Study on the effect of packaging materials on the physico-chemical, microbiological and sensory quality of *kunda*

L. Mahalingaiah · B. V. Venkateshaiah · S. Kulkarni · K. Jayaraj Rao

Revised: 5 September 2011 / Accepted: 10 October 2011 / Published online: 8 December 2011
© Association of Food Scientists & Technologists (India) 2011

Abstract *Kunda*, an indigenous heat desiccated sweet product prepared from milk and sugar, has a shelf-life of a few days under market conditions. In this study, shelf-life of *kunda* packed in select packaging materials viz. LDPE, metallised polyester and tin cans and stored at 30° and 5 °C was investigated. During storage, several changes took place in physico-chemical and sensory characteristics, the changes being faster at 30 °C than at 5 °C. The storage study indicated that *kunda* was acceptable throughout the storage period of 42 days at 30 °C and 90 days at 5 °C, irrespective of packaging material. However, the rate of changes in characteristics of the product packaged in tin cans and metalized polyester was slower. Hence, it was recommended that *kunda* be packed in tin cans and metallised polyester pouches which possess high barrier properties for achieving long shelf-life.

Keywords *Kunda* · Shelf-life · Metallised polyester · Tin cans

Introduction

Kunda is a heat desiccated indigenous dairy product popular as a sweetmeat in northern Karnataka region.

L. Mahalingaiah (✉) · B. V. Venkateshaiah
Department of Dairy Technology, Dairy Science College,
Karnataka Veterinary, Animal and Fishery Sciences University,
Hebbal,
Bangalore 560 024, India
e-mail: mahalingaiah311@rediffmail.com

S. Kulkarni · K. J. Rao
National Dairy Research Institute (Southern Campus),
Adugodi,
Bangalore 560 030, India

According to one estimate 4.0 tonnes of *kunda* is being sold or consumed in the northern Karnataka region. Most of *kunda* sold in market is being made by small scale sweetmeat makers and sold in packaged (LDPE bags or butter paper lined cardboard boxes), as well as in loose form with varying compositions (Kulkarni et al. 2001). Though the people of the region relish the typical and lingering taste of *kunda*, the product has no well defined procedure of manufacture, which varies from manufacturer to manufacturer with regard to type of milk, fat content of milk, extent of desiccation, amount of sugar etc. Hence, the product prepared by some manufacturers is more popular than the others. According to a report (Anon 2006), there were 300 manufacturing units spread across northern region of Karnataka, while in southern parts, the product is not known for many. The reason for the popularity only in limited regions is mainly attributed to low shelf-life of the product. It stays well for about four days at ambient temperature, and thereafter develops a mild sour taste. The spoilage was observed to begin with the visible growth of yeasts and molds. Thus, there is a need to enhance the shelf-life of the product if market for *kunda* has to be expanded to southern regions. So far, studies were carried out with regard to characterization (Kulkarni et al. 2001), standardization of method of manufacture (Mahalingaiah et al. 2000) and mechanization of manufacture of *kunda* (Menon et al. 2004). However, no studies were carried out on the shelf-life enhancement of *kunda*. Studies concerning improvement of shelf-life of *khoa* were reported using various packaging materials like tins (Rudreshappa and De 1971; Rao et al. 1977; Goyal and Srinivasan 1989), four ply laminates having aluminium foil, two ply packs and HDPE (Kumar et al. 1975), and preservatives like sorbate (Rao et al. 1977), natamycin (Rajarajan et al. 2006) and nisin (Kalra et al. 1973). The water activity of *kunda* is 0.80–0.89

which should provide good shelf-life to the product, but market *kunda* was found to possess short shelf-life which could be attributed to microbial contamination during and post manufacturing practices. Hence, there is a possibility of improving the shelf-life of *kunda* by using an appropriate packaging material. In this work evaluation of different packing materials was investigated with an objective to enhance the shelf-life of *kunda*.

Materials and methods

Preparation of *kunda*

Kunda was prepared from standardised cow milk according to the method reported by Mahalingaiah et al. (2000). Fresh cow milk was procured from dairy farm of National Dairy Research Institute, Bangalore, and analysed for its fat and solids not fat (SNF) (BIS 1981). It was preheated, filtered and standardised to 5.0% fat and 8.5% SNF by using cream. Milk was then taken in a cleaned, sterilized *khoa* kettle and steam was let into the jacket. It was stirred continuously to avoid burning and continued the desiccation till *khoa* was obtained.

Cane sugar crystals were added at the rate of 9.0% (w/w) on milk basis. The contents were heated to dissolve sugar with scraping and vigorous mixing. Potable water was added at about 10% to 15% (w/w) to make slurry. The slurry thus obtained was heated with continuous scraping, and desiccated to 'pat' stage. Then subsequent lots of water were added to make slurry again and desiccation was continued to 'pat' stage. These steps were continued till a typical brown colour of *kunda* was developed.

Packaging of *kunda* in different materials

Hot *kunda* (85°–90 °C) from the kettle was packaged in select packaging materials and heat sealed by foot-operated impulse sealing machine for pouches of low density polyethylene (LDPE) of 65 μ thickness (P-1) and metalised polyester (Aluminium/polyethylene) of 90 μ thickness (P-2) and can seamer for lacquer coated tin cans of 200 μ thickness (P-3). All the containers were of 200 g capacity.

Storage of *kunda*

The *kunda* samples packaged in different packaging materials were transferred to an incubator maintained at 30 $\pm$ 2 °C and BOD incubator maintained at 5 $\pm$ 1 °C for storage purpose for 90 days and samples were drawn at regular intervals for analysis. The drawing of samples was stopped when the overall acceptance of the samples was nearing 'like slightly' perception.

Analyses

Samples of *kunda* were drawn at regular intervals and analyzed for physico-chemical (moisture, water activity, acidity and browning index), microbiological (bacterial, yeast and mould and coliform counts) and sensory properties. Sealed containers were cut open and the contents were transferred to a mortar and ground thoroughly with a pestle to obtain a uniformly mixed sample, which was then used for various physico-chemical analyses. For microbiological analyses, the packs containing *kunda* were opened under sterile conditions in a laminar flow (BIS 1980a).

Physico-chemical characteristics Moisture content and acidity were determined as per methods given in BIS (1981) and BIS (1980b), respectively. Browning index determination was carried out by enzymatic method using pronase enzyme (Sigma-Aldrich) as described by Gothwal and Bhavadasan (1992) and the results were expressed as optical density (OD) per gram. Water activity of *kunda* was measured by using Rotronic Hygroskop (BT-RS1, Switzerland) as per the method of Fontana and Campbell (2004).

Microbiological characteristics Bacterial counts (SPC) were estimated by plating suitable buffer dilutions using nutrient agar and incubating the petri plates at 30 °C for 48 h (BIS 1980a), yeast and mold counts were estimated using MEA agar with incubation temperature of 25 °C for 72 h (BIS 1980a) and coliform counts using violet red blue Agar and incubation at 30 °C for 24–48 h (BIS 1980a). The counts were expressed as colony forming units (cfu) per gm of *kunda*.

Sensory evaluation *Kunda* packed in the three packaging materials was transferred to well cleaned glass bowls, tempered to ambient temperature and served to a panel of expert judges chosen from the faculty of National Dairy Research Institute, Bangalore and Karnataka Veterinary Animal and Fisheries Sciences University, Bangalore in a sensory evaluation laboratory. The panelists were asked to evaluate the sensory quality in terms of colour and appearance, body and texture, flavour and overall acceptance using a 9 - point Hedonic scale, in which a score of 1 indicated 'dislike extremely' and a score of 9 indicated 'like extremely' (Amerine et al. 1965).

Statistical analysis The various data of physico-chemical, microbiological and sensory evaluation were subjected to 2x3x7 factorial design analysis and the statistical significance of effect of various treatments and their interactions was determined by SPSS package (Version 11.0).

Results and discussion

Effect of packaging materials on physico-chemical and microbiological characteristics of *kunda* during storage

The physico-chemical characteristics of *kunda* changed during storage at 30 °C (for 42 days) and 5 °C (for 90 days), and varied with the type of packaging material used and temperature of storage. The statistical means of the physico-chemical characteristics varying with duration and temperature of storage and packaging material are presented in Table 1. As the storage progressed there was a slight loss of moisture as indicated by the lower mean values. The moisture loss was also influenced by the packaging material used, the loss being more in LDPE packed product (mean moisture value 19.2%) followed by metallised polyester (19.3%) and tin cans (19.4%) (Table 1). This was due to higher water vapour permeability of LDPE than the other two materials. The mean values indicated that moisture content of the product was lower at 30 °C (19.0%) than at 5 °C (19.5%), which showed that moisture loss was higher at 30 °C than at 5 °C. Kumar et al. (1975) and Goyal and Srinivasan (1988) reported that laminates containing aluminium foil provided good protection against

moisture losses because of superior moisture barrier properties of the foil. Loss of moisture observed with P-1 (LDPE) was higher than P-2 (metallised polyester) and P-3 (tin cans) used in this study.

There was also a decreasing trend in water activity of *kunda* during storage at both the temperatures of storage. The effect of packaging material and that of storage temperature was not of much significance, because the decrease was negligible or marginal. However, the storage period had a significant effect ($P<0.05$) with gradual decline in water activity as the storage progressed, which may be attributed to moisture loss through the packaging material or within the package. Since there is some air space left inside each packet, moisture evaporation within the packet may be expected. Similar results in *khoa* storage were reported by Goyal and Srinivasan (1988, 1989).

The browning of *kunda* decreased during storage ($P<0.05$), but there was no effect of packaging material on browning as such. It is well documented that 5 - HMF is produced in heat desiccated products in the early stages of Maillard reactions, whereas in *kunda*, browning is expected to be in advanced stage, because temperature and time to which the product was exposed ranged from 100° to 140 °C and 30 to 45 min, respectively during manufacture i.e. prior

Table 1 Effect of packaging materials on physico-chemical and microbiological characteristics of *kunda* during storage-estimated statistical means

Particulars	Treatments	Moisture,%	Browning index, OD/gm	Water activity	Acidity,%LA	SPC, log cfu/gm	YMC, log cfu/gm
Packaging	P-1	19.2 ^a	0.3 ^a	0.80 ^a	0.54 ^a	4.2 ^a	4.0 ^a
	P-2	19.3 ^b	0.3 ^a	0.80 ^a	0.51 ^b	4.2 ^b	4.2 ^b
	P-3	19.4 ^c	0.3 ^a	0.79 ^b	0.50 ^c	4.2 ^c	4.2 ^c
CD _{0.05}		0.08	NS	0.006	0.011	0.05	0.06
Temperature	T-1	19.0 ^a	0.3 ^a	0.79 ^a	0.54 ^a	4.3 ^a	4.3 ^a
	T-2	19.5 ^b	0.34 ^a	0.80 ^b	0.49 ^b	4.1 ^b	3.9 ^b
CD _{0.05}		0.06	NS	0.005	0.009	0.04	0.05
Duration	D-1	20.0 ^a	0.37 ^a	0.81 ^a	0.41 ^a	4.4 ^a	4.4 ^a
	D-2	19.8 ^b	0.36 ^b	0.81 ^b	0.46 ^b	4.3 ^b	4.3 ^b
	D-3	19.6 ^c	0.35 ^c	0.81 ^c	0.49 ^c	4.3 ^c	4.2 ^c
	D-4	19.2 ^d	0.35 ^d	0.80 ^d	0.50 ^d	4.2 ^d	4.2 ^d
	D-5	18.9 ^e	0.33 ^e	0.79 ^e	0.55 ^{ef}	4.2 ^e	4.0 ^e
	D-6	18.7 ^f	0.32 ^f	0.78 ^f	0.57 ^g	4.1 ^f	3.9 ^f
	D-7	18.5 ^g	0.32 ^g	0.77 ^g	0.60 ^h	4.0 ^g	3.8 ^g
CD _{0.05}		0.12	0.002	0.00005	0.02	0.07	0.1
Interactions	PxT	*	NS	NS	*	*	*
	PxD	*	*	NS	*	*	*
	TxD	*	*	*	*	*	*
	PxTxD	NS	*	*	*	*	*

1) P-1 = LDPE pouches, P-2 = metallised polyester, P-3 = tin cans 2) NS – non-significant 3) T-1 : 30 °C; T-2 : 5 °C 4) All superscripts with unlike terms are significant ($P\leq 0.05$) and 5) * Significant at $P\leq 0.05$ 6) D-1 to D-7=0, 7, 14, 21, 28, 35 & 42 days at 30 °C; 0, 15, 30, 45, 60, 75 & 90 days at 5 °C

8 desiccations were followed for *kunda* making

to packaging. Further, during storage, since *kunda* contained substantial quantity of fat (15%) and some of which is in free state, oxidation is expected to take place during storage. Since many browning compounds were already formed, they absorb oxygen and get oxidized themselves losing in this process browning effect. Namiki (1988) reported that browning compounds act as antioxidants. These could be the reasons for the decreasing trend of the browning index in *kunda* as storage progressed. Acidity of *kunda* increased during storage. There was

significant difference among packaging materials in this regard. The lowest acidity (0.50% LA) was observed in P-3, followed by P-2 and P-1. The temperature effect and all the interaction effects were significant for the change in the acidity (Table 1). This may be attributable to continued disappearance of basic amino acids in the product (Namiki 1988). The increase in acidity could also be due to the action of microorganisms as well as production of organic acids during processing and storage. Similar results were also reported by Goyal and Srinivasan (1988, 1989). Rao et

Fig. 1 Changes in sensory scores of *kunda* packaged in different packaging materials and stored at 30° and 5 °C (C&A Colour and Appearance; Fl. Flavour; B&T Body and Texture; OA Overall Acceptance) ($n=10$)

al. (1977) reported that the titrable acidity of *khoa* packaged in parchment paper, aluminium foil and polyethylene increased up to 0.94% after 4 days at 30 °C. Acidity also increased in retort processed *kunda* during storage, but this was attributed to browning reactions (Navajeevan and Rao 2005).

Packaging material had a significant effect on the decrease in microbial counts ($P<0.05$) (Table 1). The decrease was faster in tin cans followed by metallised polyester and LDPE with regard to SPC, but in the case of YMC the trend was reverse. The decrease in bacterial counts was due to decreasing water activity. The water activity of less than 0.90 is not suitable for growth of bacteria (Sawhney et al. 1997). Prajapati et al. (1986) also reported that as the storage period increased, water activity values of *peda* decreased which restricted the growth of bacteria. It was found that in our preliminary trials there was no growth of either aerobic or anaerobic spores in *kunda*. Ravindrakumar et al. (1997) also observed that there was a decrease in microorganism population during storage of *khoa*.

The mean yeast and mold counts in P-1, P-2 and P-3 were 4.01, 4.18 and 4.19 log₁₀cfu/g respectively (Table 1). The difference was significant ($P<0.05$). Goyal and Srinivasan (1988) reported that the multilayered packaging materials consisting of poster paper/aluminium foil/LDPE proved to be the best in checking the growth of micro-organisms. The other multi-layered laminates attempted by them fared less in this regard because of poor barrier properties.

Effect of packaging materials on sensory characteristics of *kunda* during storage

The sensory scores decreased, but remained well within acceptable limits during storage period. The colour and appearance score decreased (Fig. 1) because the colour of *kunda* slowly changed. The decrease in colour and appearance was due to oxidation of brown compounds resulting in slight fading of colour. The product slightly got dried up due to evaporation of moisture which also resulted in decrease in colour and appearance scores.

The effect of packaging material and storage temperature and their interaction however were not significant ($P>0.05$) (Table 2). It means whatever decrease in scores could be attributed to the effect of duration of storage. The flavor scores were affected by the temperature of storage, but only marginally (mean flavor score 7.72 for 30 °C v/s 7.65 for 5 °C). The flavour scores awarded to *kunda* stored in P-1, P-2 and P-3 were 7.64, 7.73 and 7.70, respectively (Table 2). Flavour score was maximum in metallised polyester packaging (P-2). It has better barrier properties to moisture and volatile flavour compounds. In tin cans, the

Table 2 Effect of packaging materials on sensory characteristics[†] of *kunda* during storage – estimated statistical means

Particulars	Treatments	Colour & appearance	Flavour	Body & texture	Overall acceptance
Packaging	P-1	7.6	7.6 ^a	7.5 ^a	7.5 ^a
	P-2	7.7	7.7 ^b	7.6 ^b	7.6 ^b
	P-3	7.6	7.7 ^b	7.7 ^b	7.7 ^c
CD _{0.05}		NS	0.05	0.05	0.06
Temperature	T-1	7.7	7.7 ^a	7.7 ^a	7.7 ^a
	T-2	7.6	7.7 ^b	7.5 ^b	7.5 ^b
C D _{0.05}		NS	0.07	0.04	0.05
Duration	D-1	8.1 ^a	8.2 ^a	8.1 ^a	8.5 ^a
	D-2	7.9 ^b	8.1 ^b	7.9 ^b	8.4 ^b
	D-3	7.9 ^c	8.1 ^c	7.8 ^c	8.0 ^c
	D-4	7.8 ^d	7.6 ^d	7.7 ^d	7.8 ^d
	D-5	7.5 ^e	7.5 ^e	7.5 ^e	7.3 ^e
	D-6	7.3 ^f	7.4 ^f	7.3 ^f	7.1 ^f
	D-7	7.1 ^g	6.1 ^g	6.8 ^g	7.3 ^g
C D _{0.05}		0.1	0.003	0.08	0.10
Interactions	PxT	NS	*	*	*
	PxD	NS	*	*	*
	TxD	*	*	*	*
	PxTxD	*	*	*	*

1) P-1 = LDPE pouches, P-2 = metallised polyester, P-3 = tin cans 2) NS – non-significant 3) T-1 : 30 °C; T-2 : 5 °C 4) All superscripts with unlike terms are significant ($P\leq 0.05$) and 5) * Significant at $P\leq 0.05$

[†] measured on 9-point hedonic scale 6) D-1 to D-7=0, 7, 14, 21, 28, 35 & 42 days at 30 °C; 0, 15, 30, 45, 60, 75 & 90 days at 5 °C. 8 desiccations were followed for *kunda* making

available oxygen content might contribute to growth of aerobes affecting the flavour. Similar results were also observed by Goyal and Srinivasan (1989) and Ravindrakumar et al. (1997) in *khoa*. The interactions amongst packaging materials, storage temperature and durations were also significant in reducing the flavour scores of *kunda* ($P<0.05$).

The body and texture scores decreased during storage because of dryness and hardness caused by loss of moisture. With regard to the effect of storage temperature, more texture related changes took place at 5 °C than at 30 °C as reflected by the mean scores of 7.5 and 7.7 respectively. In LDPE packed *kunda*, the changes took place to a greater extent than metallised polyester or tin cans ($P<0.05$) (Table 2). The reason for decrease in body and texture score could be due to loss of moisture and crystallization of sugar as reported in sensory evaluation. Because of these changes, overall acceptance of *kunda* was also affected. The overall acceptance scores gradually decreased, yet at the end of storage period of 42 days at 30 °C and 90 days at 5 °C the products remained acceptable. Mean overall acceptance score for storage temperature was 7.7 for 30 °C and that

for 5 °C was 7.5, which indicated that changes were faster at 5 °C than at 30 °C. Probably, this was caused by textural changes taking place at low temperature. The statistical mean scores of overall acceptance of *kunda* packed in P-1, P-2 and P-3 were 7.5, 7.6 and 7.7 respectively. The differences among these were significant ($P<0.05$). The lowest overall acceptance score was awarded to P-1 where there was loss of moisture more than other packaging materials. There was not much loss of flavour and texture in P-2 and P-3. Hence, the same have been considered superior because they have better barrier properties than LDPE.

References

- Amerine MA, Pangborn RM, Edward B (1965) Principles of sensory evaluation of food. Academic, New York
- Anon (2006) Research and development support for process up gradation of indigenous milk products for industrial application. Net work project report. NDRI (Southern campus), Bangalore
- BIS (1980a) SP: 18 Hand book of food analysis Part I General methods. Bureau of Indian Standards, New Delhi
- BIS (1980b) IS: 4883 Indian standards specification for *khoa*. Bureau of Indian Standards, New Delhi
- BIS (1981) SP: 18 Part XI Hand book of food analysis Part XI Dairy Products. Bureau of Indian Standards, New Delhi
- Fontana AJ, Campbell CS (2004) Water activity. In: Nollet LML (ed) Hand book of food analysis, vol.1. Marcel Dekker Inc, New York, pp 49–50
- Gothwal PP, Bhavadasan MK (1992) The role of proteins in browning in milk. Indian J Dairy Sci 45:419–423
- Goyal GK, Srinivasan MR (1988) Protective role of packaging materials in refrigerated conditions on the microbiological quality of *khoa*. Asian J Dairy Res 7:66–72
- Goyal GK, Srinivasan MR (1989) Effect of packaging on the chemical quality of *khoa* during storage. Indian J Dairy Sci 42:165–170
- Kalra MS, Laxminarayana H, Dudani (1973) Use of nisin for extending shelf-life of processed cheese and *khoa*. J Food Sci Technol 10:92–94
- Kulkarni S, Ghosh BC, Balasubramanyam BV, Jayaraj Rao K (2001) *Kunda*-desiccated dairy product of northern Karnataka. Indian Dairyman 53:65–67
- Kumar A, Rajorhia GS, Srinivasan MR (1975) Effect of modern packaging materials on the keeping quality of *khoa*. J Food Sci Technol 12:172–177
- Mahalingaiah L, Venkateshaiah BV, Jayaraj Rao K, Balasubramanyam BV, Ghosh BC, Kulkarni S (2000) Incorporation of caramelized sugar in the production of *kunda*. Poster paper presented at Indian convention of food scientists and technologists. Nov. 22–24, Mysore
- Menon RR, Magdaline EEF, Jayaraj Rao K, Ghosh BC, Balasubramanyam BV, Chand Ram (2004) Energy conservation in the production of *kunda* by interaction effect of sodium citrate and caramelized sugar. Poster paper presented at Indian convention of food scientists and technologists, 12–13, December, Mysore
- Namiki M (1988) Chemistry of Maillard reactions: recent studies on the browning reaction mechanism and developments of antioxidants and mutagens. Adv Food Sci 32:115–184
- Navajeevan B, Rao KJ (2005) Physico-chemical changes in retort processed *kunda*. Indian J Dairy Sci 58:392–399
- Prajapati JB, Ramachandran L, Dave JM (1986) Effect of added sugars on water activity and shelf-life of *khoa*. Asian J Dairy Res 5:25–29
- Rajarajan G, Naresh Kumar C, Elango A (2006) Effect of antifungal agents on keeping quality of *khoa*. Indian J Dairy Sci 59:7–9
- Rao OV, Sing S, Singh S (1977) Effect of packaging materials on the keeping quality of *khoa*. J Food Sci Technol 14:152–156
- Ravindrakumar, Bandopadhyay AK, Punjrath JS (1997) Shelf-life extension of *peda* using different packaging techniques. Indian J Dairy Sci 50:40–49
- Rudreshappa KG, De S (1971) Studies on preservation of *khoa*. J Food Sci Tech 8:50–52
- Sawhney IK, Patil GR, Kumar B, Grover S (1997) Influence of water activity adjustment on sorption characteristics and acceptability of *khoa*. J Food Sci Technol 34:123–127