and manufacturing process. Fat % in yoghurt samples has great impact on chewiness of yoghurt. Yoghurt made from skim milk or low fat milk has higher chewiness than yoghurt made from full fat milk. Increase in ripening period chewiness values is also increased. Chewiness values decreased if yoghurt made from starter culture (Eroglu *et al*., 2016). Refrigeration has positive effect on chewiness of yoghurt due to hardness of protein matrix. Our study results are resembles with Singh *et al*., (2014) and Shashikumar and Puranik, (2011) studies.

3.12. Springiness

In different treatments at intervals there is a clear difference in quinoa yoghurt springiness. Maximum value of springiness was found 1.052 cm at T_0 and minimum value was 1.038 cm at T_3. Yoghurt composition imparts special characters to texture of yoghurt. Yoghurt springiness highly influence on fat and protein. If protein matrix elasticity decreased then it cause decrease in springiness of yoghurt (Delgado *et al*., 2011). According to Karaman and Akalin, (2013) elasticity of protein influence on fat % which is present in structure of protein. Our study results are much similar to the results of Zisu and Shah, (2005). Dongare *et al*., (2019) results resemble to our study.

3.13. Gumminess

In different treatments at intervals there is a clear difference in quinoa yoghurt gumminess. Maximum value of gumminess was found 6.1 kg at T_0 and minimum value was 4.73 kg at T_3. According to Bourne, (2002) gumminess is the combination of cohesiveness and hardness. According to Goksel *et al*., (2013) gumminess has the isolated effects on cohesiveness and hardness. Gumminess depends upon the yoghurt type, yoghurt composition, milk protein and fat quantity, ripening process, manufacturing process and storage period. Percentage of moisture, level of fat, protein structure and dry matter quantity mostly effects on the gumminess of yoghurt. Our study results are accordance to Karaman and Akalin, (2013) studies.

3.14. Sensory evaluation of quinoa yoghurt

Quinoa yoghurt sample was evaluated for its sensory characteristics of odor, flavor, appearance, texture, taste and overall acceptability. Sensory quality marks of the product was based on score obtain for odor, flavor, taste, appearance, texture and overall acceptability using the 9-point hedonic scale in which 1 score was dislike extremely and 9 scores were like extremely. The result for sensory qualities of quinoa yoghurt is represented in Fig 1. Odor is a quality factor for the approval of any commodity and T_1 and T_2 contained the maximum values. For flavor T_2 was deliberated finest by the judges. T_2 was considered finest for texture parameter and T_3 was approved best by the judges for appearance. Overall acceptance of

T_3 and T_4 was considered finest. The result of sensory evaluations was according to Mumtaz *et al*. (2008); Salvador and Fiszman. (2004); Sarkar *et al*. (1996) and Radi *et al*. (2009).

evaluation of every aspect results are with encouraging impacts. Sensory profile reveals that T_2 was best in all aspects. In future, if any industry should work on it, they can commercialize it and gain extra income.

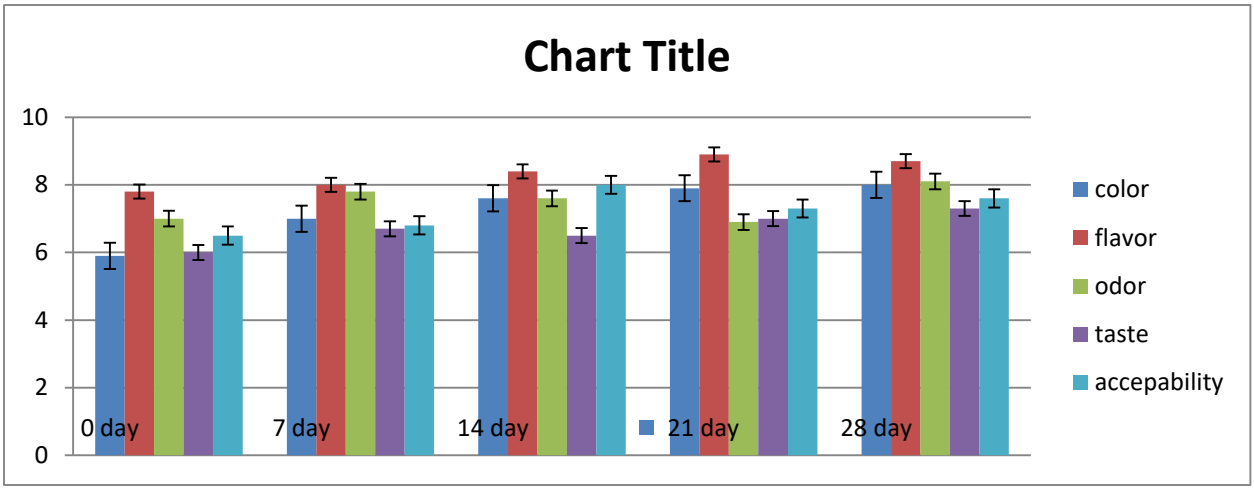

Fig. 1 sensory evaluation of quinoa yoghurt.

4. Conclusion

The present study was lead to prepare the yoghurt with the addition of quinoa flour to increase its nutritional properties. Yoghurt which is prepared without quinoa flour is T_0 while quinoa flour yoghurt was named as T_1, T_2, T_3 and T_4. Yoghurt preparation with quinoa flour was stored in refrigerator for 28 days and then evaluates its microbial, physiochemical and sensory properties. After

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6. Conflict of Interest

There is no conflict of interest in my research.

Table 3: Mineral analysis of quinoa yoghurt

Treatments	Calcium (mg/100g)		Sodium (mg/100g)		Potassium (mg/100g)	
	0 day	28th Day	0 day	28th Day	0 day	28th Day
T_0	68.011	72.677	417.02	421.99	71.002	75.348
T_1	69.667	76.004	418.69	425.06	72.678	79.101
T_2	67.667	77.005	416.69	426.07	70.678	80.001
T_3	71.532	78.677	420.01	427.99	74.005	81.076
T_4	68.243	76.421	417.13	425.08	71.009	79.564

Table 4: Texture analysis

Treatment	Hardness	Cohesiveness	Gumminess	Springiness	chewiness
T0	7.456	0.630	7.455	1.123	0.348
T1	7.328	0.401	5.789	1.032	0.101
T2	8.432	0.411	5.132	1.089	0.001
T3	8.954	0.589	4.743	1.444	0.076
T4	7.329	0.439	5.732	1..777	0.564

Table 5: Sensory evaluation

Treatment	Odor	Flavor	Appearance	Texture	Overall acceptability
T0	6.64	6.34	7.02	7.05	7.34
T1	6.64	6.32	6.65	7.34	7.65
T2	7.34	6.65	7.03	7.34	8.03
T3	7.02	6.02	6.65	7.05	7.03
T4	6.34	5.64	6.65	6.64	6.04

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