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CHANGES IN RHEOLOGICAL, MICROBIOLOGICAL AND SENSORY QUALITY OF RETORT PROCESSED KUNDA DURING STORAGE*

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ABSTRACT

Kunda, a heat desiccated dairy product was packaged in pouches and retort processed at lethalities of three F-values *viz.* 1.2, 2.2 and 21.8 in order to enhance the shelf life of Kunda. The retort processed Kunda was stored at 37°C and 55°C and the changes in rheological, microbial and sensory quality were monitored at regular intervals. Retort processed Kunda possessed initial firmness, consistency and adhesiveness values of 46.1 N, 133.7 N.sec and 0.01 N.sec, respectively. These values showed a gradually increasing during storage indicating that retort processed Kunda became firmer and more adhesive during storage, which was partly responsible for the decreased sensory scores. The microbial count during storage slightly increased; but was negligible. It was concluded that the spoilage of retort processed Kunda was more of physical in nature than a microbial one.

INTRODUCTION

Retort processed technology is extensively used for production of long life ready-to-eat products of various types – vegetables, vegetable products, dairy products, food products, fruits etc. It employs suitable heat treatment to a product within the package, eliminating vegetative forms of microorganisms avoiding subsequent contamination. Various food products such as paneer based curries (Rao and Patil, 1999), and some of the dairy products like whey-based soup (Sudheer, 2000) and kheer (Jha, 2000) have all been retort processed successfully. The retort processed products are microbiologically stable, but deteriorate due to accelerated chemical changes caused by intense heat treatments, affecting the sensory characteristics of products. The common physico-chemical changes in high heated products are maillard browning, caramelisation and oxidation, whose rate of reaction shoots up with the intensity of heat treatment. These changes, in turn, are the chief factors of spoilage of a retort processed product.

Kunda is a Khoa based sweet delicacy prepared normally from buffalo milk and is popular in northern regions of Karnataka. It is light brown with a semi solid consistency and rich nutty flavour (Kulkarni *et al.,* 2001). The shelf life of Kunda is reported to be about 15 – 28 days at 30°C (Jayaraj Rao *et al.,* 2000). This limited shelf life of Kunda is due to the growth of yeasts and molds. Recently, Mahalingaiah (2008) worked on various facets of technology of including method of manufacture, energy conservation, packaging and shelf life enhancement. In order to enhance the shelf life, Navajeevan (2004) employed retort processing of Kunda in 3-ply retort pouches. He reported that during storage, retort processed Kunda undergoes extensive changes with regard to physical and chemical changes depending on the temperature of storage. Chemical changes such as browning, lipolysis and proteolysis taking place during the storage of retort processed Kunda were also described by Navajeevan and Jayaraj Rao (2005). In this paper, changes taking place in the various physico-chemical, microbial and sensory characteristics of retort processed Kunda during storage are presented.

MATERIAL AND METHODS

Cow milk used in the study was obtained from the dairy farm of the Institute, while cane sugar was procured from the local market. Retort pouches for in-package processing of Kunda with the configuration of 12.5 μ PET/12.5 μ Al/ 80 μ

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cast PP with a size of 17 x 15.5 cm were obtained from Central Institute of Fisheries Technology (CIFT), Cochin.

Stainless steel jacketed kettle with steam line and steam control valve was used for concentrating the milk. Pilot scale Millwall Model 24 Rotary Retorting System (John Fraser Co., UK) was used for in-package heat – treatment of Kunda available at CIFT, Cochin. Texture Analyser TA.XT Plus Model of Stable Microsystems, U.K. was used to measure rheological characteristics.

Manufacture of Kunda : Kunda was manufactured as per the standardized procedure suggested by Mahalingaiah *et al.* (2000). Standardised cow milk having 4% fat and 8.5% SNF was used. The milk was taken in steam kettle and heat desiccated with minimal stirring to form Khoa. Crystal sugar @ 9 per cent on milk basis and potable water @ 10-15 per cent on Khoa basis were added and desiccation continued with vigorous stirring to obtain product of Khoa consistency. Again potable water @ 10 – 15 per cent of the kettle contents was added and desiccation continued. This process was repeated about eight times to obtain final products of Kunda.

Retort processing of Kunda : Two hundred grams of Kunda in each pouch was vacuum packaged and sealed. The sealed retort pouches were subjected to retort processing at three F-values viz. 1.2, 2.2 and 21.8 as described in Navajeevan and Jayaraj Rao (2005). The retort processed Kunda was stored at 37°C and 55°C and changes in rheological characteristics *viz.* firmness, consistency and adhesiveness; microbiological counts *viz.* SPC (standard plate count), YMC (yeast and mold count) and spore counts, and sensory quality viz. colour and appearance, flavour and body and texture of retort processed Kunda were recorded.

Rheological characteristics : Firmness, consistency and adhesiveness of the stored samples of Kunda were determined using Texture Analyser (Stable Micro Systems, London, UK). The measurements were performed under the following load settings: Mode : Measure Force in Compression; Option: Return to Start; Pre-Test speed: 1.0 mm/sec; Test speed: 1.0 mm/sec; Post-Test Speed: 10.0 mm/sec; Distance: 10 mm; Trigger type: 5.0 g; Data Acquisition rate: 400 pps; Probe: 25 mm cylinder probe (P/25) using 5 kg load cell.

The Kunda sample was taken out from the incubator and tempered to about 30°C. The product was cut into a block of about 5x5x3 cm depth and kept in a 100 ml polystyrene cup. The cup containing the sample was kept on the platform and the test was 'run'. The probe moved down and when it touched the sample and sensed 5 g of back force, it started moving onto the product unto a preset depth of 10 mm. After that, the probe returned to the original position creating a force – time plot. From the plot obtained, maximum force (peak force) was taken as firmness (N), the area of the plot as consistency (N.sec) and the area of the negative peak as adhesiveness (N.sec) (Fig. 1).

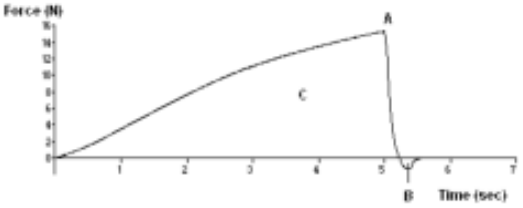

Fig. 1. Force-time plot obtained by Texture Analyser [A- Firmness Maximum value of the peak); B-Adhesiveness (Area of negative peak); C-Consistency (area of positive peak)]

Microbiological analysis : The microbiological analysis of Kunda was carried out by ISI (1962). The pouch containing Kunda was thoroughly shaken for 15 sec. Alcohol was applied on one of the corner of the pouch or lid of the bottle. The pouch / bottle was opened and 11 g of the product was weighed and transferred into 99 ml of the sterile phosphate buffer aseptically. Thus a 1:10 dilution was obtained, which was used for the analysis.

Spore count : The 1:10 dilution of the Kunda suspension was heated to 80°C for 10 min to destroy all the vegetative cells and plated using nutrient agar (Hi Media). The number of spores were counted after 48 h of incubation at 37°C.

Yeast and mold count : Yeast and mold counts were determined by plating 1:100 dilution of Kunda suspension using Potato Dextrose Agar (Hi Media). The counts were made after 3-5 days of incubation at 30°C.

Standard Plate Count : Standard Plate Counts were determined by plating 1: 100 dilution of Kunda suspension using Nutrient agar (Hi Media). The counts were made after 48 h of incubation at 37°C.

Sensory evaluation : The organoleptic quality of Kunda at different treatments, at different temperatures were evaluated by an expert panel of five judges. The expert panel of judges was developed by thoroughly exposing them to all aspects of Kunda quality and were made well acquainted with the various attributes like flavour, colour and textural characteristics of Kunda following the sensory evaluation guidelines as per ISI (1971). The samples were coded for judging and the criticism expressed by common agreement of the judges was recorded.

Statistical analysis : Data obtained during the present study was subjected to statistical analysis described by Snedecor and Cochran (1994) and employing Minitab computer package (2x4x4 factorial design).

RESULTS AND DISCUSSION

Changes in rheological characteristics of retort processed Kunda during storage :

Firmness : Firmness values are expressed in terms of Newtons and are measure of force required to move the probe of Texture Analyser to a predetermined distance into the product. Therefore higher values indicate firmer body of Kunda. The results are presented in Table 1. From the results it may be observed that the firmness of Kunda first increased and then decreased during storage at 37°C, whereas changes to that extent were less when stored at 55°C. In any case the storage temperature has statistically non-significant effect on the rheological characteristics of Kunda ($P \leq 0.05$) (Table 4). The changes in firmness during storage period were significant ($P \geq 0.05$) which can be ascribed to continued structural changes in proteins of Kunda. As Kunda making process involves intensive heat treatment, proteins might have undergone thorough denaturation. During storage, conformational changes caused by heat denaturation might have continued to take place causing an increasing and decreasing trend in firmness of Kunda. According to Palit (1998) burfi when vacuum packed has showed decreasing hardness up to 20 days of storage and then increased thereafter. The inconsistent changes in the hardness of burfi when packed in vacuum was attributed to the formation of thin moisture layer between surface of burfi and inner side of the packaging material. Similar moisture layer formation is observed in Kunda also. As per ANOVA in Table 4 , heat treatment given to Kunda had no influence on the firmness changes during storage.

Table 1. Changes in firmness (N) of retort processed Kunda at various F-values and stored at 37°C and 55°C

F-value	Storage temperature	Storage period (weeks)			
		0	1	2	3
0 (Control)	37°C	46.10	75.08	83.34	60.45
1.2		50.57	84.28	98.67	82.04
2.2		66.29	89.43	100.83	79.25
21.8		50.53	70.31	56.67	50.53
0 (Control)	55°C	46.10	113.69	92.59	123.00
1.2		50.57	74.20	55.73	62.23
2.2		66.29	79.19	57.58	66.12
21.8		50.53	81.93	72.99	81.97

Consistency : Consistency of Kunda is measured as total work done during the travel of Texture Analyser probe into the product up to a predetermined distance and is expressed as N. sec.

The data in Table 2 display an increasing trend and then decreasing trend during storage at 37°C but at 55°C the trend was varying. However, the storage temperature had no effect on consistency ($P \geq 0.05$). From the figures, it can also be noted that the consistency values were higher during storage than the initial values ($P \leq 0.05$) confirming that some changes did take place during storage with regard to the structure and or conformation of proteins. ANOVA also indicates that the effect of heat treatment was non-significant on the consistency (Table 4). Palit (1998) reported an increasing trend of cohesiveness of burfi during storage. In case of retort processed kheer, the grains became firmer during storage. Also, the apparent viscosity generally tended to decrease and, as observed in the present study, F-value had no effect (Jha, 2000).

Table 2. Changes in consistency (N.sec) of retort processed Kunda at various F-values and stored at 37°C and 55°C

F-value	Storage temperature	Storage period (weeks)			
		0	1	2	3
0 (Control)	37°C	133.7	369.6	510.0	279.8
1.2		271.4	520.7	545.4	511.1
2.2		141.8	456.2	681.2	437.7
21.8		252.0	444.9	266.9	251.6
0 (Control)	55°C	133.7	770.3	492.1	761.3
1.2		271.3	315.7	276.2	438.3
2.2		141.8	505.3	339.1	291.8
21.8		252.0	464.3	368.0	540.5

Adhesiveness : Adhesiveness refers to the total work done by the Texture Analyser probe in pulling back from the product. Hence, higher the magnitude, higher is the adhesiveness.

According to Table 3, the adhesiveness of Kunda showed an increasing trend initially but decreased in the 3rd week of storage. The initial adhesiveness from 0.01, 0.02, 0.07 and 0.45 N.sec increased to 0.04, 0.45, 0.32, 0.89 N.sec at second week and again changed to 0.22, 1.13, 0.30 and 0.45 N.sec at third week for control, 1.2 and 21.8 F-values respectively at 37°C; while it rose to 0.66, 1.61, 1.37 and 1.10 N.sec on second week and changed to 0.27, 1.71, 0.39 and 1.14 N.sec on 3rd week at 55°C of storage.

Table 3. Changes in adhesiveness (N.sec) of retort processed Kunda at various F-values and stored at 37°C and 55°C

F-value	Storage temperature	Storage period (weeks)			
		0	1	2	3
0 (Control)	37°C	0.01	0.02	0.04	0.22
1.2		0.02	0.27	0.45	1.13
2.2		0.07	0.43	0.32	0.30
21.8		0.45	0.08	0.89	0.45
0 (Control)	55°C	0.01	0.19	0.66	0.27
1.2		0.02	0.12	1.61	1.71
2.2		0.07	0.03	1.37	0.39
21.8		0.45	0.36	1.10	1.14

Statistical analysis (Table 4) revealed that storage temperature and F-values had a significant effect on adhesiveness and that during storage, the changes on adhesiveness were also significant ($P \leq 0.05$). The continued structural changes in Kunda might have led to expulsion of fat from the product especially at higher temperatures and higher heat treatment leading to more adhesiveness.

The results of the changes in rheological characteristics indicate that there was variation in their pattern, which may be attributed to the fact that Kunda was not a product in which constituents are homogeneously distributed. The product is particulate with denatured proteins, which are surrounded by melted sugar (Mahalingaiah, 2008). The oozing out of free fat during storage further interfered in the pattern of rheological changes. However, in certain products like cheese (Khamrui and Goyal, 1998) and paneer (Rao and Patil, 2001, 2006), the rheological changes followed a certain mathematical pattern.

Table 4. ANOVA for changes in rheological characteristics of retort processed Kunda at various F-values and stored at 37°C and 55°C

Source of Variation	d.f.	Firmness		Consistency		Adhesiveness	
		MSS	F-value	MSS	F-value	MSS	F-value
F-value (F)	3	370.9	2.21^{NS}	8477	3.16^{NS}	0.41	3.18*
Storage temperature (ST)	1	28.8	0.17^{NS}	3.27	24.76*	0.59	4.58*
Storage period	3	1387.6	8.27*	3.76	28.49*	0.95	7.38*
Fx ST	3	1051.1	6.26	0.068	0.51	0.02	0.14
Error	21	167.8	-	0.132	-	0.13	-
Total	31	3006.2	-	8484.23	-	2.10	-

NS : Not significant; * Significant at P ≤0.05

Changes in Microbiological counts : The total count of the Kunda samples has been very less ranging from 1 - 31 when stored at 37°C and 3-10 at 55°C. The minor counts obtained for SPC can be attributed to three factors *viz.* (i) Kunda contains higher sugar content and when it is desiccated along with heat treatment, it acts as preservative against microbial growth. (ii) Kunda is also an intermediate moisture food (IMF) with water activity of about 0.882 which is a hurdle for microbial growth. (iii) When the product is subjected to retort processing by packaging in 3-layered retortable pouch with target heat treatment, the microbial growth is not expected to take place, hence product is microbially stable. The counts reported may be mainly because of contamination during analysis. Yeasts and molds have been nil throughout the storage period at both temperatures of 37°C and 55°C. It is mainly due to the retort processing treatment, given to the product. The spore count also has been nil throughout the storage period for all the treatments for both the temperatures of storage which is again attributed to the retort processing treatment and less water activity besides sugar acting as preservative.

Changes in Sensory characteristics :

Colour and appearance : The scores for colour and appearance for Kunda samples were 6.75, 7.00, 6.93 and 7.13 on 0 day which reduced to 5.70, 5.70, 5.60 and 5.60 on 3rd week at 37°C and to 4.94, 5.14, 5.04, 5.15 at 55°C on 3rd week of storage as depicted in Fig. 2. The scores decreased drastically at 55°C of storage. Similar observations were made in tomato-whey soup when stored at 45°C and 37°C after 21 and 28 days of storage (Sudheer, 2000). Milk cake also showed reduction in colour and appearance scores. When it was packed in PET with vacuum, the reduction was higher as surface of samples were wet with moisture (Ramesh Babu, 2000). The reduction in scores could be attributed to the continuation of Maillard reactions which causes dark brown colour and dry appearance of the samples. ANOVA of the scores for colour and appearance indicated that storage temperature and period had significant effect (P=0.05) decreasing the score, while F-values have not shown any ifluence (Table 5).

Flavour : Flavour, the perception of taste and odour, of Kunda has also decreased rapidly. From

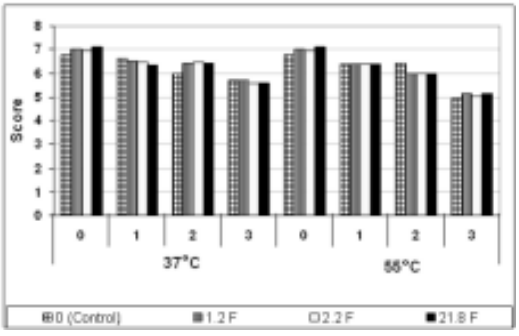

Fig. 2. Changes in colour and appearance score of retort processed Kunda at various F-values and stored at 37°C and 55°C

Table 5. ANOVA for changes in sensory characteristics of retort processed Kunda at various F-values and stored at 37°Cand 55°C

Source of Variation	d.f.	Colour and appearance		Flavour		Body and texture		Overall acceptability	
		MSS	F- value	MSS	F- value	MSS	F- value	MSS	F- value
F-value (F)	3	0.01	0.41^{NS}	0.42	3.16*	0.08	5.43*	0.06	4 28^{NS}
Storage temperature (ST)	1	0.48	13.97*	3.27	24.76*	0.01	0.79^{NS}	3.713	15.98*
Storage period	3	3.50	101.88*	3.76	28.49*	1.90	129.27*	5.748	24.75*
Fx ST	3	0.01	0.14	0.07	0.51	0.006	0.4	0.034	0.14
Error	21	0.034	-	0.132	-	0.015	-	0.232	-
Total	31	4.034	-	7.652	-	2.011	-	9.791	-

NS : Not significant; * Significant at P=0.05

an initial value of 6.92, 6.87, 6.75 and 6.50 at 0 day to 6.14, 5.64, 5.60 and 5.16 on 3rd week at 37°C and to 5.30, 4.74, 4.70 and 4.04 at 55°C (Fig. 3). Similar results were also observed in tomato-whey soup (Sudheer, 2000) the decrease being the maximum at 45°C of storage, and in milk cake the decrease in flavour score was not rapid when vacuum packed (Ramesh Babu, 2000), while burfi also exhibited a similar trend. The rapid increase in acidity and decrease in pH which caused sourness in the product can be said to have influenced the flavour score reduction. Proteolysis, lipolysis and browning might also have played a role. The ANOVA shows that storage at higher temperature and storage period had significant effect on flavour score, but 1.2 and 2.2 had no effect (Table 5).

Body and texture : Kunda exhibited gradual decrease in the scores of body and texture from an initial value of 6.12, 6.43, 6.62 and 6.55 on 0 day to 5.20, 5.36, 5.20 and 5.46 on 3rd week of storage at 37°C, while the scores decreased to 5.00, 5.40, 5.40 and 5.20 at 55°C of storage for control, 1.2, 2.2 and 21.8 F-values, respectively (Fig. 4).The decrease can be attributed to a combination of factors such as dry appearance and increased hardness. Milk cake has also received gradual decline in scores for body and texture which became dry and hard as storage period progressed (Ramesh Babu, 2000). ANOVA of the scores revealed that storage period has significant effect on decreasing scores while temperature has not showed any effect while F-value has improved the scores for body and texture marginally (Table 5). The increased heat treatment in package might have mellowed down the product.

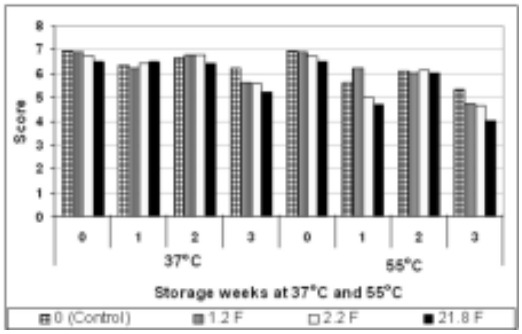

Fig. 3. Changes in flavour score of retort processed Kunda at various F-values and stored at 37°C and 55°C

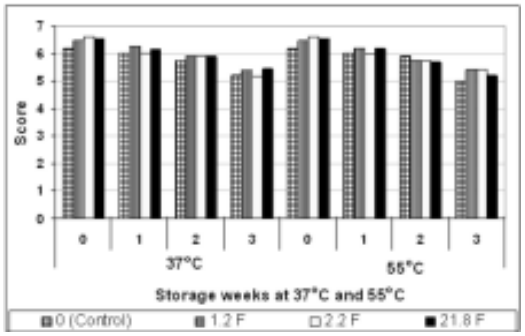

Fig. 4. Changes in body and texture score of retort processed Kunda at various F-values and stored at 37°C and 55°C

Overall acceptability : Kunda which is retort processed has received consistent reduction in scores for overall acceptability by all the judges. From an initial scores of 6.37, 6.50, 6.75 and 6.55 at 0 day to 5.70, 5.38, 5.28 and 5.34 on 3rd week at 37°C, while it further reduced to 3.94, 3.66, 3.54 and 3.24 at 55°C on 3rd week for control, 1.2, 2.2 and 21.8 F-values respectively (Fig. 5).

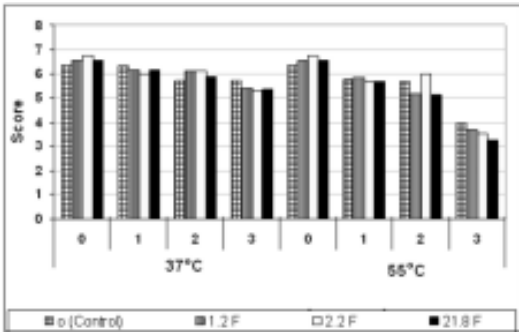

Fig. 5. Changes in overall acceptability score of retort processed Kunda at various F-values and stored at 37°C and 55°C

These scores are the reflection of the predominant flavour reduction, with increased sourness as storage proceeded, followed by the deteriorating colour and appearance due to Maillard reactions causing dark brown colur and moist/wet appearance. Similar results were observed in milk cake when packed in PP and PET both at room and refrigeration temperature and the same was rejected due to mold growth (Ramesh Babu, 2000).

Whey – tomato soup which was retort processed was also observed to have got lesser scores due to rapid colour degradation (Sudheer, 2000). Kunda was acceptable for 2 weeks when stored at 37°C and for 1 week at 55°C. ANOVA indicated that storage period and temperature had significantly reduced the overall acceptability scores, while F-values have not influenced the score (Table 5). It may be noticed from Fig. 5 that the Kunda remained just above like slightly range up to 2 weeks at 37°C (scores 5.70, 6.13, 6.13 and 5.88 for control, 1.2, 2.2 and 21.8 F-value samples respecytively) and up to 1 week at 55°C (scores 5.78, 5.80, 5.65 and 5.63, respectively). Therefore, it can be stated that Kunda packaged in retort pouch and vacuum sealed with or without retort processing kept well for about 2 weeks at 37°C and 1 week at 55°C.

CONCLUSION

It is concluded that in retort processed Kunda, changes occurred with regard to rheological characteristics during storage are due to intense heat treatment of retort processing. The changes with regard to microbial counts were negligible. During storage the product quality decreased and was limited by chemical and rheological changes rather than microbial growth. Hence, for a keeping quality of two weeks at 37°C, Kunda can be retort processed at 1.1 F-value.

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