Asian J. of Bio Sci. (2007) Vol. 2 No. 2 : (96-101)

Influence of solar radiation and microwave heating on microbiological, chemical and sensory quality of fresh khoa

K.D. CHAVAN* AND M.B. KULKARNI
Department of Animal Science and Dairy Science, M.P.K.V. Rahuri, AHMEDNAGAR (M.S.) INDIA

(Accepted : August, 2007)

In a maiden attempt in utilizing solar radiation in dairy product preservation, the solar radiation was passed on to khoa through some media in order to extend its shelf life under room temperature (32 to 37ºC). Similarly, application of microwave heating technique for the same purpose was also tried. Influence of the solar radiation through plain glass (S_1) and convex lense (S_2) and microwave heating powers (ranging from 40% to 60%) for 60 sec to 80 sec) on microbiological, chemical and sensory qualities of the fresh khoa was studied. The mean Standard Plate Count (SPC), Yeast and Mould Count (YMC) and spore count of fresh khoa (day-0) ranged from 0 to 4.33 x 10^2, 0 to 11.66 and 0 to 9.67 cfu/g. The chemical and sensory qualities of the samples remained almost similar (8.5 points out of 9) of control (8.6 point) The application of microwave heating was observed to be quite superior in reducing the SPC, YMC, and spore count of the khoa samples.

Key words : Solar radiation, Microwave heating, Khoa, SPC, YMC, Spore count.

INTRODUCTION

Solar energy is one of the most promising of the unconventional energy sources. It has been found to be utilized in technology of drying, heating of milk (Katre and Prasad, 1992), vegetables, fruits (Bhatia, 1978 and Khurdia and Roy, 1986), generating steam/hot water for dairy plants (Katre and Prasad, 1992) etc. However, the available literature indicates that probably, it has not yet been used in dairy product preservation by improving their bacteriological quality. A lot of energy in the farm of fuel, oil, steam, water, electricity, chemical is needed for products preservation and this adds to the cost of production of dairy products. Solar energy not only saves all these costs but is reported to be beneficial in maintaining high nutritional and sensory quality (Bhatia, 1978, Khurdia and Roy, 1986 and Sudheer and Das, 1999) Moreover, its use might bring pollution free atmosphere. This is certainly going to be a new approach in food preservation area because no reported literature probably indicates that the solar energy had ever been utilized in bacteriological preservation of dairy products.

Microwave energy has been gainfully utilized in the food industry for various applications such as cooking, pasteurization, sterilization, blanching, tempering baking, drying etc. Microwaveable convenience foods represents a rapidly growing segment of the food processing industry. Dairy industry applications of microwave processing include enhancement of pasteurization, efficiency, thermising milk prior to cheese manufacturing, inactivation of bacteriophase, clarification of butter into ghee, thermization of yoghurt (Mathur and Sachdeva, 2000). However, the available literature indicates that it has not yet been used in product preservation like khoa by improving their bacteriological quality.

Both, solar and microwave energies seem to be the ideal and promising techniques for preservation of dairy products including khoa. If they prove to be effective and economical, they might pave a new path in the field of dairy industry. Considering these facts in view present investigation was planned.

MATERIALS AND METHODS

The composite samples of fresh crossbred cow milk were obtained from the University dairy farm. The present research work was carried out in the laboratory of the department of Animal Science & Dairy Science during the year 2003-2004, Post Graduate Institute, M.P.K.V. Rahuri, Dist. Ahmednagar (M.S.).

Khoa samples were prepared using the method of De and Ray (1952). The khoa samples, 200 g each were immediately filled into 250 g capacity sterilized PP squats.

Application of solar and microwave treatments :

S_0 (control) : No solar or microwave treatments to khoa samples.

* Author for Correspondence

S_1 : Khoa samples exposed to solar radiation through plain glass for 10 min.

S_2 : Khoa samples exposed to solar radiation through convex lense for 10 min.

M_1 : Khoa samples exposed to 40 per cent microwave heating power level for 60 sec.

M_2 : Khoa samples exposed to 40 per cent microwave heating power level for 80 sec.

M_3 : Khoa samples exposed to 50 per cent microwave heating power level for 60 sec.

M_4 : Khoa samples exposed to 50 per cent microwave heating power level for 80 sec

M_5 : Khoa samples exposed to 60 per cent microwave heating power level 60 sec.

M_6 : Khoa samples exposed to 60 per cent microwave heating power level 80 sec.

Under the treatment S_1 the samples packaged in the polypropelene (PP) squat and kept in thermocol boxes (45 cm x 45 cm x 15 cm and thickness 2.5 cm) were opened and exposed to the sun rays passing through plain glass for 10 minutes during the maximum sunshine intensity hours (i.e. between 1400 and 1430 hrs) on each experimental day. The samples under treatment S_2 were kept in the similar thermocol boxes and over the same, the lense was held 20 cm apart from the surface. The sun rays were allowed to pass through the lense for 10 minutes. However, during this period, the lense was rotated over the entire surface of the sample uniformly.

For the microwave treatments, domestic microwave oven was used. All the samples were kept room temperature (32–38ºC) throughout the experimental period.

Microbiological quality :

Standard plate count (SPC) and yeast and Mould count (YMC) were determined by following the method in IS : 1479- Part III(1962). The spore count in the khoa samples was determined as per the method described in BIS : (1981)

Chemical composition :

The moisture protein, lactose, peroxide value of the khoa samples were determined as per the method of BIS : (1981). The fat content was determined by Gerber method as per the procedure described. The titratable acidity was determined by the procedure in IS : 4883 (1980). The pH of the khoa samples was determined by the method of Kosikowaski (1982)

Free falty Acids (FFA) :

The FFA in khoa samples was determined by the method of Thomas *et al.* (1954). The total HMF values were determined.

Sensory quality :

The khoa samples under different experimental treatments were subjected to sensory evaluation using the method described in the IS : 6273, part –I and II (1971) adopting 9 point Hedanic scale.

The experiment was laid out in completely Randomised Design (CRD) with three replications. The data on microbial counts were transformed in to square root values and used for calculations of S.E. and C.D.. The experimental data were analysed using the statistical methods of Snedecor and Cochran (1994).

Results and Discussion

In the present investigation, the attempts were mode to utilize solar radiation energy and microwave energy in preserving khoa, hence their impact on the microbiological quality was of prime importance. Since, the khoa samples after production were exposed to the aforesaid energies only once i.e. soon after production of the samples, it was significant interest to study their influence on the microbiological quality of fresh khoa i.e. day 0. since, it has been probably a maiden attempt to utilize the solar energy and bacteriological preservation of dairy product, the khoa samples were exposed to solar radiation only once immediately after their production. Thereafter, all the experimental samples including the control were preserved in their respective packaging materials at room temperature (32-38ºC).

The data reveal that the differences in SPC, YMC and the spore counts of the khoa samples due to the treatments were significant ($P < 0.05$) on day 0 of the preservation (Table 1). The SPC was zero in the treatments M_3 to M_6 indicating that the microwave heating of the khoa for 50 and 60 per cent power level with 60 second exposure time onwards almost made the product sterile, because in these samples, the YMC and spore counts were also found to be zero. The samples under treatments M_1 and M_2 showed the presence of only 1.0 and 0.67 cfu/g, respectively. While, the YMC and spore count again being zero in these treatments. So far as solar radiation treatments are concerned. The SPC was 4.33×10^2 cfu/g for control sample, while it was 4.00×10^2 and 2.33×10^2 cfu/g for treatments S_1 and S_2. In the

Table 1: Influence of solar radiation and microwave heating on microbiological quality of fresh khoa (Day 0)

Treatment	SPC (x 10^2 cfu/g)	Spore Count (cfu/g)	YMC (cfu/g)
S_0	4.33 (2.19)^c	11.66 (3.48)^b	9.67 (3.47)^b
S_1	4.00 (2.12)^{bc}	11.33 (3.44)^{ab}	8.33 (2.92)^{ab}
S_2	2.33 (1.60)^{ab}	8.00 (2.91)^a	0.00 (0.71)^a
M_1	1.00 (1.18)^{ab}	0.00 (0.71)^a	0.00 (0.71)^a
M_2	0.67 (1.05)a	0.00 (0.71)^a	0.00 (0.71)^a
M_3	0.00 (0.71)^a	0.00 (0.71)^a	0.00 (0.71)^a
M_4	0.00 (0.71)^a	0.00 (0.71)^a	0.00 (0.71)^a
M_5	0.00 (0.71)^a	0.00 (0.71)^a	0.00 (0.71)^a
M_6	0.00 (0.71)^a	0.00 (0.71)^a	0.00 (0.71)^a
S.E. ±	0.17	0.0624	0.138
C.D. at 5%	0.513	0.185	0.409

(Figures in parentheses indicate square root values)

treatments S_2, the yeast and mould count was nil. The treatments S_2 was also significantly ($P < 0.05$) superior to S_0 and S_1 in reducing the spore count. The results therefore, indicated that both the solar radiation and the microwave were found to be significantly effective in controlling the microbiological quality of khoa favourably at its fresh state i.e. day 0. The microwave heating for 40 per cent power level for 60 second was, in fact sufficient to make the product almost sterile. Whereas under solar radiation, the use of convex lense for passing the solar radiation on to the khoa sample was found to be considerably effective.

Chiu *et al*. (1984), Knutson *et al*. (1988) and Thompson and Thompson, 1990 also reported the utility of microwave heating for extending the shelf life of food products. However, there are probably no research reports on this aspect in which solar radiation had been used.

Chemical composition :

Moisture :

The mean moisture content in the khoa samples under different treatments ranged from 28.70 per cent (M_6) to 30.69 (S_0) (Table 2). The difference due to various treatments were significant ($P < 0.05$). It is noted that the samples under the various microwave treatments showed significantly higher reduction in moisture than that found in solar treated samples. The treatment S_0 and S_1 were found to be at par but differed significantly ($P < 0.05$) from rest of the treatments. All the treatments under microwave i.e. M_1 to M_6 were found to be at par. The data further indicate that the khoa samples under the treatment M_6 (Microwave power level 60 per cent with 80 second) lost the moisture to the extent of 6.28 per cent immediately after microwaving from control sample on day 0. This was followed by the sample under treatment S_2 which lost about 3 per cent moisture and M_1 loosing nearly 2 per cent moisture immediately after exposure to the treatment. The moisture levels in khoa samples as noticed in this investigation closely agree with the reports made by Kumar and Srinivasan, (1982) and Patel *et al.* (1985).

Fat :

The mean fat content in the samples under different treatments ranged from 22.17 (S_0) to 23.02 per cent (M_6). However, the treatment differences were non-significant. As expected, the samples containing lower moisture levels contained the higher fat and vice versa. The values for the fat content observed in this investigation agree with research reports of Abhaykumar *et al*., (1975), Kumar and Srinivasan (1982) and Suryawanshi (2000). The results indicate that both solar radiation and microwave

Table 2 : Chemical composition of Fresh Khoa (Day 0) as influenced by solar radiation and microwave heating.

Treatment	Moisture (%)	Fat (%)	Protein (%)	Lactose (%)	Titratable acidity (%LA)	pH	FFA (% oleic acid)	Peroxide value (1 of 0.002 N sodium thiosulphate/g)	Total HMF (moles 100g)
S_0	30.69[a]	22.170	17.790	23.380	0.620	6.210	0.0590	0.063	15.92
S_1	30.36[a]	22.680	17.560	23.400	0.630	6.210	0.0600	0.063	15.927
S_2	29.79[b]	22.850	17.890	23.790	0.620	6.220	0.0600	0.063	16.023
M_1	30.04[b]	22.700	17.750	23.710	0.620	6.200	0.0500	0.063	16.087
M_2	29.59[bc]	22.900	18.000	23.750	0.590	6.220	0.0600	0.062	16.207
M_3	29.46[bc]	20.900	17.740	23.770	0.580	6.240	0.0600	0.062	16.627
M_4	29.26[bc]	22.950	17.920	23.830	0.570	6.230	0.0610	0.063	17.113
M_5	28.86[bd]	23.000	18.090	23.910	0.570	6.230	0.0600	0.063	17.653
M_6	28.70[bd]	23.020	18.140	24.030	0.570	6.240	0.0610	0.063	18.933
S.E. ±	0.183	0.749	0.163	0.396	0.016	0.050	0.0007	0.063	1.995
C.D. at 5%	0.542	NS	NS	NS	NS	NS	NS	NS	NS

energy could not significantly influence the fat levels in khoa samples.

Protein :

The mean protein content in khoa samples was non-significantly influenced due to experimental treatments. The lowest protein content was possessed by control sample (17.79%) while the highest content was found in the sample under M_6 (18.14%). The protein content in the rest of experimental samples fall in between these values. The protein content in fresh khoa samples, as reported by Bhosale (1972), Kumar and Srinivasan (1982) and Choudhari (1998) were almost similar to the values observed in this investigation.

Lactose :

The differences in mean lactose content in various khoa samples under experimental treatments were statistically non-significant. The content ranged from 23.98 per cent (S_0) to 24.03 (M_3). The level of lactose as found in this investigation agree with the reports of Bhosale (1972) and Kumar and Srinivasan (1982).

Titratable acidity and pH :

The titratable acidity and pH is one of the indications of the microbiological activity in khoa. It also causes spoilage of sensory quality of the product during storage. The mean values of titratable acidity in the khoa samples ranged from 0.57 per cent (M_4) to 0.63 per cent (S_1). The pH of the different samples also showed similar pattern of variation. The values of acidity and pH closely agree with the reported values by Patil (1981), Kumar and Srinivasan (1982), Choudhary (1998) and Suryawanshi (2000).

Free fatty acids (% oleic acid) :

The levels of free fatty acids was observed to range from 0.059 (S_0) to 0.061 (M_6) per cent oleic acid. The differences due to experimental treatment were non-significant. There was negligible difference in the FFA amongst all the experimental treatments tried. These values confirm with the reports of Abhaykumar et al. (1975) and Goyal and Srinivasan (1989).

Peroxide value :

The peroxide value in different khoa samples also showed non-significant differences due to various treatments. The values ranged from 0.062 to 0.063 ml of 0.002 N $Na_2S_2O_3$/ g. In this case, too, there were negligible differences in values amongst all the treatment samples.

Total 5-Hydroxymethyl furfural (HMF) :

The 5-hydroxymethyl furfural (HMF) is one of the intermediate products of maillard reaction and its formation in the milk products is an indication of the type of heat treatment given to the product during processing or preservation. The total HMF values in khoa samples under different treatments ranged from 15.92 moles/100g (S_0) to 18.93 moles/100g(M_6). It seems to be related to the moisture content of the product because the sample containing lower moisture in product (M_6) had the highest HMF and vice versa.

Sensory quality of fresh khoa (day 0) :
Immediately after exposure to the different experimental treatments, the khoa samples were subjected to the sensory evaluation for testing their sensory parameters on day 0. From the consumers point of view the sensory quality of khoa holds the highest position in the marketability. However, it was intended to study this aspect of sensory quality. The data presented in Table 3 reveal that the differences in the sensory scores obtained for all the parameters showed non significant.

Flavour :
The mean sensory score ranged from 8.5 to 8.6, almost no difference except the treatment M_6, obviously the difference in the flavour quality of the product due to different treatments was non-significant. This indicate that neither the solar radiation nor the microwaves could adversely affect the flavour of the product initially. The points scored by almost all the samples were near 9.0 i.e. the ideal score for the product. Thus, the samples under the different treatments could be categorized as 'liked extremely' under the hedonic scale. The application of new technology in the preservation of khoa, therefore, could not adversely affect flavour parameter. Except the sample under treatment M_6 which had developed 'heated flavour' according to the opinion of the judges all the samples had perfectly the acceptable flavour.

Body and texture :
The differences in the mean scores obtained by the samples under different treatments for body and texture were non-significant. The score ranged from 8.0 (M_6) to 8.6 (S_0). The samples under treatments S_1 and S_2 scored the higher points than those obtained by the samples under M_1 to M_6 except that for M_3. This might be directly related to the moisture content of the samples under various Treatment (Table 2). In the marketing of the khoa alongwith the flavour, body and texture holds an important position and form that point of view, it was seen that the application of solar radiation or microwaves in preservation of khoa was not unfavourable. Like flavour, this parameter also scored nearly similar values and the category on hedonic scale.

Colour and appearance :
The mean sensory score offered to colour and appearance of the product under different experimental treatments also showed non-significant differences. However, a general trend of lower scores could be seen for the samples under microwave treatments than those from solar treatment. While the solar radiation treatment could not bring about any obvious change in colour and appearance of the product, the microwave heating probably affected the colour and appearance of the product and therefore, the score of some of the treatments were lower. The opinions of the judges in this respect suggested that slightly darker, brownish, spotted colour appeared with presence of some burnt particles.

Overall acceptability :
In this case, too, the treatment differences in the mean scores were found to be non-significant. The mean score ranged from 8.2 (M_6) to 8.7 (S_0). In the individual sensory parameter as well as overall acceptability, the product

Table 3 : Sensory quality of fresh khoa (day 0) as influenced by solar radiation and microwave heating.

Treatment	Flavour	Body and texture	Colour & appearance	Overall acceptability
	(Sensory score out of 9)			
S_0	8.6	8.6	8.7	8.7
S_1	8.6	8.4	8.5	8.5
S_2	8.6	8.4	8.5	8.5
M_1	8.6	8.3	8.4	8.5
M_2	8.6	8.3	8.5	8.5
M_3	8.6	8.5	8.6	8.6
M_4	8.6	8.3	8.5	8.5
M_5	8.6	8.3	8.5	8.5
M_6	8.5	8.0	8.1	8.2
S.E. ±	0.105	0.182	0.106	0.119
C.D. at 5%	NS	NS	NS	NS

under treatment M_6 scored the lowest points, indicating thereby that microwave heating of the khoa for 60 per cent power level with 80 seconds duration was not favourable from sensory quality point of view. In case of rest of the treatments, the scores were more or less similar suggesting that the product quality was not influenced adversely by the application of solar radiation and microwaves.

REFERENCES

Abhaykumar; Rajorhia, G.S. and Srinivasan, M.R. (1975). Effect of modern packaging materials on the keeping quality of khoa. *J.Food Sci. Technol.,* India, **12:**172.

Bhatia, A.K. (1978). A simple solar fruit dryer for the rural areas. *Indian Food Packer,* **32 (1) :** 127-129.

Bhosale, D.N. (1972). Studies on chemical and microbiological quality of khoa sold in Poona city. M.Sc. (Agri.) thesis submitted to the M.P.K.V. Rahuri. Dist. Ahmednagar (M.S.)

BIS (1981). Handbook of food Analysis XI : Dairy Products, SP **:18**. Bureau of Indian Standards, New Delhi.

Chiu, C.P., Tateishi, K., Kosikowski, E.V. and Armbruster, G. (1984). Microwave treatment of pasteuriszed milk. *J. Microwave Power,* **19(4) :** 269-272.

Choudhari, D.S. (1998). Preparation of khoa and chhana from high acid milk. M.Sc. (Agri.) thesis submitted to the M.P.K.V. Rahuri Dist. Ahmednagar (M.S.)

De, S. and Ray, S.C. (1952). Studies on the indigenous method of khoa making. Part I : The influence of the conditions of dehydration and the type of milk on the production of khoa. *Indian J. Dairy Sci.,* **5 :** 147-153.

Goyal, G.K. and Srinivasan, M.R. (1989). Effect of packaging on the Chemical quality of khoa during storage. *Indian J. Dairy Sci.,* **42 :** 165.

IS : 1479 (1962). Methods of test for dairy industry. (Part III) Microbiological analysis of milk. Bureau of Indian Standards, New Delhi.

IS : 4883 (1980). Specification of khoa, First Revision. Bureau of Indian Standards. New Delhi.

IS : 6273, Part I (1971). Guide for sensory evaluation of foods. Indian Standard Institutions. Manak Bhavan. New Delhi.

IS : 6273, Part III (1971). Guide for sensory evaluation of foods. Indian Standard Institutions. Manak Bhavan. New Delhi.

Katre, B.C. and Prasad, S. (1992). Utilization of solar energy in pasteurization process. *Indian Dairyman,* **41 (5) :** 251-253.

Khurdia, D.S. and Roy, S.K. (1986). Solar drying of fruits and vegetables. *Indian Food Packer,* **40(4) :** 28-39.

Knutson, K.M., Marth, E.H. and Wagner, M.K. (1988). Use of microwave ovens to pasteurize milk. *J. Food protect,* **51 (9) :** 715-719

Kasikowaski, F. (1982). Cheese and fermented milk products. Koiskowaski, F.Y. and Associates, P.O. Box , 139, Boktondate, News York. 568.

Kumar, G. and Srinivasan, M.R. (1982). A comparative study on the chemical quality of three types of khoa. *Indian J. Dairy Sci.,* **35 :** 56

Mathur, B.N. and Sachdeva, S. (2000). Futuristic Technologies for amelioration of processing efficiencies and product attributes. *Indian Dairyman,* **52 (12) :** 73-81.

Patel, K.H., Sai Prakash and Sharma, R.S. (1985). Effect of sodium and potassium metabisulphites on the shelf life of Khoa. *Asian J. Dairy Res*., **4 :** 89.

Patil, S.J. (1981). To study the effect of addition of different levels of potassium sorbate and different packaging materials on keeping quality of khoa. M.Sc. (Agri.) thesis submitted to the M.P.K.V. Rahuri Dist. Ahmednagar (M.S.)

Snedecor, G.W. and Cochran, W.G. (1994). Statistical methods. 1994 Eighth Edition. East-West Press Pvt. Ltd. New Delhi.

Sudheer, K.P. and Das, S.K. (1999). Osmo-solar dehydrations of fruits and vegetables an overview. *Indian Food Packer,* **53 (3) :** 28-39.

Suryawanshi, C.M. (2000). Studies on process alteration in preparation of khoa from high acid cow milk. M.Sc. (Agri.) Thesis, submitted to M.P.K.V. Rahuri, (M.S.)

Thomas, W.R. Harper, W.J. and Gould, I.A. (1954). Free fatty acids content of fresh milk related to portion of milk drawn *J. Dairy Sci*., **37 :** 717.

Thompson, J.S. and Thompson, A. (1990). In-home pasteurization of raw goat's milk by microwave treatment. *International J. Food Microbial*, **10:**59-64.