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EFFECT OF HOT AIR OVEN, MICROWAVE, MICROWAVE CONVECTIVE, FREEZE DRIED PINEAPPLE PULP ON STORAGE STABILITY OF CASEIN BALL (RASGULLA)

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ABSTRACT

Casein ball (rasgulla) is a round-shaped white coloured cheese ball of a very soft springy and porous texture dipped in sugar syrup and is one of the traditional milk-based sweets of India. Both fresh pineapple pulp (PP) and hot air (PH), microwave (PMW), microwave convective (PMWC) and freeze-dried (PF) pineapple powder mixed with chhana in 1:4 ratio were used to prepare the pineapple fortified rasgulla and coded as PP, PH, PMW, PMWC and PF, respectively. Pineapple (*Ananas comosus*) was chosen mainly due to its high amount of bioactive components, which reduce the rate of deterioration along with value addition purpose. The study aims to observe the effect of period of storage over 0-50 hours at room temperature (25±2°C) on casein ball (rasgulla) samples (fortified using differently dried pineapple), based on different physicochemical parameters such as phenolic content, antioxidant activity, colour change, hardness and sensory analysis. With the progress in storage time, the colour difference and hardness of all the rasgulla samples also increased and on the other hand, the total polyphenol content (TPC) and DPPH activity values decreased. The addition of differently dried pineapple powder to rasgulla helped to increase the TPC and DPPH scavenging activity, TPC and DPPH both increased by 3.5 fold and 5 fold respectively for PMWC (Microwave convective dried pineapple rasgulla). Also, hardness was decreased by 8.07 % in PMWC than NR (Normal rasgulla).Least colour difference was observed for PP (Pineapple pulp rasgulla) after 50 hours of storage. Significant changes on different sensory parameters were also observed with increase in storage time. Among all the samples the best result was observed for PMWC rasgulla.

Keywords: Sweetmeat, Drying, Antioxidant, Texture, Colour, Shelf-life

INTRODUCTION

India is one of the largest milk-producing countries in the world with a global market share of 9.5 % for the year 2018 and 176.3 million tons milk was produced for the year 2017-18 (Basic Animal Husbandry Statistics, DAHD&F, NDDB). Near about 60 % of the milk produced is used in the processing of different types of milk and milk-based products like sweetmeats, yoghurt, cheese etc. (**Vaswani *et al.*, 2002**). All the traditional dairy products have played a crucial role in daily Indian diet since ancient time and it accounts for more than 90% of all kinds of dairy products (**Aneja *et al.*, 2002**). Among all the sweet products that are prepared from milk, rasgulla or rosogolla is one of the most popular traditional sweetmeats all over India. Rasgulla is a sweet syrupy round shaped white coloured cheese ball with a very soft springy and mushy texture (**Bandyopadhyay *et al.*, 2008**). The principal raw material for preparing rasgulla is chhana which is acid coagulated milk protein mass. Traditional preparation methodology of rasgulla starts with the preparation of chhana from milk, transforming it into small size balls of 6-7 g. each followed by dipping and soaking of these small balls into sugar syrup for overnight **(Kaur *et al.*, 2017**). Various types of rasgullas are available in the market concerning different textural, flavour characteristics. The shelf-life of rasgulla is about 20-25 hours under ambient temperature of 25-30 °C (**Bandyopadhyay *et al.*, 2008**). Similar to other dairy products rasgulla is very prone to lipolytic degradation due to oxidative rancidity and also undergoes different types of physiochemical changes during storage (**Kaur *et al.*, 2019**).To prevent rancidity in rasgulla different treatments like adding anti-oxidants like butylated hydroxyl anisole, butylated hydroxyl toluene and tertiary butyl hydroquinone are extensively used (**Bandyopadhyay *et al.*, 2008**). But all of these anti-oxidants are synthetic and thus toxicity is a crucial factor due to which use of these anti-oxidants are not favorable and safe in rasgulla (**Kaur *et al.*, 2019**). Therefore to prevent the quality deterioration and to further fortify the rasgulla with nutrients, the main alternative is adding organic anti-oxidants. Pineapple had never before used to fortify or to extend shelf-life of rasgulla. Pineapple is a popular fruit which is very popular in almost all over Asia (**Jovanović *et al.*, 2018**). As a fruit pineapple is very rich in vitamin A, vitamin C, phenolic acid, tannins, flavonoids, organic acids and other polyphenol compounds (catechins and quercetin). The principal source of characteristics yellow colour in pineapple is carotenoid pigments which are a very competent antioxidant that snuffs out free radicals, which may cause oxidation, physicochemical damages and different diseases (**Bandyopadhyay *et al.*, 2008**). The characteristic flavour of pineapple comes from a very complex combination of oxygenated aliphatic compounds which imparts a vital sensory attribute in rasgulla (**Jovanović *et al.*, 2018**). Along with providing oxidative stability the phenolic compounds are also responsible for flavour, astringency, colour, and texture of fruits and are also effective towards prevention of hydrolytic and oxidative rancidity and anti-inflammatory functions in human cells (**Amaral *et al.*, 2018**). As pineapple is a seasonal fruit (**Sarkar *et al.*, 2019**), drying may be a sustainable approach to use pineapple throughout the year (**Sarkar *et al.*, 2018**). Hot-air drying generally used in small and medium scale industries, though long drying time and loss in product quality is the main problem associated with this type of drying. Microwave and microwave convective drying is less common in industrial purposes, though both of these techniques are less time consuming, hence heat labile bioactive phytochemicals get protected. To keep product quality similar to fresh one, freeze drying is selected by researchers, though high energy consumption in this process is the main constrain for its use in industry (**Sarkar *et al.*, 2020**). The effect of raw pineapple pulp, hot air, microwave, microwave convective and freeze-dried pineapple powder in shelf life extension, antioxidant activity, instrumental colour and texture analysis and palatability of rasgulla was studied in this paper.

MATERIALS AND METHODS

Pineapples were procured from local market of Jadavpur, Kolkata, India. Fresh premium quality cow milk (fat 3.8 %, solid not fat 8.7 %) was collected from local dairy outlet with HACCP and ISO 9622:2013 certification. All other

ingredients like sugar, wheat flour were procured from local market of Jadavpur, Kolkata, India.
Pulp from pineapples was collected after peeling and coring the fruit. The pulp was stored in different sterile glass bottles. For freeze drying, the pulp was frozen at -50 °C for 12 hours in deep freezer (New Brunswick Scientific, England; Model no: C340-86) and then freeze dried for 20 h in a laboratory freeze dryer (FDU 1200, EYELA, Japan) at - 40 °C under 0.1 mbar pressure. For hot air oven (Concepts International, Kolkata, India) drying, the pulp was dried at 60 °C temperature in the hot air oven dyer for 16 hours. For microwave drying (MW), the pulp was dried in the microwave (Samsung, Combi CE1031LAT, Mumbai, India) for 108 minutes at 100 W. For microwave convective (MWC) drying, the pulp was dried in the microwave (Samsung, Combi CE1031LAT, Mumbai, India) for 95 minutes at 40 °C temperature (600 W). In order to reduce the equilibrium moisture content from 5.30 to 0.22 kg water/kg dry basis, these prolonged drying time was required. The dried samples were required to be dehydrated enough so as to grind them to the powdered form. Thereafter all the four types of dried samples were ground in a mixer grinder into powder. chhana and Casein ball (rasgulla) were prepared by following **Sarkar *et al.,* 2018** and same methodology were followed in all types of rasgulla preparation, where only 20 parts of pineapple powder was mixed with 80 parts of chhana. Samples were stored at room temperature (25±2°C) to study the shelf life of the prepared rasgulla samples over a storage period of 50 hours. During home storage rasgullas are generally stored at 4 °C but in shops rasgullas are generally kept at 25 °C for 24 hours or 36 hours. In this study the shelf life extension was studied only at ambient temperature similar to that of Bandyopadhyay *et al.*, 2008, who studied the shelf life extension up to 40 hours at 25 °C only. The study was done at ambient temperature to simulate the conditions in the sweet shop where rasgullas are kept before consumers buy them. Samples were taken at every 10 hours of intervals and following tests were performed for each sample.

Sample extraction procedure

1g of samples was weighed from each of the six different types of rasgullas and then all six samples were mixed with 30 ml isopropyl alcohol and distilled water (1:1) mixture then ultra - sonicated (Trans-O-Sonic, Mumbai, Model no: D-150/IH) for 30 minutes. Then all the six samples were filtered by using whatmman filter paper no. 1 and the filtrate was stored at -50 °C for further experiments.

Total phenolic content (TPC)

In order to determine the TPC of all the six different sample of pineapple rasgullas, a modified version of the Follin Ciocalteu (FC) assay was used (**Hazra *et al.,* 2019**). At first 1.58 ml of distilled water was added to each of the six extracted samples (20 µl each) of rasgullas and blank solution. Then 300 µL sodium carbonate ($NaCO_3$) solution and 100 µL FC reagent were mixed with all the samples and they were coded as PF (freeze dried pineapple rasgulla) , PM (microwave dried pineapple rasgulla), PMWC (microwave convective dried pineapple rasgulla , PH (hot air oven dried pineapple rasgulla) , NR (normal rasgulla), B (blank). After that all the mixtures were incubated for 90 minutes at 40 °C in dark, the absorbance was measured using UV-Vis spectrophotometer (UV-Vis Spectrophotometer, Thermo Fisher Scientific, India) at 765nm. Results were expressed in term of mg of GAE (Gallic acid equivalent) /g from.

DPPH (2, 2-diphenyl-1-picrylhydrazyl) radical scavenging activity

DPPH radical-scavenging activity of all six types of rasgulla extracts were evaluated with respect to a blank solution. At first 100 µL of each of six types of extracts were pipetted out into six test tubes and also a blank was prepared by adding 100 µL distilled water instead of samples. Then 1.4 mL methanolic solution of DPPH (10^{-4}M) was added to each of test tubes. After that all the test tubes containing samples were incubated for 30 min at dark. Finally, absorbance reading of all the samples was measured in spectrophotometer at 517 nm. The following expression was used to calculate the percentage of radical-scavenging activity as per the equation given below (**Hazra *et al.,* 2019**).

Radical scavenging activity (%) = $\{(A_0-A_s)/A_0\} \times 100$

Where, A_0 = Absorbance of control, A_S= Absorbance of sample extract.

Colour analysis

Surface colour of all the rasgullas were measured by Hunter colourimeter (colour Flex 45/0, D 65, 10° observer; Hunter Associates Laboratory Inc. Reston, VA, USA), which was calibrated by using a standard white plate (L*= 93.49; a*= −1.07; b*= 1.06; X= 79.22; Y= 84.10; Z= 88.76) and also with standard black plate. The colour values was expressed in ΔE (Total colour difference) and ΔE was calculated from the following equation (2). All the tests were performed for three times and average values were taken as final result. (**Onwude *et al*., 2017**)

$$\Delta E = \sqrt{(L-L_0)^2 + (a-a_0)^2 + (b-b_0)^2}$$

Where, L_0, a_0 and b_0 refer the L-value (Lightness/Darkness), a-value (redness/greenness) and b-value (yellowness/blueness) of NR initially.

Hardness analysis

The hardness test for the rasgullas were conducted with the texture analyser (model: TA.XT Express, Stable Micro Systems, Surrey, UK) equipped with P5 probe, which is a 5 mm smooth end cylindrical aluminum body. At first all the rasgullas were placed on an aluminum base, the P5 probe was moved down freely with a velocity of 2.5 mm/s and was allowed to compress the rasgullas. The direction of the compressive force was set in perpendicular direction with the core of the rasgullas. The maximum indicative force in the force-deformation curve was reflected as hardness (**Omolola *et al*., 2015**). All the tests were repeated for three times and average values were taken as final result.

Sensory analysis

Sensory analysis was performed by a semi-trained panel consisting of 35 members including 18 male and 17 female members of Jadavpur University and the sensory analysis was performed inside the laboratory. colour, flavour, texture, mouthfeel, and overall acceptability of all the rasgulla samples were evaluated with the help nine point hedonic scale (9 = excellent, 8 =very good, 7 = good, 6 = satisfactory, 5 = neither good nor bad, 4 = bad, 3 = moderately poor, 2 = poor, 1 = worst) (**Sarkar *et al.,* 2019**).At room temperature under ambient environmental conditions randomly coded samples were served to the panel members. Crackers and potable water were supplied to the panelists between two successive sensory evaluations. For the sensory analysis all the average values of the hedonic scores (colour, flavour, texture, mouthfeel, and overall acceptability) were recorded.

Statistical analysis

Preparation and analysis of all the samples were done in triplicate. ANOVA followed by Tukey's test was performed to measure statistical significance of the results obtained (SPSS 14.0.0, U.S.A).

RESULTS AND DISCUSSION

[Entire experimentation was done in triplicate (n=3)]

Total phenolic content (TPC)

Phenolic compounds are antioxidants which have large efficiency to remove free radicals, and pineapple is an important source of these constituents (**Hossain *et al.,* 2011**). The TPC (3.33 mg GAE/g) value was maximum for PMWC at the initial phase of storage (time = 0 minute), while the minimum of 1.39 mg GAE/g. was attended at 50 hours of storage for PMWC (Table 1). Fig. 1 depicted the change in TPC values at 50 hours of storage. The TPC values of different types of pineapple rasgulla increased in the following order: PMWC > PMW > PF > PH > PP. NR samples also contained a lower amount of total phenolics compound from milk (**Niara da Silva *et al*., 2015**). The reason behind these type of order was the influence of heat treatment and breakage of cell wall which in turn helped in better extraction of polyphenol components (**Hihat *et al.,* 2017**). Several factors like method of sample extraction, different enzymatic activity, temperature, drying methods, chemical structure of polyphenols and different intermolecular interaction may have an impact on the amount of polyphenol extracted from pineapple rasgulla (**İzli *et al.,* 2014**). During thermal processing, the increase in the total phenolics was there because of bound phytochemicals were released from the cell matrix (**Özcan *et al.,* 2019**). For PMWC and PMW, the amount of polyphenol was significantly higher ($p < 0.05$) than others because of rising in temperature during different drying process affected the fruit specifically on microwave heating leads to rupture of cell wall which may enhance the release of more phenolic compounds. Similar incremental trend for TPC in case of MW and MWC was also observed by **Hihat *et al.,* 2017.** Also, high-temperature short-time drying may have caused less thermal loss of polyphenol compounds. With an increase in drying time, the loss of polyphenol content may be related to different intermolecular interactions between polyphenols and other compounds present inside the fruit cell. For the case of PH, the drying time was quite long as the drying temperature was low, which may cause a significant decrease ($p < 0.05$) in TPC. **İzli *et al*., 2017** found analogous decrease in TPC for hot air dried mango. The reason for a significant decrease ($p < 0.05$) in TPC for all samples during storage may be attributed to oxidation of antioxidant components under favorable conditions during storage at room temperature (25±2°C). **Walkowiak *et al.,* 2007** reported that during storage TPC decreased in black chokeberry juice concentrates.

Table 1 TPC values (mean ± standard deviation) of different rasgullas at different storage time under normal temperature

Sample name	Storage time (hours)					
	0	**10**	**20**	**30**	**40**	**50**
NR (mg. GAE/g.)	**0.56±0.09**	**0.54±0.06**	**0.51±0.03**	**0.48±0.05**	**0.42±0.06**	**0.31±0.03**
PF (mg GAE/g.)	**0.78±0.08**	**0.70±0.08**	**0.61±0.07**	**0.53±0.03**	**0.49±0.01**	**0.40±0.01**
PH (mg GAE/g.)	**0.72±0.04**	**0.63±0.03**	**0.55±0.02**	**0.46±0.02**	**0.39±0.01**	**0.33±0.02**
PMWC (mg GAE/g.)	**3.33±0.38**	**2.91±0.29**	**2.23±0.42**	**2.01±0.15**	**1.63±0.13**	**1.39±0.11**
PMW (mg GAE/g.)	**1.04±0.02**	**0.96±0.03**	**0.91±0.04**	**0.85±0.04**	**0.74±0.02**	**0.65±0.03**
PP (mg GAE/g.)	**0.62±0.03**	**0.53±0.04**	**0.41±0.03**	**0.35±0.03**	**0.31±0.02**	**0.28±0.01**

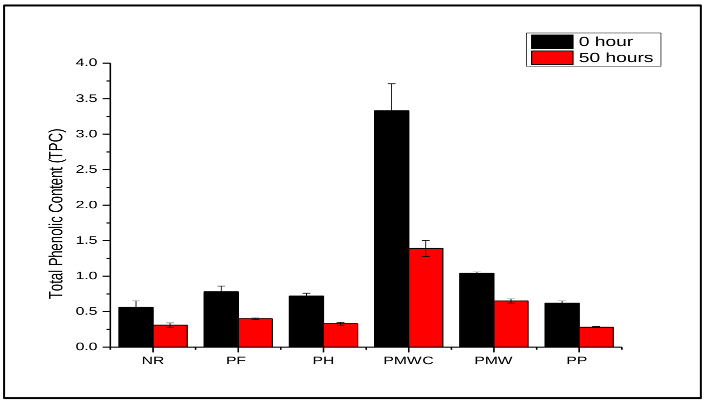

Figure 1 Error bar plots of Total Phenolic content (TPC) values of normal rasgulla (NR), pulp (PP), hot-air (PH), microwave (PMW), microwave convective (PMWC) and freeze (PF) dried pineapple fortified rasgulla at 0 and 50 hours of storage.

DPPH (2, 2-diphenyl-1-picrylhydrazyl) scavenging activity

DPPH values significantly decreased ($p < 0.05$) over the total experimental period of 0 to 50 hours (Fig. 2). This is mainly due to oxidation of phenolic compounds under room temperature at ambient condition and may be due to slow rate of proteolysis (**Mediani, *et al.*, 2014).** From table 2, it can be seen that for PP and NR the rate of reduction of DPPH scavenging activity was 60.08 % and 59.10 % respectively, whereas the rate of reduction of DPPH scavenging activity for PH, PF, PMW and PMWC were 82.43 %, 87.39 %, 85.78 % and 84.84 % respectively during the total storage period. Though the loss of DPPH scavenging activity was high in case of PH, PF, PMW and PMWC but due to high initial polyphenol content, after 50 hours of storage time, the rate of order of DPPH scavenging activity was as follows PMWC > PF > PMW > PH > PP > NR. Our observations were in line with the findings of **Hihat *et al.*, 2017** where they observed a higher DPPH value for microwave drying compared to oven drying for coriander leaves and **İzli *et al.*, 2017** also found a higher DPPH value for freeze drying compared to microwave drying of man.

Table 2 DPPH values (mean ± standard deviation) of different rasgullas at different storage time under normal temperature

Sample name	Storage time (hours)					
	0	**10**	**20**	**30**	**40**	**50**
NR (%)	**15.26±0.07**	**15.06±0.06**	**14.29±0.09**	**13.54±0.03**	**11.17±0.03**	**9.02±0.02**
PF (%)	**62.42±1.50**	**61.28±1.92**	**60.35±1.35**	**59.05±2.01**	**56.03±2.07**	**54.05±0.93**
PH (%)	**46.52±0.79**	**45.36±0.96**	**44.31±0.84**	**42.65±1.05**	**40.27±0.87**	**38.35±0.66**
PMWC (%)	**62.75±1.08**	**61.47±1.24**	**59.88±1.09**	**57.89±0.90**	**55.07±1.65**	**54.29±1.04**
PMW (%)	**58.23±1.32**	**57.06±1.17**	**55.27±1.47**	**53.13±1.18**	**51.36±0.92**	**49.95±1.21**
PP (%)	**23.41±0.94**	**21.98±1.08**	**20.11±1.19**	**17.93±1.03**	**16.03±0.85**	**14.25±1.17**

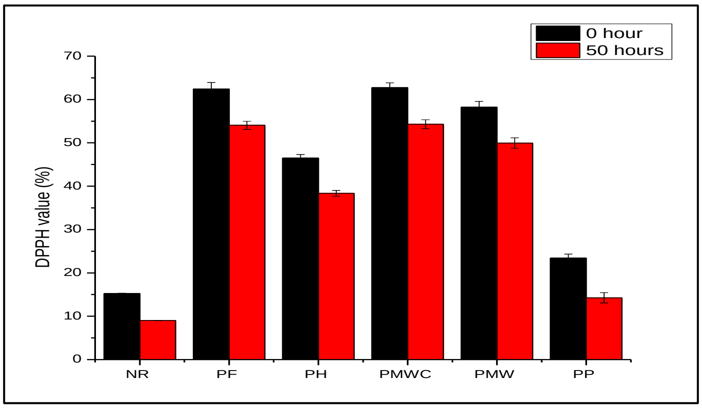

Figure 2 Error bar plots of DPPH values of normal rasgulla (NR), pulp (PP), hot-air (PH), microwave (PMW), microwave convective (PMWC) and freeze (PF) dried pineapple fortified rasgulla at 0 and 50 hours of storage.

Colour analysis

To access the quality of pineapple rasgulla, the colour change is a very crucial parameter. Here in this experiment, the net colour difference (ΔE) was calculated for five different types of rasgulla for their different storage times. From table 3, it was seen that as the storage time was increasing the colour became darker. There might be several reasons for this colour change such as non-enzymatic browning reactions (Maillard reaction) and oxidative rancidity. The reason behind the browning was the reaction between sugar syrup and organic acids (**Srivastava *et al.*, 1994**). The rate of browning reaction increased with storage time. The difference in the rate of browning reaction was observed for different types of rasgulla as the protein content was different for each type of rasgulla. The highest rate of browning reaction was observed for normal rasgulla due to higher amount of lysine content, the principal component of casein. From table 3, it was seen that at the initial stage (10 hours and 20 hours) the rate of colour changes for all five types of rasgulla were slow and as the storage time progressed, the rate of colour changes also increases and highest colour changes was observed between 30-40 hours storage time. Similar result of colour changes of over different storage period at refrigerated temperature was reported by **Bandopadhyay *et al.*, 2008**. Of all the five types of rasgulla, the initial colour difference value was very high in microwave dried (PMW) and microwave convective dried (PMWC) pineapple fortified rasgulla, because in both cases heat treatment result in higher amount of browning which caused high colour changes (ΔE) ranging from 15.9-17.42 and 48.79-52.3 respectively throughout the total storage time . The extent of browning was comparatively low in case of pineapple pulp and freeze dried pineapple, so the PP and PF encompasses a small ΔE value ranging from 7.41 to 8.51 and 6.26 to 7.48 respectively over the total storage time of 0 to 50 hours. Lesser amount of browning for freeze dried apple was also observed by (**Cortés *et al.*, 2009**). The colour differences were found significant (P<0.05) over the entire the storage time period.

Table 3 Difference in colour values (mean ± standard deviation) of different casein ball (rasgulla) samples at different storage time under room temperature

Sample name	Storage time (hours)					
	0	**10**	**20**	**30**	**40**	**50**
PF	**7.41±0.72**	**7.62±0.54**	**7.87±0.24**	**7.98±0.81**	**8.33±0.36**	**8.51±0.65**
PH	**8.26±0.63**	**8.89±0.82**	**9.09±0.75**	**9.45±0.48**	**9.93±0.68**	**10.29±0.92**
PMWC	**48.79±1.34**	**49.23±1.08**	**50.07±0.96**	**50.93±1.27**	**51.69±1.44**	**52.30±1.17**
PMW	**15.90±0.43**	**16.28±0.72**	**16.52±0.39**	**16.92±0.93**	**17.29±0.86**	**17.42±0.88**
PP	**6.26±0.09**	**6.35±0.13**	**6.58±0.35**	**6.69±0.47**	**6.85±0.37**	**7.48±0.32**

Hardness analysis

The quality of rasgulla was monitored by their textural properties. From table 4, it can be seen that the values of hardness for PMWC was significantly lower (5.26 N) than other samples. Here the generalized order for hardness values of rasgulla samples were NR > PP> PF > PH > PMW > PMWC. In the present study, a gradual increase in hardness of rasgulla sample irrespective of storage time was observed and similar result was also observed by **Chavan *et al.*, 2010.** Among all the rasgulla the maximum hardness value was observed in NR (6.07 N after 50 hours). Except for NR, in all other rasgullas a certain amount of chhana was replaced by the incorporation of same amount of different types of dried pineapple which in turns resulted in a lower amount of casein in rasgulla, thus might be a reason for lesser values of hardness factor in all pineapple fortified rasgullas. For NR, a significant ($p < 0.05$) changes in hardness values over the total experimental storage period of 0 to 50 hrs can be observed from table 4. The changing order of hardness values over the storage time of all the samples were as follows - PMWC (94.26 %) >PP (94.24 %) >PF (94.16 %) >PMW (93.6 %) >PH (93 %) > NR (91.76 %).The changes in hardness values for all other rasgulla samples were also found significant ($p < 0.05$) throughout the total storage period of (0-50) hours

Table 4 Hardness values (mean ± standard deviation) of different rasgullas at different storage time under normal temperature

Hardness (N)						
SAMPLE NAME	**0 hours**	**10 hours**	**20 hours**	**30 hours**	**40 hours**	**50 hours**
NR	**5.57±0.42**	**5.63±0.34**	**5.75±0.39**	**5.89±0.32**	**5.93±0.71**	**6.07±0.68**
PF	**5.49±0.09**	**5.57±0.59**	**5.63±0.88**	**5.71±0.17**	**5.79±0.57**	**5.83±0.39**
PH	**5.45±0.16**	**5.53±0.85**	**5.69±0.79**	**5.76±0.22**	**5.81±0.83**	**5.86±0.55**
PMW	**5.31±0.21**	**5.39±0.74**	**5.46±0.72**	**5.52±0.64**	**5.59±0.11**	**5.67±0.52**
PMWC	**5.26±0.30**	**5.33±0.15**	**5.40±0.29**	**5.49±0.85**	**5.52±0.37**	**5.58±0.49**
PP	**5.55±0.19**	**5.61±0.14**	**5.72±0.66**	**5.79±0.74**	**5.83±0.79**	**5.89±0.75**

Sensory analysis

In this table 5, sensory scores of four different quality parameters of all the different types of rasgulla samples stored at normal condition is described. Sensory scores were continuously decreased with increase in storage time from 0 to 50 hours due to quality degradation for various reasons like oxidative rancidity, microbial spoilage, browning reactions. Changes of sensory scores over the storage period were observed similarly by **Kaur *et al.*, 2019** and **Dongare *et al.*, 2015**.

But sensory scores of pineapple rasgulla over different storage periods is studied for the first time. Here in this study it was observed that the rate of rancidity was less in different types of pineapple fortified rasgulla than normal rasgulla due to presence of high amount of organic acids in different types of pineapple rasgulla. Organic acids like citric acid and ascorbic acid which are reported extensively for their oxygen scavenging activity, acidulant and reducing property to inhibit or retard the oxidation of lipid molecules in various food systems (**Aubourg *et al.*, 2004**).The various types of drying had a vital effect on the amount of organic acids in pineapple and with the increase in temperature as the water removed out, the amount of organic acid increased (**Slatnar *et al.*, 2011**). Oxidation of free fatty acids over storage period had a vital influence on the different quality parameters. Free fatty acids with 4-10 numbers of carbon atoms are generally produced during degradation of milk fat by lipases. A cascade of chemical reaction propagate the auto oxidation process along with aldehydes and free radical formation, which ultimately impart off flavors to the product and are the initiator for Maillard products. Proteases degrade casein to peptides, which are further degradedby peptidases and a complex mixture of flavour components like aldehydes, esters, thio-esters, methanethiol and sulphur compounds are formed. Hydrogen sulphide from cysteine and methanethiol from methionine are formed which impart rotten egg smell with a rubber like taste (**Ruijschop *et al.*, 2009**). Due to generation of unpleasant smell from NR after 30 hours, panelists were unable to assign sensory scores for NR after 30 hours. After analyzing all the values of table 5 it was found that- maximum changes in colour occurred in PH (78 %), maximum changes in texture occurred in PP (63.8 %), maximum flavour changes occurred in PP (70.4 %) , maximum changes in mouthfeel occurred in NR (76.4 %) , maximum changes in overall acceptability occurred in PF (70.73 %) over the experimental duration. All the sensory values of colour parameters except first 20 hours were found insignificant ($p>0.05$). The sensory values for colour significantly ($p<0.05$) changed for 0-20 hours for all six rasgulla samples. The sensory values of other parameters like texture, mouthfeel and overall acceptability were also found insignificant ($p>0.05$) throughout the total storage period. As some of the sensory attributes (flavour, mouthfeel and overall acceptability) for NR was not acceptable after 30 hours of storage, and PMWC was observed superior in terms of sensory qualities for 50 hours. Therefore, a considerable enhancement in shelf-life was there for PMWC with respect to NR.

Table 5 Sensory scores of different casein ball (rasgulla) samples at different storage time under normal temperature

Quality attributes		**Storage time (hours)**					
	Sample name	**0**	**10**	**20**	**30**	**40**	**50**
Colour	**NR**	8.14±0.04	7.90±0.13	7.71±0.14	6.94±0.57	6.09±0.23	5.82±0.77
	PF	7.82±0.08	7.21±0.89	6.80±0.76	6.20±0.51	5.93±0.35	5.82±0.54
	PH	7.51±0.06	7.19±0.15	6.92±0.98	6.12±0.67	5.91±0.38	5.91±0.63
	PMWC	6.93±0.09	6.52±0.35	5.93±0.79	5.35±0.34	4.93±0.92	4.64±0.17
	PMW	7.11±0.11	6.92±0.58	6.01±0.39	5.81±0.28	5.18±0.78	4.83±0.39
	PP	8.01±0.07	7.83±0.25	7.22±0.65	6.73±0.73	6.16±0.47	5.91±0.71
Texture	**NR**	8.51±0.16	7.72±0.37	6.52±0.30	5.91±0.11	5.32±0.43	5.01±0.25
	PF	8.15±0.14	7.54±0.34	6.85±0.11	6.14±0.41	5.54±0.66	5.15±0.33
	PH	7.83±0.23	7.12±0.43	6.61±0.27	5.90±0.52	5.21±0.53	4.80±0.17
	PMWC	7.26±0.17	6.55±0.57	6.14±0.19	5.55±0.39	4.84±0.26	4.15±0.52
	PMW	7.57±0.18	6.76±0.41	6.25±0.44	5.84±0.19	5.15±0.40	4.54±0.31
	PP	8.33±0.24	7.72±0.29	7.21±0.32	6.43±0.26	5.80±0.21	5.31±0.19
	NR	8.31±0.22	7.61±0.35	6.42±0.07	5.70±0.06	-	-

Flavour	**PF**	8.70±0.74	8.22±0.09	7.71±0.21	6.90±0.37	6.23±0.15	5.72±0.08
	PH	8.30±0.31	7.51±0.10	7.10±0.18	6.72±0.20	6.13±0.38	5.50±0.20
	PMWC	7.92±0.57	7.22±0.27	6.81±0.13	6.12±0.44	5.53±0.24	4.94±0.12
	PMW	8.06±0.46	7.50±0.33	6.93±0.39	6.31±0.32	5.80±0.17	5.13±0.11
	PP	8.80±0.21	8.32±0.20	7.92±0.08	7.30±0.19	6.93±0.09	6.24±0.49
Mouthfeel	**NR**	8.55±0.17	8.01±0.13	7.20±0.03	6.51±0.07	-	-
	PF	8.23±0.08	7.72±0.07	7.14±0.05	6.50±0.13	6.12±0.20	5.51±0.21
	PH	8.00±0.09	7.61±0.08	6.92±0.08	6.24±0.06	5.80±0.08	5.43±0.18
	PMWC	7.52±0.15	7.14±0.21	6.73±0.11	6.21±0.15	5.57±0.19	4.92±0.06
	PMW	7.71±0.11	7.20±0.23	6.92±0.09	6.33±0.08	5.81±0.13	5.14±0.07
	PP	8.43±0.14	7.82±0.26	7.11±0.17	6.70±0.09	6.22±0.11	5.71±0.22
Overall acceptability	**NR**	8.54±0.18	8.09±0.07	7.33±0.15	6.07±0.08	-	-
	PF	8.22±0.23	7.63±0.16	7.12±0.30	6.91±0.14	6.53±0.09	5.82±0.07
	PH	8.08±0.31	7.40±0.20	6.81±0.06	6.23±0.35	5.82±0.13	5.21±0.14
	PMWC	7.42±0.14	6.91±0.09	6.32±0.12	5.92±0.21	5.21±0.21	4.83±0.05
	PMW	7.71±0.11	7.11±0.13	6.80±0.19	6.21±0.10	5.53±0.06	5.10±0.15
	PP	8.40±0.09	7.92±0.22	7.41±0.23	6.90±0.09	6.22±0.18	5.71±0.19

CONCLUSION

The observations from this study, revealed that consolidation of raw or differently dried pineapple powder and chhana extend the shelf life of rasgulla from 30 hours to 50 hours. The antioxidant property was enriched most for PMWC as TPC and DPPH radical scavenging activity enhanced for PMWC by 3.5 fold and 8 fold with respect to NR after 50 hours of storage period. After 30 hours of storage NR become spoiled from sensorial view point, though all the pineapple fortified rasgulla remained palatable for 50 hours of storage time. Though all the different pineapple fortified rasgullas were found superior than NR. Though NR was found better in case of colour retention, as the incorporation of heat treated pineapple in the chhana impart a darker appearance. A softer texture was maintained by PMWC after 50 hours of storage as the hardness value was found 8.07 % less than NR after the same storage time. PMWC fortified rasgulla was found to be 40 % more shelf stable than NR. Apart from this a more profound anti-oxidant portfolio as well as softer texture was achieved from PMWC. Though the shelf life of pineapple fortified rasgulla was enhanced to 50 hours at 25±2 °C, shelf-life of the product at refrigeration condition would definitely differ from that of ambient condition and should studied separately.

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