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DEVELOPMENT OF MICROENCAPSULATED WHEY MELON JUICE

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Abstract: Whey melon has conquered the Indian diet as a refreshment drink in terms of its acceptable flavor and energy benefits. Microencapsulation studies by spray drying were done with the objective of increasing the shelf stability of whey melon. Microencapsulation was done with whey melon as the core material and maltodextrin as the wall material. Initially, microencapsulated whey by spray drying was made at 20% and 25% levels of maltodextrin. This was done and optimized at drying air inlet temperature of 180ºC, pressure of 2 kg/cm^2 and feed rpm of 2000. By sensory analysis, it was found that 25% levels of maltodextrin were optimized for microencapsulated spray dried whey. Emulsion characteristics were analyzed for physical parameters such as pH, acidity, re-dispersion time and total soluble salts which were 6.2, 14%,37 sec and 18^{0}Brix. The feasibility of spray dried whey led to further studies on microencapsulation of whey melon. Whey melon emulsion was made at maltodextrin, melon and sugar levels of 25%, 15% and 15% of the total volume of whey. The yield obtained was 250 g. Based on sensory analysis, sugar concentration of 15% and maltodextrin level of 25% were optimized for the production of microencapsulated whey melon by spray drying. The process parameters were optimized at 200ºC inlet air temperature and feed pump rpm of 1700. Proximate analysis was performed formed for standardized sample protein content was 3.9 g/100 g, vitamin C 12.8 mg/100 g, carbohydrate 89 g/100 g, energy 356 kcal ,ash 3.3%. Scanning electron microscopy was performed for the optimsed sample and particle size was found to be 37.5±5.6 µm. Microbial analysis was performed by TPC was found to be 1 x 10^3 cfu/ml, which was found to be within the acceptable limit.

Keywords: Spray drying; Microencapsulation, Wheymelon, Malto dextrin.

INTRODUCTION

Whey or milk serum is the liquid remaining after milk has been curdled and strained. It is a by-product of the manufacture of cheese or casein and has several commercial uses.Whey protein contains all of the essential amino acids in the proportions that the body requires for good health. It also provides about 26 g per 100 g of protein of the branched-chain amino acids (BCAAs) leucine, isoleucine and valine. BCAAs are unique among amino acids in their ability to provide glucose and a readily available energy source during endurance exercise. In addition, preliminary studies show that a certain form of hydrolyzed whey protein may offer advantages in lowering high blood pressure. There are even some suggestions of protection against infections and viruses.

Watermelon (Citrullus lanatus var. lanatus, family Cucurbitaceae) is a vine like flowering plant originally from southern Africa. The watermelon fruit, loosely considered a type of melon although not in the genus Cucumis has a smooth exterior rind (usually green with dark green stripes or yellow spots) and a juicy, sweet interior flesh (usually deep red to pink, but sometimes orange, yellow, or white).

Spray drying is the most common and cheapest technique to produce microencapsulated food materials. Compared to freeze-drying, the cost of spray drying method is 30–50 times cheaper. The process has usually proved not only economic but also efficient. Considering the above cited facts, a study was undertaken with an objective of Standardization of spray drying parameters to get powder from whey melon and Quality evaluation and storage studies on the final product.

2. MATERIALS AND METHODS

2.1. Materials and chemicals

Whey was procured from the dairy plant, Mannuthy. Fresh watermelons (C. lanatus) variety was purchased from local supermarket, Tavanur, in Kerala, India. Watermelons with an average of 3.5 kg and had no bruises on the skin

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were chosen for the experiments. The maltodextrin was from Coimbatore. All chemicals used in this study were of reagent grade.

2.2. Preparation of Whey melon juice and spray drying

For each run, watermelons were cut and sliced and juice is made, then juice was filtered by using muslin cloth. To this juice sugar was added and stirred thoroughly and this prepared juice is added into the whey and maltodextrin was then added and stirred it thoroughly and the whey melon juice is filtered by using muslin cloth.

The Microencapsulation was carried out in Tall type spray dryer with two fluid nozzles. The pressure dryer was set to 2 kg/cm^2. Two inlet temperatures were used in the experiments namely 180 and 200°C. The outlet temperature was 100°C. The feed pump rate for the spray dryer was set to 12 rpm. The slurry or solution is spray dried.

Figure 1: Process flow diagram for the whey melon preparation

2.3. Moisture content

The moisture content of Wheymelon powder was determined by gravimetric method. (Ranganna, 1995).

2.4. pH

The pH of the whey melon powder samples was determined using a digital pH meter. (YORCO pH meter, model: YSI – 601)

2.5. Titrable acidity

Acidity in the sample was determined by titrating the reconstituted whey melon sample against a standard alkali (NAOH) solution using phenolphthalein as an indicator.

2.6. Total soluble solid (TSS)

TSS was measured using a hand refractometer. (Ranganna, 1995).

2.7. Water activity

Measurement of water activity was carried out using an Aqua lab water activity meter.

2.8. Bulk density

Bulk density of the sample was determined by the method demonstrated by Bhandari et al. (1993).

2.9. Wettability

Wettability of the sample was determined by the method demonstrated by Falade and Omojola, 2010; Desousa et al., (2008).

2.10. Scanning Electron Microscopy analysis

Scanning Electron Microscopy analysis of the samples were carried out using, JSM-6400 scanning electron microscope (JEOL, Tokyo, Japan). The micrographs were taken at magnification of 500X and 200X for the samples.

2.11 Microbiological analysis

Microbiological analysis of prepared samples included determination of total viable count (Anjineyulu Kothakota et al., 2014). Experiments were conducted in triplicate.

2.12 Sensory evaluation

The drink prepared from powder were assessed for their sensory attributes like appearance, odour, flavour, taste and overall acceptability by using a 5-point scale with 18 panelists to find out the consumer acceptability.

3. PROXIMATE ANALYSIS

3.1 Determination of protein

The protein content was determined from the organic nitrogen content by Micro-Kjeldal method.

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3.2 Vitamin C

The direct colorimetric method is based on measurement of extent to which a 2, 6-dichloophenol –indophenols solution is decolorized by ascorbic acid in sample extracts and in standard ascorbic acid solutions. Since inferring substances reduce the dye slowly, rapid determination would be measuring mainly the ascorbic acid.

Reagents:

1. 2% metaphosphoric acid in glass distilled water.
2. Dye solution: Dissolve 100 mg of 2, 6-dichloophenol-indophenol dye and 84 mg of sodium bicarbonate in hot (85-95^{0}C) distilled water, cool and make up to100 ml. Filter and dilute 25 ml to 500 ml with distilled water.
3. Standard ascorbic acid solution: accurately weigh 100 mg of ascorbic acid and make up to 100 ml to 500 ml with 2% HPO_3. Dilute 4ml of this solution to 100 ml with 2% HPO_3

Procedure

Preparation of sample: prepare the sample as in visual dye titration method but using 2% HPO_3. If the sample is solid, to blend 50 to 100 g of the sample with an equal weight of 6% HPO3 and make an aliquot of the macerate to 100 ml.

Standard curve : to dry cuvettes or test tubes, pipette the requisite volume of standard ascorbic acid solution- 1,2,2.5,3,4and 5 ml and make up to 5 ml with the requisite amount of 2% HPO_3 . Add 10 ml of dye with a rapid delivery pipette, shake and take the reading within 15 to 20 sec. Set the instrument to 100% transmission using a blank consisting of 5 ml of 2% HPO_3 solution and 10 ml of water. Measure the red color at 518 nm or a wavelength nearest to the required wavelength using a suitable filter. And Plot absorbance against concentration.

Sample: place 5ml of extract in dry cuvette or test tube, add 10 ml of dye and measure as in standard.

Calculation

Note the concentration of ascorbic acid from the standard curve and calculate the ascorbic acid content in the sample as shown below:

$$\text{mg of ascorbic acid per 100mg of sample} = \frac{\text{ascorbic acid} \times \text{volume made up for estimation} \times 100}{\text{ml of solution taken} \times 1000 \times \text{wt of sample taken}}$$

3.3 Determination of Total Carbohydrate by Anthrone Method

Procedure

Weigh 100 mg of the sample into a boiling tube. Hydrolyse by keeping it in a boiling water bath for three hours with 5 mL of 2.5 N HCl and cool to room temperature.Neutralise it with solid sodium carbonate until the effervescence ceases.Make up the volume to 100 mL and centrifuge.Collect the supernatant and take 0.5 and 1 mL aliquots for analysis.Prepare the standards by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 mL of the working standard '0' serves as blank.Make up the volume to 1 mL in all the tubes including the sample tubes by adding distilled water.Then add 4 mL of anthrone reagent.Heat for eight minutes in a boiling water bath.Cool rapidly and read the green to dark green colour at 630 nm.Draw a standard graph by plotting concentration of the standard on the X-axis versus absorbance on the Y-axis.From the graph calculate the amount of carbohydrate present in the sample tube.

Calculation

$$\text{Amount of carbohydrate present in 100 mg of the sample} = \frac{\text{mg of glucose} \times 100}{\text{Volume of test}}$$

3.4 Determination of total ash

Note the tare weight of silica dishes. Weigh 5-10 g of sample into each. If moist, dry on a water bath. Ignite the dish and the contents on a Bunsen burner. Ash the material at not more than 525^{0}C for 4-6 hrs; if need be, ash overnight. Cool the dishes and weigh. The difference in weights gives the total ash is expressed as percentage.

3.5 Standardization of whey melon powder

About 750 ml of the Wheymelon juice were taken in spray dryer. The drying of Wheymelon juice was carried out at different feed rate-treatment combinations. For this purpose nine temperature-treatment combinations are used and are represented by T1, T2, T3, T4, T5, T6, T7, T8 and T9.

Treatment	Watermelon juice (%)	Sugar (%)	Maltodextrin (%)	Corn starch(%)
T1	-	-	20	-
T2	-	-	25	-

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T3	7.5	7.5	25	-
T4	7.5	7.5	20	-
T5	7.5	7.5	-	25
T6	10	10	20	-
T7	10	10	25	-
T8	12	12	25	-
T9	15	15	25	-

Table 1: Selected proportions of melon juice, Malto dextrin and sugar in whey

3.6 Packaging

The powder obtained spray dryer is packed for shelf life studies. The samples were packed using a hand sealing machine and stored in ambient condition (temp 29-30˚C with 40-50% RH) and the different quality parameters of the powder were evaluated. The powder was packed in Aluminium foil.

3.7 Storage studies

The most acceptable treatment was selected for storage studies at room temperature. Bio-chemical analysis of powder obtained by spray drying was carried out to evaluate the quality deterioration during drying and storage. The moisture content, total solids, pH, bulk density, and wettability were estimated in every week using the standard procedures.

4. RESULTS AND DISCUSSION

4.1 Preparation of juice

Juice was prepared by altering proportions of maltodextrin, sugar and melon; and composition was standardized as 15% sugar, 25% maltodextrin and 15% melon of whey. Standardization was done according to spray drying parameters and yield of product obtained.

Since the yield was better than the other samples and also the taste was acceptable than the others, T9 was opted as standard one by us.

4.2 Standardization of spray drying parameters

The spray drying parameters were optimized based on the yield and external appearance of the powder. Temperature and other process parameters were adjusted by considering the above attributes. At 200^{0}C more yield and better appearance was observed.

The time required for the spray drying was significantly high at low feed rate whereas a substantial reduction in powder was observed at higher pump feed rate (>12 rpm). The pressure and blower speed of spray dryer were adjusted to 2 kg/cm^2 and 1700 rpm, respectively in order to obtain good quality powder with the above attributes.

From these observations spray drying parameters were optimized as shown in the table 4.1.

Table: 4.1. Spray dryer standardized parameters

Spray drying parameter	**Results**
Inlet temperature	200^{0}C
Outlet temperature	100^{0}C
Feed pump rpm	12 rpm
Pressure	2 kg/cm^2
Blower rpm	1700

4.3 Physico chemical analysis

4.3.1 Moisture content determination of microencapsulated Wheymelon

The moisture content of the sample was estimated as 4% From the figure it was observed that during the initial period of drying there was a sudden decline in moisture content due to the evaporation of moisture from the surface. After that there was a decrease in drying rate. This was due to the time taken for diffusion of moisture from the interior to the surface.

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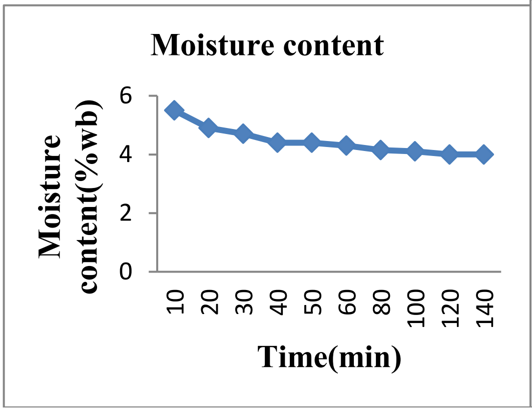

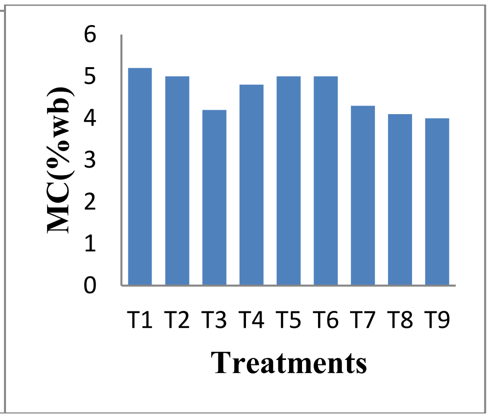

Fig. 4.1.1: drying curve **Fig. 4.1.2.: Moisture content variation in various treatments**

Moisture content of various treatments was found to be decreasing; this variation may be due to increase in maltodextrin and other components which would decrease the available moisture content in the sample. Similar results were obtained by Quek et al., 2007.

4.3.2 pH

pH of the optimized sample was found 6.6.

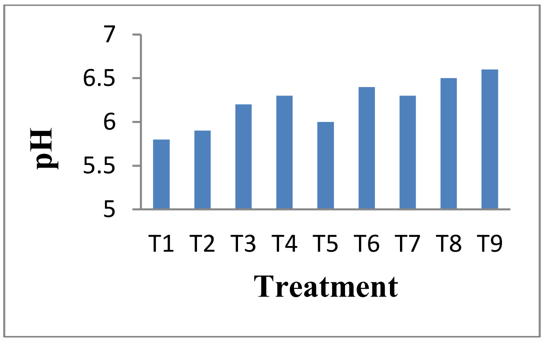

Fig. 4.2.: pH variation of various treatments

pH values analyzed for various samples showed the gradual increase since the content in juice is varying and is greater in the T9 sample, hence its pH was found to be higher. T1 has low pH because it contains only whey and maltodextrin. pH increases with increase in melon, sugar and maltodextrin.

4.3.3 Titrable acidity

Acidity for standardized sample was found to be:
Whey melon juice 17%
Rehydrated powdered whey melon 14%

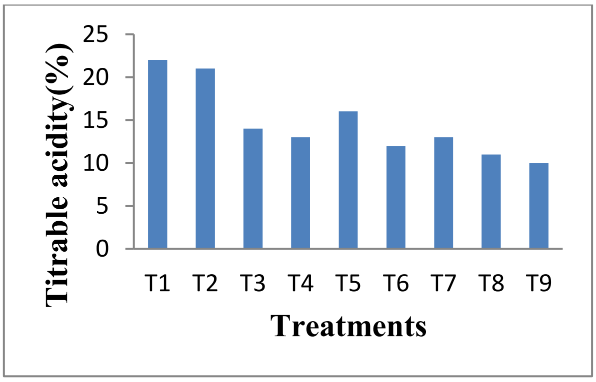

Fig. 4.3.: Acidity variation of various treatments

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Graph shows that acidity values of sample decreases and this variation may be due to increase in concentration of the melon juice and maltodextrin in the samples.

4.3.4 Total soluble solid

TSS obtained is,

Water melon juice 12° Brix
Whey 9° Brix.
Whey melon juice 26^0 Brix
Powdered juice 28^0 Brix

Brix of the four samples kept for sensory evaluation were predetermined and result obtained was:
Sample A: 17.5° Brix
Sample B: 17° Brix
Sample C: 17° Brix
Sample D: 18.5° Brix

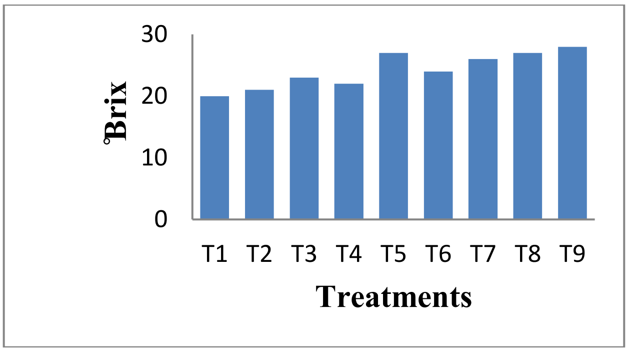

Fig. 4.4.: TSS Variation in various treatments

TSS value of the sample increases due to increase in the solid content of each sample till T9. Since concentration of components like melon juice, maltodextrin and sugar increases this trend was found to be acceptable.

4.3.5 Water activity

The variations in water activity for different treatments are shown in Fig. 4.5. Food stability usually decreases with increase in water activity. From the figure it is evident that the water activity is maximum for T1 treatment (without addition of melon 20% maltodextrin) and minimum for T9 treatment (spray drying with addition of 25% maltodextrin and 15% sugar). In general the water activity is within the permissible limit. Microorganisms respond differently to water activity depending on a number of factors. Microbial growth, and in some cases the production of microbial metabolites, may be particularly sensitive to alteration in water activity. An increase in temperature usually decreases microbial growth.

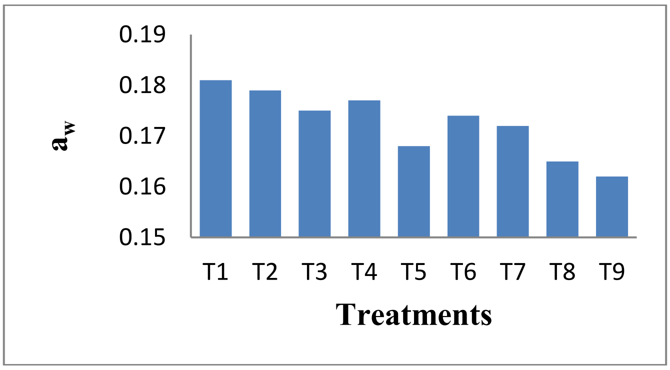

Fig. 4.5: water activity variation in various treatments

4.3.6 Bulk density

Bulk density was found to be 0.34 g/ml for standardized sample.

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4.3.7 Wettability

Wettabilty was determined as 37 seconds. The wetting time of the powder should be low for good reconstitution. It can be seen that as the temperature increases, the time required for wetting of the powder increases which implies the wettability of the powder decreases. This may be due to reduced product residual moisture content. Similar results were found by Bhandari et al. (1993) and Jumah et al. (2000)

4.4 Scanning electron microscopy analysis

Average particle size range obtained for the standardized sample is 37.5±5.6 µm

Plate 3.9 **200X Magnification of particle**

Plate 3.10 **500X Magnified image of**

Plate 3.11 Magnified image of particle

4.5 Microbiological Analysis

Microbial load of standardized sample was found to be $1X10^4$ CFU/ml and is safe and at acceptable level.

4.6 Sensory evaluation

Sensory evaluation was done on 4th February with 4 different samples of varying composition

Sample I: 100ml water + 3gm sample + sugar

Sample II: 100ml water + 3gm sample +.2% ginger+ sugar

Sample III: 100ml water +3gm sample +cardamom + sugar

Sample IV: control (fresh sample juice was prepared)

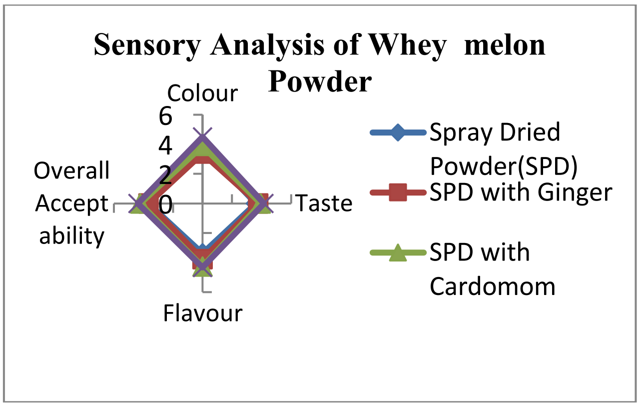

Fig. 4.6.Sensory analysis

The result obtained is shown in the graph. Sensory evaluation gave the opinion that sample flavored with cardamom came closer to control and next it was followed by unflavored sample and then by sample flavored with ginger.

4.7 proximate analyses

Parameters	Spray dried sample
Protein(g/100g)	3.9
Carbohydrate(g/100g)	89
Vitamin C(mg/100g)	12.8
Energy (K calories)	356
Ash (%)	3.3

Table: 4.2. Proximate analysis results

The result shows that powder is rich in nutrients.

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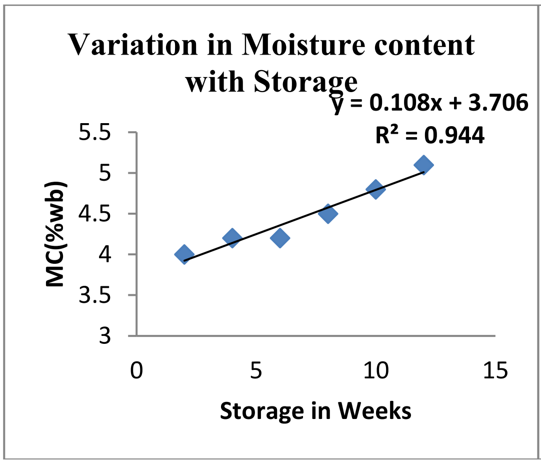
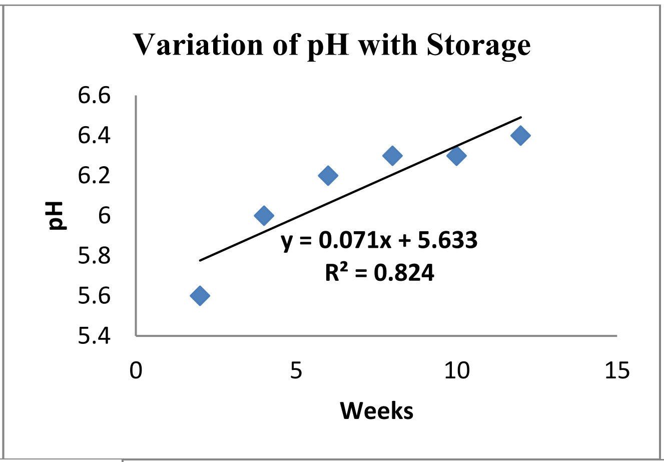
4.8 Standardization of Wheymelon powder

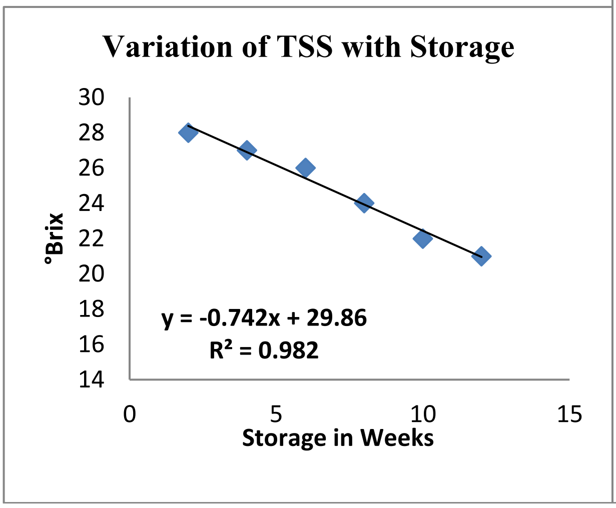
Standardization of Wheymelon powder was done after various trails. Various trails were done altering composition of sugar and maltodextrin varying from 20% maltodextrin to 25% and sugar from 10% to 15% depending on yield and quality of product. Treatment 1and 2 was done as a trail check whether product will get powdered or not without addition of melon. Treatment 3 and 4 was done with 7.5% melon and 20% and 25% maltodextrin. Next sample treatment 5 was with cornstarch instead of maltodextrin and it was found that cornstarch was very sticky and trail was rejected since low yield and sticky nature. Treatment 6, 20% maltodextrin and 10% sugar and 10% melon of whey was taken. Treatment 7 was tried adding 25% maltodextrin with 10% sugar and 10% melon. Treatment 8 was tailed with 25% maltodextrin and 12% sugar and 12%melon and last sample treatment 9 was done 25% maltodextrin and 15% sugar and 15% melon yield and taste was acceptable for this sample. Considering results of the physiological tests, T9 was standardized.

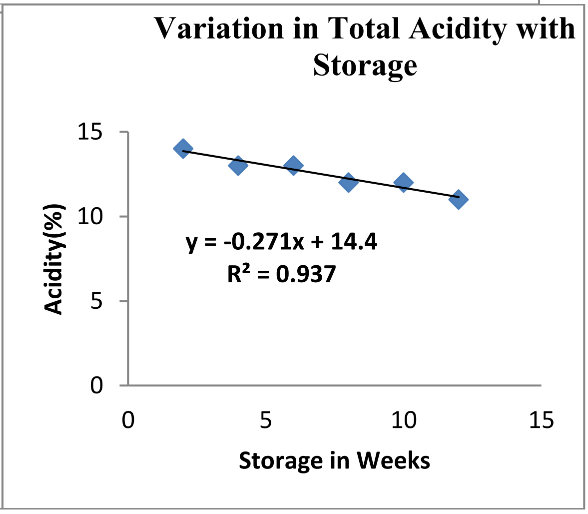
4.9 Shelf life study of the powder

The optimized sample was further subjected to shelf life study of storage. The results obtained are discussed below.









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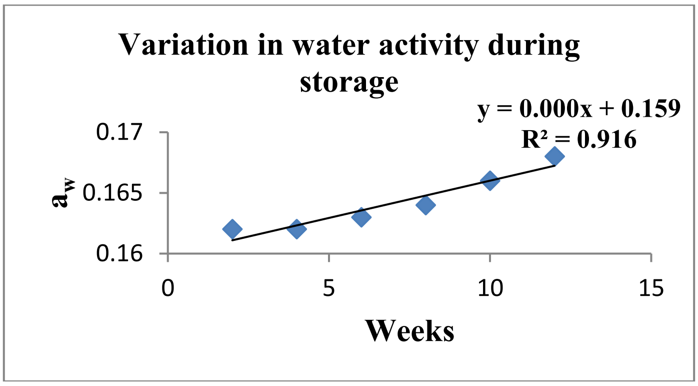

The increase in moisture content during storage may be due to the exposure of powder to atmospheric conditions during filling and sealing of dried material in the package. Also the increase in moisture content may be due to the accumulation of water molecule in the powder which may be due to permeability of packaging material. Similar results of increase in moisture content were reported by Mishra et.al, (2002) for apple powder.

It is found that pH increases during storage. The increase in pH may be due to the acid hydrolysis of polysaccharides (Luh and Woodrff, 1975).

When storage period increases total solid value decreases. This is due to the increase in moisture content during storage.

It is found that titrable acidity slightly decreases during storage. This may be due to the acid hydrolysis of polysaccharides (Luh and Woodrff, 1975).

Up to 4 weeks of storage the water activity was constant and after that a slight increase was observed. It may be due to improper sealing which causes penetration of moisture.

CONCLUSION

This study also proved that out of treatments being analyzed favorable outcome resulted out of standardized sample which was clear from the storage studies carried out and it was also clear that if the packaging improved, storage life could be improved since the product was highly hygroscopic. Our studies showed that the yield, taste and quality were better for the product made by the composition as 15% of water melon, 15% sugar and 25% of maltodextrin.

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