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Research Article

Quality evaluation of yoghurt stabilized with sweet potato (*Ipomoea batatas)* and taro (*Colocassia esculenta*) starch

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Abstract

Stabilizers are important component in manufactured products such as yoghurt. The addition of stabilizers improves body, texture, appearance, mouth feel and prevents technical defects such as synersis in yoghurts. In this study, starch was extracted from plant sources (sweet potato, taro) with and without use of chemicals. Yoghurt was enriched with different levels of extracted starch. Yoghurt samples were analyzed for physicochemical and functional attributes such as pH, acidity, synersis, water holding capacity, viscosity, total solids and sensory profile. Use of chemically extracted starches at the level of 0.3-0.4% (Sweet potato) and 0.2-0.3% (Taro) in yoghurt manufacturing showed better results in terms of lowering synersis, increasing water holding capacity, viscosity and overall acceptability as compared to the yoghurt containing stabilizer i.e. gelatin 0.5% w/w. Use of starches did not significantly affect the sensory attributes. Yoghurt that contains sweet potato and taro starch at 0.5% gave excellent results for water holding capacity, viscosity and for all sensory attributes as compared to gelatin.

1. Introduction

Stabilizers are ingredients, when added to solution they will improve increase viscosity, stability and sensory attributes. The ethical concerns have resulted in a global interest for Halal and natural stabilizer. In order to replace the objectionable ingredient, various native starches can be used. Therefore, the use of roots and tubers like potato, sweet potato and taro (*arvi*) as a starch source has been gaining importance. Sweet potato is a creeping dicotyledonous plant and belonging to the *Convolvulaceae* family. It is globally the sixth main crop and annually production is 105 million metric tons. Developing countries produce about 95% of the world sweet potato. Production of sweet potato in Pakistan is 11,951 tons/year. It consists of 50-80% starch on dry matter basis. Sweet potato starch possesses A-type (high swelling) pattern and its granules are medium sized with a smooth round or oval shape. Sweet potato is highly nutritive and source of vitamins (A and C), iron, potassium, calcium, other minerals and fiber. It is essential for immune function, vision, skin and bone health (Khan et al., 2008). Sweet potato starch is usually added to foods as thickener, binder, adhesive, gelling agent, encapsulating agent, film former, stabilizer, texturizer and fat-replacer (Ozturk et al., 2012).

Arvi is the local name of Taro (*Colocassiaesculenta*). It belongs to family *Araceae*. The total production of *arv*i in the world is 9.22 million tons. The corms of the *arvi* are known to be good source of starch because they contain tiny, digestible starch grains in range of 70-80% (Ammar et al., 2009). *Arvi* is high in carbohydrate and energy but low in fiber but good source of fat and oil. It is rich in nicotinic acid, carotene, riboflavin, thiamine and ascorbic acid. It is high in magnesium, zinc and phosphorus. Taro (*Arvi)* cormels and corms are important sources of industrial starch and flour (Aboubakar et al., 2008). Yoghurt is oldest fermented dairy product, commonly consumed food product due to its nutritional and therapeutic properties. The main problem face by the yoghurt industry in the production and maintenance of yoghurt is the stability and optimum consistency. Stabilizers are added to improve the texture, mouth feel, appearance and reduce synersis in yoghurt (El-Sayed et al., 2002). Keeping in view all the benefits of starch as stabilizer, the present study was planned to extract starch from sweet potato and taro (with and without use of chemicals) and find out their suitability as stabilizer in yoghurt manufacturing.

2. Materials and Methods

2.1. Procurement of raw materials

Fresh buffalo milk was obtained from dairy farm of University of Agriculture, Faisalabad. Sweet potato, Taro (Arvi) and yoghurt starter culture (Nestle yogurt) were purchased from local market of Faisalabad.

2.2. Starch Extraction

2.2.1. Extraction without chemical

Sweet potato was washed, peeled, sliced to obtain the pulp and sieved through muslin bag. The filtrate (starch milk) was allowed to stand for some time to settle before decanting the supernatant to obtain wet starch cake. The wet starch cakes of the samples were sun dried, ground into fine powder and stored for analysis (Oladebeye et al., 2009). Taro (*arvi)* was washed, peeled and trimmed and dried in dehydrator at 50 ± 2ºC. The dried slices were first hammer milled to pass through a 500µm screen. 100g of arvi flour was steeped in water solution (3L) for 12h. Slurry was homogenized using a blender then suspension was screened using 150µm sieve and kept to sediment for 24h. The crude starch was collected, washed, dried in an oven and stored for analysis (Aboubakar et al., 2008).

2.2.2. Extraction with chemical

Sweet potato and taro was rinsed, peeled, diced and then blended by a domestic blender in a 50 mg/mL sodium bisulfite water solution (750 mL/L). The mixture was then passed through a 200 mesh (74 mm) sieve. The residue was exhaustively rinsed on the sieve, again with the sodium bisulfite solution and the filtrate was allowed to stand at 4ºC overnight. The starch sediment was treated with 0.1 g/100 mL sodium hydroxide solution and then centrifuged at 6000g. The precipitate was collected and rinsed several times with distilled water until the pH of the starch was closed to 7.0. The starch sediment was rinsed with ethanol. The precipitate was evaporated and dried in conventional oven at 40ºC overnight. The starch was then ground in order to pass through a 74 mm (200mesh) sieve. The resulting starch powder was collected, double bagged in polyethylene and stored (Hung et al., 2010).

2.3. Starch analysis

2.3.1. Ash, moisture content and crude protein

Ash, moisture content and protein were determined by their respective method as described in AOAC (2000).

2.3.2. pH

5g starch was mixed with 20 mL of distilled water and pH was measured by using pH meter (WTW series pH-720) (Mweta, 2009).

2.3.3. Water-holding capacity (WHC):

WHC of starch was determined by centrifuging 1g of starch at 16000 rpm for 15 minutes at 25ºC (Garg & Jana, 2011).

2.3.4. Swelling power and solubility

The swelling power and solubility of starch in water were determined by taking 0.1g starch sample with 10mL of distilled water and centrifuged at 3000rpm for 20 min (Garg & Jana, 2011).

2.3.5. Syneresis

Syneresis of the starch sample at different storage period was determined by heating (2% w/v) suspension at 85ºC for 30 min and centrifuged at 3200 rpm for 15 min (Singh et al., 2009).

2.3.6. Viscosity

Viscosity of starch was determined by using Brookfield DV-E viscometer at 4-6ºC temperature as the method described Mweta (2009).

2.4. Preparation of yogurt:

Yogurt was prepared by following the method of Malik (2011). Starch extracted with or without use of chemical from plant sources (Sweet potato, Taro) was used in yogurt at different concentration (0.1, 0.2, 0.3, 0.4 and 0.5%) in preliminary trials. 0.5% level was selected and used for subsequent study to investigate their effectiveness as stabilizer in yogurt during storage as shown in the Table 1. Yogurt

Table 1: Treatment Plan

Yoghurt samples	Sweet potato starch %(w/v)	Taro starch %(w/v)	Gelatin %(w/v)
Y_G	_	-	0.5
Y_P	_	-	-
Y_1S_1	0.5	-	-
Y_1S_2	0.5	-	-
Y_2S_1	-	0.5	-
Y_2S_2	-	0.5	-

Y_G = Control (Yoghurt contain 0.5% gelatin)
Y_P = Plain yoghurt (without any stabilizer)
Y_1S_1 = 0.5% sweet potato starch (extract without chemical)
Y_1S_2 = 0.5 % sweet potato starch (extract with chemical)
Y_2S_1 = 0.5% taro starch (extract without chemical)
Y_2S_2 = 0.5% taro starch (extract with chemical)

manufactured by using gelatin (0.5%) was used as control.

2.5. Analysis of yoghurt:

Yoghurt was analyzed in triplicate for pH, acidity, total solids viscosity, synersis and water holding capacity within 15 days storage at 4ºC.

2.5.1. pH:

Electronic digital type pH meter (WTW series pH-720) was used.

2.5.2. Acidity and total solids

The acidity values were determined as the amount of 0.1N NaOH solution (mL) used to neutralize 10g of yoghurt sample. Total solids were measured by using 5g of yoghurt sample (AOAC, 2000).

2.5.3. Viscosity:

Viscosity of the yoghurt was determined by means of Brookfield DV-E viscometer at 4-6ºC temperature as described by Aryana & McGrew (2007).

2.5.4. Syneresis

Syneresis of the yoghurt samples at different storage period was determined as free whey by using the method of Nafiseh et al. (2008).

2.5.5. Water-holding capacity (WHC)

WHC of yoghurt was determined by method in which 10 g of yoghurt sample was centrifuged at 13500 rpm for 30 minutes at 10ºC (Spasenija et al., 2007).

2.5.6. Sensory analysis

Sensory analysis was carried out by a panel of 5 judges.

2.6. Statistical analysis

Data obtained was subjected to statistical analysis by using Complete Randomized Design (2-factor factorial) to determine the level of significance by using R statistical design (Steel et al., 1997).

3. Results and Discussions

3.1. Analysis of starches

Sweet potato and taro starch was subject to different analysis. All the analyses were performed in triplicate and mean values are presented in Table 2. Results showed the results of sweet potato and taro starch analysis (extracted with and without chemical). For sweet potato values for pH, WHC, swelling power, solubility, synersis, ash, moisture, protein and viscosity was in the range of 5.36-5.63, 82.73-83.56%, 10.1-10.3%, 3.33-3.36%, 24.83-25.4%, 0.72-0.76, 10.4-10.5%, 0.31-0.34%, 7573-7586cp respectively. However, for taro these values were in the range of 5.6-5.81, 82.41-83.41%, 12-12.2%, 4.26-4.42%, 28.5-29.3%, 0.13-0.14%, 10.5-10.6%, 0.50-0.60% and 7429-7475cp respectively. Data showed that there is no significance ($P>0.05$) difference between values of starch extracted with chemicals and without chemical. pH, swelling power and synersis of taro starch were greater than sweet potato starch whereas viscosity of taro starch was less than sweet potato. The results obtained in present study are in line with the findings of Mweta et al. (2009), who also reported the same pattern of change in different parameters with change in starch source.

3.2. Physicochemical analysis of yoghurt

Table 3 indicates mean values for physicochemical parameters of yogurt in the present study. Yoghurt pH was gradually decreased in all treatments during storage either in control sample or treated samples during 15 days of storage. Maximum decrease in pH was observed in Yp followed by Y_2S_1 whereas in Y_1S_2 there was minimum change in pH value. During storage, decrease in pH was mainly due to the conversion of lactose into lactic acid. pH decrease

Table 2: Physicochemical analysis of starch

Physic-chemical Analysis	Sweet potato starch		Taro starch	
	Extraction with chemical	Extraction without chemical	Extraction with chemical	Extraction without chemical
pH	5.36±0.2	5.63±0.11	5.81±0.01	5.6±0.005
Water holding capacity	82.73% ±0.49	83.56%±2.9	82.41% ±0.10	83.41% ±0.16
Swelling power	10.1% ±0.1	10.3%±0.6	12% ±0.05	12.2% ±0.15
Solubility	3.33% ±0.11	3.36%±0.1	4.26% ±0.23	4.42% ±0.017
Synersis	25.4% ±0.7	24.83%±1.4	29.3% ±0.21	28.5% ±0.25
Ash	0.76% ±0.04	0.72%±0.02	0.14% ±0.02	0.13% ±0.01
Moisture	10.5% ±0.2	10.4%±0.81	10.6% ±0.3	10.5% ±0.15
Protein	0.34%±0.02	0.31%±0.03	0.60% ±0.14	0.50% ±0.13
Viscosity	7586cp±126	7573cp±296	7475cp ±24.37	7429cp ±15.53

Table 3: Mean values for physicochemical analysis of yoghurt during storage

Treatments	Storage days	pH	Acidity%	Total solids%
	0 day	4.74	0.69	14.43
Y_G	7^{th}	4.51	1.05	14.43
	15^{th}	4.30	1.40	14.46
	0 day	4.45	0.82	12.53
Y_P	7^{th}	4.03	2.20	12.63
	15^{th}	3.69	3.30	12.83
	0 day	4.68	0.76	14.00
Y_1S_1	7^{th}	4.46	1.14	14.60
	15^{th}	4.21	1.46	14.90
	0day	4.72	0.73	14.56
Y_1S_2	7^{th}	4.56	1.05	14.86
	15^{th}	4.41	1.42	15.33
	0 day	4.62	0.78	13.66
Y_2S_1	7^{th}	4.25	1.18	13.96
	15^{th}	4.13	1.51	14.26
Y_2S_2	0 day	4.65	0.77	14.13
	7^{th}	4.42	1.16	14.56
	15^{th}	4.18	1.49	14.73

Y_G = Control (Yoghurt contain 0.5% gelatin)
Y_P = Plain yoghurt (without any stabilizer)
Y_1S_1 = 0.5% sweet potato starch (extract without chemical)
Y_1S_2 = 0.5 % sweet potato starch (extract with chemical)
Y_2S_1 = 0.5% taro starch (extract without chemical)
Y_2S_2 = 0.5% taro starch (extract with chemical)

Table 4: Mean values for Viscosity, Synersis and Water holding capacity

Treatments	Storage days	Viscosity (cp)	Synersis %	WHC %
	0 day	2235	1.87	12.96
Y_G	7^{th}	1981	2.01	11.45
	15^{th}	2182	2.17	10.03
	0 day	1302	3.26	10.11
Y_P	7^{th}	1031	5.13	8.67
	15^{th}	1212	6.52	6.98
	0 day	2388	2.02	30.32
Y_1S_1	7^{th}	2119	2.24	28.49
	15^{th}	2203	2.39	25.48
	0day	2846	1.91	31.66
Y_1S_2	7^{th}	2598	2.09	29.73
	15^{th}	2660	2.18	26.60
	0 day	1938	2.12	29.36
Y_2S_1	7^{th}	1668	2.69	27.44
	15^{th}	1798	2.99	25.31
Y_2S_2	0 day	2362	2.04	30.41
	7^{th}	2050	2.31	28.80
	15^{th}	2179	2.52	25.92

WHC=Water holding capacity
Y_G = Control (Yoghurt contain 0.5% gelatin)
Y_P = Plain yoghurt (without any stabilizer)
Y_1S_1 = 0.5% sweet potato starch (extract without chemical)
Y_1S_2 = 0.5 % sweet potato starch (extract with chemical)
Y_2S_1 = 0.5% taro starch (extract without chemical)
Y_2S_2 = 0.5% taro starch (extract with chemical)

patterns in the present study is in accordance with Hussaein et al. (2011), who also reported the decrease in pH during storage. Guler-Akin & Akin (2007) and Seelee et al. (2009) also reported that pH of yoghurt decreases during the storage. Acidity increased in all yoghurt treatments. Yp showed maximum change in acidity with storage and the minimum acidity was observed in Y_G followed by Y_1S_2 as these have shown more resistance against acidity change during storage. Khalifa et al. (2011) also reported the gradual increase in acidity of yoghurt with storage. Andic et al. (2013) and Anwer et al. (2013) correlated the increase in acidity of yoghurt during the storage with lactic acid production from lactose by lactic acid bacteria. As far as total solids are concerned, there was no significant change in all treatments. Y_G showed minimum change in total solids during storage whereas maximum change was observed in Y_1S_1 followed by Y_1S_2. Increase in total solids with storage days was due to syneresis in yoghurt as a result water losses and solid content ratio increase (Peroni et al., 2006). But results of our study are not in accordance with the findings of Anjum et al. (2007) who reported that total solids decreased gradually with the succession of storage period.

3.3. Viscosity, synersis and water holding capacity of yoghurt

Viscosity, synersis and water holding capacity of yoghurt samples were affected significantly due to different concentrations of starch as well as storage (Table. 4). Viscosity for all samples was decreased from 1st to 7th days and there was increased in viscosity from 7th to 15th days for all samples. Maximum decrease in viscosity was recorded in Y_1S_2 (2846-2660 cp) followed by Y_1S_1 (2388-2203 cp) and Y_2S_2 (2362-2179 cp). However, minimum decrease was in Y_G i.e. 2235-2182 cp). Increase in viscosity during storage is due to protein rearrangement and protein-protein contact (Iseleton & Karagul-Yuceer, 2006). The viscosity is affected by the state and concentration of fats and protein, temperature, pH and age of milk (Park, 2007). Malik (2011) also reported the same pattern for viscosity change with storage in his study. The results were found to be in accordance with Eissa et al. (2011), who reported that the viscosity decreases with the storage because of increased acidity and synersis. Against reduction in synersis Y_G showed excellent results. In this study, highest synersis was recorded at day 15th of storage as compared to 0 day and 7th day of storage in all treatments. Maximum synersis was observed in Y_P and minimum in Y_1S_2. Hussein et al. (2011) also reported the increase rate of synersis with increase in storage period. The results were agreed with Chye et al. (2012) and Sakandar et al. (2014) they also found that the synersis of yoghurt increases with storage period. Y_1S_2 showed maximum water holding capacity (WHC) as compared to all other treatments. Results showed that sweet potato and taro starch containing samples have higher water holding capacity as compared to gelatine and plain yoghurt (Table 4). During storage of yoghurt, WHC was reduced due to interaction between casein aggregates and polysaccharides that leads to weaker casein micells and this interaction was developed when the lactose is converted into lactic acid (Vliet, 1993). Sakandar et al. (2014) also reported that water holding capacity decreases with the storage because of increased acidity and synersis. Sample containing sweet potato and taro starch showed more viscosity and water holding capacity and less synersis as compared to sample containing gelatin.

Table 5: Mean values for sensory evaluation of yoghurt during storage

Treatments	Days	Appearance	Texture /body	Flavour	Sensory Acidity
	0	13.00	28.13	33.00	8.00
Y_G	7th	13.00	27.16	32.67	7.00
	15th	12.06	26.67	32.00	6.00
	0	12.06	25.90	31.00	6.57
Y_P	7th	11.00	24.36	30.00	5.00
	15th	10.00	22.83	28.33	3.59
	0	12.80	26.93	32.23	7.63
Y_1S_1	7th	12.40	26.26	31.46	7.00
	15th	12.06	25.16	30.46	5.96
	0	13.33	28.43	33.03	8.33
Y_1S_2	7th	13.40	27.66	32.60	7.73
	15th	13.00	27.36	32.46	7.20
	0	12.36	26.36	31.20	7.13
Y_2S_1	7th	12.00	25.33	30.80	6.13
	15th	11.73	24.26	29.96	5.00
Y_2S_2	0	12.73	26.73	31.93	7.46
	7th	12.46	26.33	31.23	6.56
	15th	12.03	25.20	30.46	5.20

Y_G = Control (Yoghurt contain 0.5% gelatin)
Y_P = Plain yoghurt (without any stabilizer)
Y_1S_1 = 0.5% sweet potato starch (extract without chemical)
Y_1S_2 = 0.5 % sweet potato starch (extract with chemical)
Y_2S_1 = 0.5% taro starch (extract without chemical)
Y_2S_2 = 0.5% taro starch (extract with chemical)

3.4. Sensory evaluation

The results for appearance, texture, flavor and sensory acidity indicated that the interaction of samples and treatments are non-significant while the different concentrations of starch have significant affect with respect to the storage time (Table. 5). Y_1S_2 has got highest scores for all sensory parameters during whole storage time then other treatments and Y_P awarded lowest score. There is no significance difference in sensory characteristics values of samples containing sweet potato and taro starch at different concentrations. Salwa et al. (2003) also reported that chemical and sensory properties of yoghurt were decreased with passage of time.

4. Conclusion

Stabilizers play important role in yoghurt formation as they increase stability, viscosity, improve texture, mouth feel and inhibit the synersis. Samples containing 0.5% starch from each source i.e. sweet potato and taro, showed best results quality and overall sensory acceptability as compared to other treatments. It also observed that yoghurt can be stored up to 15 days at 4º C by giving proper storage and specially packaging condition.

5. Declaration of interest

There is no conflict of interest among authors regarding the submission of this research work

6. References

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