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RESEARCH ARTICLE

Development and quality characteristics of functional Kulfi enriched with malted quinoa flour

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Abstract: Kulfi is a frozen traditional indigenous dessert which is liked by consumers of all age groups. The main objective of this study was to optimize and develop a sugar free, high protein and fiber rich kulfi using malted quinoa flour. Pseudo cereal quinoa was incorporated in kulfi at the rate of 10%, 15% and 20% in order to optimize the functional kulfi. The optimized sample K_2 contained moisture (56.60±0.06 %), fat (10.90±0.12 %), protein (4.45±0.07 %), carbohydrate (25.76±0.18 %), total solids (42.31±0.02 %), energy (218.75±0.81 Kcal), crude fiber (1.92±0.01 %), and ash (0.71±0.03 %), respectively. Storage period of 35 days was taken into consideration and changes in physico-chemical properties, antioxidant activity, melting resistance as well as microbial count was observed during this period at an interval of 7 days. The antioxidant activity was reported higher in optimized product then the control sample. Slight change in the acidity was recorded and the microbial activity decreased significantly over storage period.

Keywords: Antioxidant; Functional kulfi; Quinoa; physico-chemical; Melting resistance; Optimization

Introduction

Quinoa is a pseudo-cereal native to the Andes region of the South America. It belongs to the family Chenopodiaceae, class Dicotyledoneae, species quinoa and genus *Chenopodium* (Maricorena and Quezada,1985). Quinoa is known as super food due to its massive health benefits. It has gained importance in day- to- day lives in the past few years due to its nutritional benefits. Quinoa is gluten free, high in antioxidants, has low glycemic index and also possess some anti-cancerous properties (Tichy et al. 2020). It is refer as a complete food due to its fiber content and protein quality. Starch present in quinoa has physico-chemical properties such as freeze stability and viscosity which makes it a functional crop for novel uses. In the past decade it has also been recognized as an oil seed crop with an ample amount of omega-6 fatty acids as well as vitamin E content (Lilian and Abugoch, 2009). In order to enhance the nutritional properties and eliminate the anti-nutritional factors such as saponins from the quinoa seeds it is subjected to germination. Germination is a basically a cost effective process and also beneficial in many ways (Lan et al. 2023). Lintschinger et al. (1997) reported that various nutritive factors such as vitamin concentrations and bioavailability of trace elements and minerals increase during germination of wheat, buckwheat and quinoa.

Kulfi is one of the most liked traditional indigenous frozen dessert prepared by concentration of milk to a specific content. The texture of the kulfi is harder when compared to ice cream due to lack of air incorporation. It is also rich in total solids per unit volume. It is manufactured and marketed mainly in the unorganized sector in different flavors during summer season (Dutta et al. 2021). The method of production of kulfi often varies from producer to producer. Addition of some functional compounds namely pistachio powder, banana as well as other fruits and nuts increases the value and nutrient content of kulfi and makes it a functional product for consumption (Singh and David, 2018). This study reports the effect of addition of Malted Quinoa Flour (MQF) on physico-chemical, antioxidant and microbial properties of functional kulfi.

Materials and Methods

Raw materials

Fresh cream with 25 % milk fat, full cream milk and butter (Amul) was obtained from the local market of Varanasi, Uttar Pradesh. Skim milk powder (Amul), sodium alginate (Akshar chem.), glycerol mono stearate, stevia (Stevi0cal, by Rigil Biotech. Pvt.

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Ltd.) and quinoa were procured from online source.

Preparation of malted quinoa flour (MQF)

The process of development of malted quinoa flour is shown in (Figure.1). Sandberg and Svanberg,(1991) & Gustafsson and Sandberg, (1995) reported that in legumes and cereals the techniques such as soaking, germination and fermentation helps in the removal of the anti-nutritional factors such as endogenous phytates, saponins etc., Quinoa was soaked for about 7 to 8 hours in water. Germination of quinoa seeds was carried out in an incubator at 27±2°C for a period of 24 hrs. After incubation, the germinated quinoa seeds were tray dried at 55°C for 2 hrs. Drying for a short period of time resulted in retaining its maximum nutritional qualities. Dried quinoa seeds was then ground in a blender to make fine flour. Vacuum packaging of flour was done in Low Density Poly Ethylene (LDPE) and was stored in a cool dry place.

Process optimization of MQF enriched kulfi

Formulation of kulfi was done with some modification in traditional method proposed by (Salooja and Balachandran, 1982). Full cream milk was condensed to half of its volume and other essential ingredients i.e. skim milk powder, stabilizer, emulsifier as well as stevia was added based on laboratory trials. Vacuum packed malted quinoa flour was used in three different proportions for the primary trials @ 10, 15 and 20 % of the mix. Quinoa flour was gelatinized before adding to the mix. All the three samples along with a control sample (without malted quinoa powder) were aged for 3 to 4 hrs at 4±1°C. The mix was further transfer to a kulfi mould and freezed at -4 ± 1°C for 25 ± 5 min. Further hardening was done at -23 ± 2°C for 10 to 12 hrs as per modified method.

Treatment details used during the study were:

K= 0% MQF (Control)

K_1 =10 % MQF (Treatment 1)

K_2 = 15 % MQF (Treatment 2)

K_3= 20 % MQF (Treatment 3)

Sensory analysis

Sensory analysis of different samples of MQF enriched kulfi was done by a panel of 15 semi- trained judges from Centre of Food Science and Technology, Banaras Hindu University on the basis of 9-point hedonic scale (Stone and Sidel, 2004). The samples were placed in a random order with unique codes. The attributes analyzed were color & appearance, body and texture, flavor and taste and overall acceptability.

Physico-chemical analysis of MQF enriched kulfi

The physico-chemical analysis namely acidity was determined by taking 1.0 g of sample and dissolving it in 100 ml of distilled water and then taken 10 ml from the solution for estimation purpose. Melting resistance (g/min. of kulfi melted at room temperature for 30 min.) was determined by using 5 g of sample and pH was determined by using 5 g of sample dissolved in 100 ml of the distilled water was estimated by using the methods of

Fig. 1 Pictorial representation of preparation of malted quinoa flour

(AOAC, 2000). Moisture content, ash content, crude fiber and fat of moisture free sample was determined by Soxhlet apparatus. Protein (%) was estimated by the macro-Kjeldahl method in which the percentage total nitrogen present in the sample was calculated and then it was multiplied by a factor of 6.38 in order to get the final protein content.

Total phenolic content and DPPH radical scavenging activity

Total phenol content (mg/g GAE) was determined using the Folin-Ciocalteau reagent and gallic acid as a standard (Slinkard and Singleton, 1977). The antioxidant activity was calculated as % anti-radical activity by the DPPH assay (2, 2-diphenyl 1-picryl hydarzyl assay) by the method of (Li et al. 2009).

Mineral analysis

The mineral content such as Ca, Mg, Mn, Fe and Zn was estimated by AAS (atomic absorption spectroscopy): Model-Thermo Fisher Scientist- IN at λ 422.7, 285.2, 457.4, 248.3, 213.9, respectively by wet digestion method (Chiş et al. 2020).

Microbiological analysis

The microbial analysis of the samples was carried out by pour plate method, by pouring approximately 10 ml media using plate count agar media (Kim & Cheigh, 2022).

Shelf-life study

The optimized product was stored for 35 days and was analyzed for certain physico-chemical properties, antioxidants activity and microbial load at an interval of 7 days.

Statistical analysis

Analysis of data was done by using different statistical tools. For testing significant difference test such as two tailed t-test, ANOVA was used with Microsoft excel and NCSS 19 software.

Results and Discussion

Sensory evaluation of MQF incorporated kulfi

For preparation of kulfi, malted quinoa flour was added at the rate of 10%, 15% and 20%. The sensory analysis results showed that the concentration of the MQF had significant effect on the sensory attributes ($p<0.05$) of treatment 2 (Table 1). The overall acceptability score for the MQF enriched kulfi (K_2) prepared with 15% MQF was found to be most satisfactory by the sensory panelists. Treatment 3 containing 20% MQF was not liked by the sensory panelists due to the dominant flavor of quinoa. The overall acceptability of (K_2) was 8.13 ± 0.13, (K_1) 7.33 ± 0.19 and (K_3) 6.50 ± 0.23, respectively. The sample containing 15% MQF had a rich flavor and mouthfeel and most liked by the sensory panelists. Based on the sensory report treatment (K_2) was selected for further study.

Physico-chemical analysis of MQF enriched kulfi

The physico-chemical properties of optimized kulfi (K_2) and control (K) are listed in (Table 2). Moisture (%) of the best variant (K_2) was less than the control sample due to the incorporation of malted quinoa flour. Wang and Zhu, (2016) reported similar results while studying the formulation of different quinoa products. The total solids (%) of the optimized kulfi significantly increased as compare to control from 42.31% to 40.30%, respectively. Similar type of study was conducted by (Cody et al. 2007) prepared ice cream with rice flour. The protein and fat content of optimized kulfi tend to increase due to incorporation MQF as quinoa is rich in protein. The results showed significantly higher protein content than the control sample. The results are similar to that reported by Ali et al. (2016); Ayar and Gurlin, (2014). The authors reported the functional, antioxidants and sensory qualities of ice- cream from pomegranate seed powder. The viscosity of K_2 was towards higher side than the control sample. The value increased from 25.57 (mPa.s) in control to 26.77 (mPa.s) in optimized kulfi. Arbuckle, (1977) discovered that acidity in the ice cream affects the viscosity. pH of control sample was higher that is 6.41 than the optimized one that is 6.19. Similar results have been reported by (Patel et al. 2020). They develop kulfi incorporated with amaranthus (*Rajgara*) which showed a significant decrease in the pH. The carbohydrate content in optimized product increased eventually after the addition of MQF. The results of this study were accepted because carbohydrate-based fat replacers exhibit a very thick and viscous behavior and have a capability to imbibe water, which would increase the viscosity of the mixes (Hafids et al. 2019). Carbohydrate has good water binding capacity, sometimes even better than proteins (Clark, 1994; Akoh, 1998). Melting resistance is one of the most important factors of frozen

Table 1 Sensory score of MQF enriched kulfi

Amount of MQF (%)	Body andtexture	Color andappearance	Flavor andtaste	Overallacceptability
K_0 (0)	7.70± 0.21	7.60 ± 0.26	7.50 ± 0.26	7.60 ± 0.12
K_1 (10)	7.30 ± 0.36	7.80 ± 0.20	6.90*± 0.31	7.33 ± 0.19
K_2 (15)	8.20 ± 0.20	8.00 ± 0.25	8.20 ± 0.24	8.13 ± 0.13
K_3 (20)	6.60*± 0.40	7.30*± 0.30	5.60*± 0.26	6.50*± 0.23

Values mentioned as Mean ± Standard deviation (n=3)
*Attributes with different scores shows significant difference ($p<0.05$)

Table 2 Physico-chemical analysis of MQF enriched kulfi

Parameters	Control (K)	Optimized (K_2)	t-value
Fat (%)	10.01 ± 0.11	10.90 ± 0.12	2.21
Moisture (%)	57.35* ± 0.08	56.30* ± 0.06	0.09
Total solids (%)	40.30* ± 0.02	42.31* ± 0.02	0.24
Crude fiber (%)	0.23* ± 0.00	1.92* ± 0.01	122.55
Ash (%)	0.58 ± 0.03	0.71 ± 0.03	2.44
Protein (%)	3.57* ± 0.02	4.45* ± 0.07	11.48
Carbohydrate (g)	24.99* ± 0.17	25.76* ± 0.18	12.33
pH	6.41 ± 0.00	6.19 ± 0.02	1.80
Acidity (%)	0.17 ± 0.00	0.21 ± 0.00	3.46
Melting resistance (g/min.)	6.06 ± 0.01	6.41 ± 0.01	18.82
Viscosity (mPa.s)	25.57* ± 0.03	26.77* ± 0.66	9.38
Energy (Kcal)	213.23* ± 0.67	218.75* ± 0.81	4.26

Values mentioned as Mean ± Standard deviation (n=3)
*Attributes with different scores shows significant difference ($p<0.05$)

Table 3 Mineral content, antioxidant activity and total phenolic compounds of MQF enriched kulfi

Minerals (mg/100g)	Control (K)	Optimized kulfi (K_2)	t- value
Calcium	304.84* ± 0.29	345.14* ± 0.35	83.73
Magnesium	35.19* ± 0.11	51.31* ± 0.47	33.24
Iron	0.61* ± 0.00	1.93* ± 0.02	46.70
Zinc	0.12* ± 0.01	1.61* ± 0.12	11.85
Manganese	0.63* ± 0.18	1.11* ± 0.05	2.47
Total phenolic content (mg/g GAE)	Nil	16.71 ± 0.61	NA
Antioxidants (%)	Nil	68.81 ± 1.30	NA

Values mentioned as Mean ± Standard deviation (n=3)
*Attributes with different scores shows significant difference ($p<0.05$)

dairy products such as kulfi. Kulfi should always melt into a smooth viscous liquid. The increased melting resistance of K_2 might be due to the highly viscous mix.

Mineral analysis

The mineral content which tends to increase after incorporation of MQF is depicted in (Table 3). The Ca, Mg, Zn, Fe and Mn increased to 345.14 mg/100g, 345.14 mg/100g, 1.61 mg/100g, 1.93 mg/100g, 1.11 mg/100g, respectively in optimized kulfi when compared to the control sample. The increase in the mineral content is attributed to the presence of high amount of minerals such as Ca, Mg, S, P and K in the quinoa seeds. Quinoa seeds are rich in total phenol content (TPC) and antioxidants. It has α-tocopherol, γ-tocopherol and phytoestrogens. Degradation of the phenolic compounds tends to decrease the level of TPC at the time of storage due to the fact that the polyphenols are not stable in long term, because they are affected by factors such as temperature, light, metallic ions, pH, etc., (Bukowska et al. 2003). But in this study TPC and the antioxidant content of the test sample increased significantly. A decrease in the antioxidant value occurred during the storage period which is depicted in (Table 4). Thus it might be concluded that a decline in the antioxidant value may be due to the decreased TPC. Karaaslan et al. (2011) observed similar results while studying phenolic fortiûcation of yoghurt using grape and callus extracts. The major disadvantage of the quinoa seed is the presence of phytic acid and saponins but is can be completely removed by giving certain treatments (Valencia, 2003).

Effect of storage on physico- chemical properties of kulfi

Acidity plays a very important role in flavor of the product as well as spoilage (Gupta et al. 2020). The acidity of the optimized kulfi sample showed very slight change from 0.22 % on 0 day to 0.20% on 35th day of storage (Table 4). Gokhale et al. (2017) reported that acidity content increased possibly due to the action of the lactic acid bacteria during storage condition. pH also showed decreasing trend from 6.19±0.00 to 6.12±0.00 from zero day to 5th week of storage. Melting resistance of K_2 showed more resistance then the control and was 66.41(g/min.) on 0th day and 66.30(g/min.) on 35th day. Siva et al. (2019) developed functional kulfi and concluded that melting resistance is influenced by many important factors such as additives used in it, fat globules and formation of the crystals.

Effect of storage on antioxidant activity and microbial load of developed kulfi

Table 4 Effect of storage on some physico-chemical properties of MQF enriched kulfi

Attributes		Antioxidant activity (%)	Acidity (%)	pH (%)	Melting resistance (g/min.)
	No. of days				
0	Control sample (K)	Nil	0.17 ± 0.10	*6.41 ± 0.02	*6.06 ± 0.02
	Accepted sample (K_2)	68.61 ± 0.10	0.21 ± 0.04	*6.19 ± 0.01	*6.41 ± 0.03
7th	Control sample (K)	Nil	0.16 ± 0.01	*6.40 ± 0.00	*6.06 ± 0.03
	Accepted sample (K_2)	68.59 ± 0.03	0.22 ± 0.05	*6.18 ± 0.00	*6.38 ± 0.02
14th	Control sample (K)	Nil	0.16 ± 0.02	*6.38 ± 0.02	*6.05 ± 0.01
	Accepted sample (K_2)	67.90 ± 0.01	0.21 ± 0.02	*6.13 ± 0.01	*6.35 ± 0.03
21st	Control sample (K)	Nil	0.17 ± 0.06	*6.35 ± 0.02	*6.04 ± 0.05
	Accepted sample (K_2)	67.57 ± 0.00	0.20 ± 0.01	*6.13 ± 0.03	*6.32 ± 0.03
28th	Control sample (K)	Nil	0.16 ± 0.02	*6.35 ± 0.04	*6.04 ± 0.11
	Accepted sample (K_2)	67.32 ± 0.00	0.22 ± 0.01	*6.12 ± 0.05	*6.31 ± 0.06
35th	Control sample (K)	Nil	0.16 ± 0.02	*6.32 ± 0.07	*6.03 ± 0.02
	Accepted sample (K_2)	67.01 ± 0.10	0.21 ± 0.01	*6.12 ± 0.05	*6.30 ± 0.04

Values mentioned as Mean ± Standard deviation (n=3)
*Attributes with different scores shows significant difference ($p<0.05$)

The antioxidant content tends to decrease slightly from 68.61% radical activity at 0th day to 67.01% radical activity on 35th day as shown in (Figure 2). Similar observations has been recorded by (Fernandes et al. 2020). They observed that freezing can affect the antioxidant content which can tends to decrease during storage conditions. It may get lost during storage. A decreasing trend of microbial growth varies from 4.99 cfu/ml on the 0 day to 4.12 cfu/ml on 35th day as shown in (Figure 3). Lee and White (1991) demonstrated that the storage condition plays an important role in the reduction of the microbial content due to the low temperature. The formation of the ice crystals during the storage leads to the disruption of the cell wall of the microbes which kills the microbes during storage (Davidson et al. 2000).

Conclusions

Malted quinoa flour enriched kulfi can be prepared commercially and stored at freezing temperature. It has high amount of polyphenols as well as antioxidants. MQF enriched kulfi has a unique flavor and color and hence does not require any additional artificial coloring or flavoring agents. Quinoa can be a core ingredient of great importance in many other value added products. High fiber and gluten free property of quinoa makes it valuable product for those having celiac disease and digestive problems. With low glycemic index it serves as a promising food for diabetic patients.

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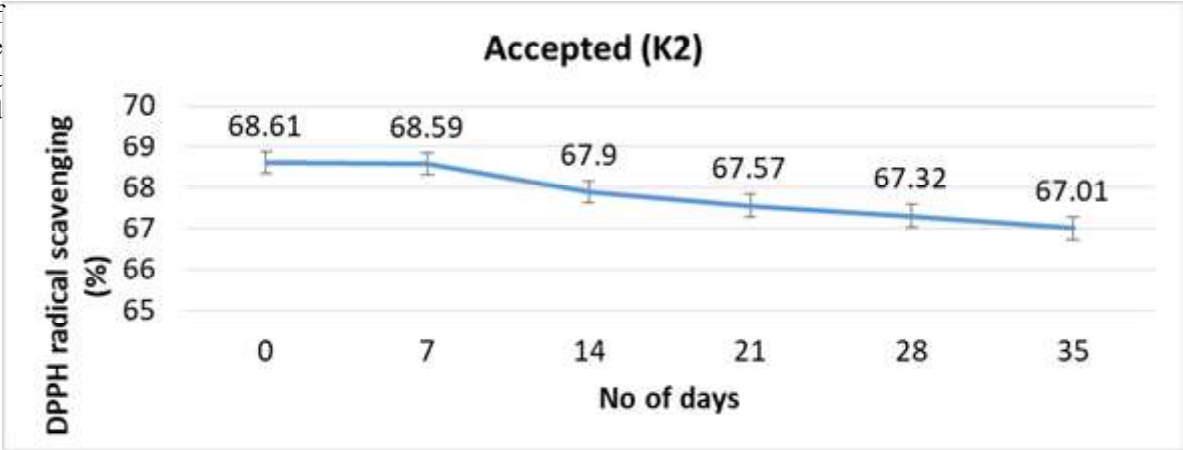

Fig. 2 Effect of storage on the antioxidant content of the MQF enriched kulfi

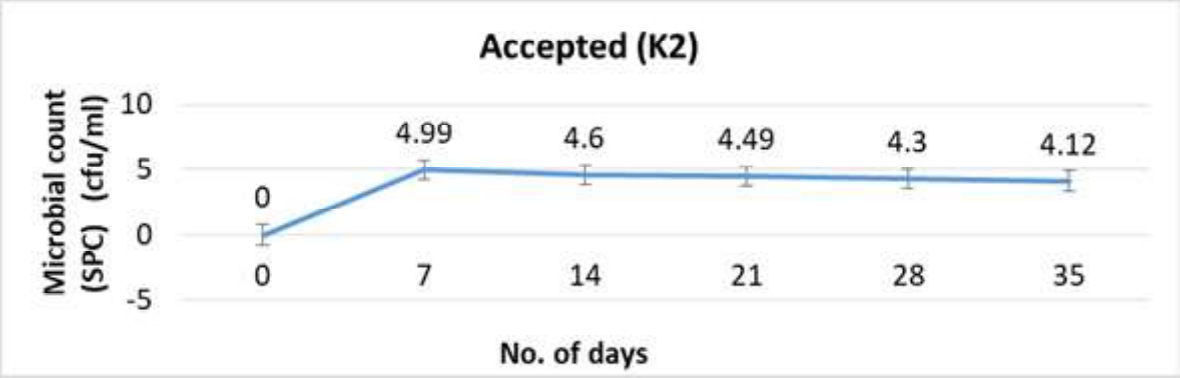

Fig. 3 Effect of storage on standard plate count of MQF enriched kulfi

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