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Comparison of chemical properties of milk when conventionally and ohmically heated

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Abstract

Ohmic heating is a food processing method in which an alternating current (AC) is passed through a food sample, which results in internal energy generation in foods. It is an alternative fast heating technique. Its principal advantage is its ability to heat food material with different density rapidly and uniformly. This work contains the analysis of chemical properties such as Acidity (as lactic acid), Fat, SNF, Protein and Total solids of buffalo milk before and after ohmic and conventional heating methods. Milk treated by ohmic heating technology, Acidity (as lactic acid), Fat, SNF, Protein and Total solids were 0.063, 6.033, 5.840, 2.777 and 11.840 respectively which were very much comparable to those found in conventionally heating technology process. Time reduction in ohmic heating was about 18% as compared to conventional heating.

Introduction

Ohmic heating is an advanced thermal processing method wherein the food material, which serves as an electrical resistor, is heated by passing electricity through it. Electrical energy is dissipated into heat, which results in rapid and uniform heating. Ohmic heating is also called electrical resistance heating or joule heating. There are wide applications of ohmic heating in Food Processing industries like blanching, evaporation, sterilization, thawing and pasteurization. The shelf life of ohmically processed foods is comparable to that of canned and sterile, aseptically processed products. Electrical conductivity of food should be in the range of 0.01 to 10 Sm^{-1} at 25°C for ohmic heating process. pH should be necessarily above 4.6 to avoid corrosion of electrodes. Several factors affecting the performance of ohmic heater are physical parameters of food, parameter of the ohmic heating system, orientation and concentration of food particles.

Electrical conductivity is the main critical parameter for heating the food material by ohmic heating techniques. Most of the food contain ionic species such as salts and acids hence, electric current can be made to pass through the food and generate heat inside it. (Palaniappan *et al.*, 1991). Electrical conductivity of most foods increases with temperature, Ohmic heating becomes more effective as the temperature increases (Sastry *et al.*, 1992). Electrical conductivity increased almost linearly with temperature. But in all case this is not applicable especially when food product containing starch granules.

In conventional aseptic heating, demonstrated that it is not possible to sterilize particulate foods at temperatures much above 130ºC without serious overheating of the liquid phase (Parrot, 1992). Several authors have demonstrated that in ohmic heating, it is possible to heat the centre of the particle faster than the liquid (De Alwis *et al.*, 1989; Sastry *et al.*, 1992a). Ohmic heating offers an alternating because it simultaneously heats both phases by internal energy generation (Palaniappan *et al*., 2002). In ohmic heating process for particulates foods, the most desirable situations is that in which the electrical conductivities of fluid and solid particle are equal (Wang *et al*.,1993a). This technique has been applied to blanching of vegetables (Mizarahi *et al*., 1975), thawing of frozen foods (Naven *et al*., 1983) and evaporation, dehydration, fermentation & extraction (Butz *et al*., 2002). Microbial inactivation is also carried out by ohmic heating process. *Bacillus subtilis* revealed that a two stage ohmic treatment resulted in accelerated death rates (Cho *et al.*, 1999). The objective of this study was to compare the changes in chemical properties of milk when it undrergoes to ohmic and conventional heating.

Materials and Methods

Ohmic Heating Chamber

An ohmic heating chamber of 500 ml capacity was fabricated using toghened borosilicate transparent

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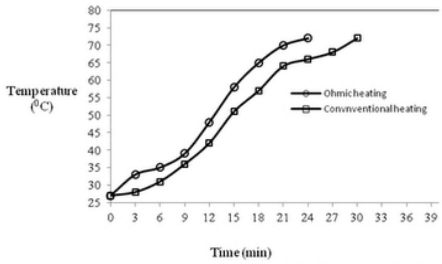

Figure 1. Comparison of temperature histories for ohmic heating and conventional heating at each set temperature.

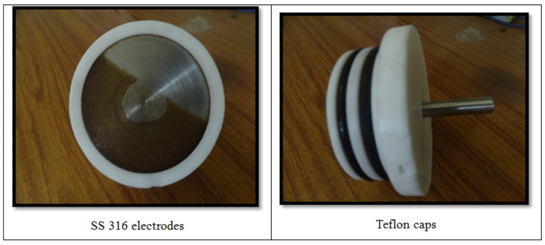

Figure 2. Electrodes of ohmic heater

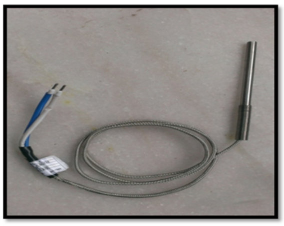

Figure 3. "K" type thermocouple

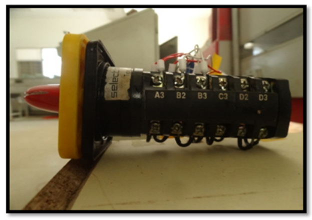

Figure 4. Thermocouple adjusting switch

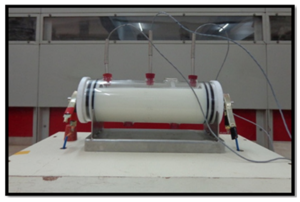

Figure 5. Thermocouple positioning

glass of length 20 cm and inner diameter 6 cm. Internally male adapter having external diameter same as that of internal diameter of the pipe with rubber gasket, to stop leakage, is fitted with glass pipe.

Electrodes and thermocouple

The suface of the food grade SS 306 elctrodes (D = 5.8 cm) is polished to smooth finish using fine emery sheet. Polished electrode plates of 1.5 mm thick are fixed closedly adjacent to the end of the screw caps of the ohmic heating chamber using bolts and nuts. A hole of 0.6 cm is drilled on the centre end side to fasten the elctrodes with the chamber using bolts and nuts. The themocouple used for the experiment was "K" type (Chromel-Alumel) for the range of 40-500°C). Figure 2 shows the electrodes of ohmic heater and the tefelon cap with rubber rings, where as figure 3 and 4 shows the thermocouple and its adjusting switch. Figure 5 shows the position of thermocouples.

Power source

Power from Domestic supply (220V, 50Hz) was used. Voltage was supplied to the electrodes at the end sides. Digital ammeter was used to measure the amount of current in amperes. It displayed the output on an electronic display and is more precise and more effective than the analog substitutes. It also provided readings up to many decimal places, which offered greater accuracy. It has positive and negative leads built into them and it has a very low resistance which is usually almost negligible so that accurate readings can be acquired. Figure 6 shows the experimental setup of ohmic heating. Fresh raw buffalo milk was obtained from the identified farm at Anand, India. The change in chemical properties of Untreated (raw milk), Conventionally heated and Ohmically heated were studies. The chemical properties which were studied during experiments was fat content, acidity content, solid-not-fat content and protein content (Huixian et al., 2008). Milk is conventionally heated in water bath at 72°C for 15 seconds, whereas in ohmically heating, milk is kept in ohmic heating chamber with supplied voltage 110V, current 0.6A, and electric field intensity 8.38V/cm to obtain 72°C temperature.

Results and Discussion

A comparison of the different chemical properties of samples subjected to untreated, conventionally and ohmically heated are shown in table 1, 2 and 3. Untreated fresh identified buffalo milk is heated in water bath at 72°C for 15 seconds. Time taken to reach the 72°C from room temperature is 29 minutes and 16 seconds whereas in ohmically treated the time taken was only 23 minutes and 52 seconds. Conventional heating takes about 18% more time to reach the same temperature. A comparison of the thermal histories of samples subjected to ohmic and conventional heating is shown in figure 1. The data indicate that the sample temperatures were properly controlled at each set temperature.

When buffalo milk is heated in through an electric field of 8.38V/cm at pasteurization temperature time combination some conclusion are drawn from the

Table 1. Chemical properties of untreated milk

Tests performed	R_1	R_2	R_3	Average
Acidity (% lactic acid)	0.063	0.068	0.068	0.066
Fat (%)	5.900	5.700	5.900	5.833
SNF (%)	8.570	8.530	8.570	8.557
Protein (%)	4.080	4.250	4.080	4.137
Total solids (%)	14.470	14.230	14.470	14.390

Table 2. Chemical properties of conventionally heated milk

Tests performed	R_1	R_2	R_3	Average
Acidity(%lactic acid)	0.077	0.077	0.072	0.075
Fat (%)	6.200	6.400	6.200	6.267
SNF (%)	7.630	7.670	7.630	7.643
Protein (%)	3.570	3.400	3.570	3.513
Total solids (%)	13.830	14.070	13.830	13.910

Table 3. Chemical properties of ohmically heated milk

Tests performed	R_1	R_2	R_3	Average
Acidity(% lactic acid)	0.063	0.063	0.063	0.063
Fat (%)	6.000	6.100	6.000	6.033
SNF (%)	5.840	5.840	5.840	5.840
Protein (%)	2.890	2.550	2.890	2.777
Total solids (%)	11.840	11.840	11.840	11.840

Table 4. Average chemical properties of Untreated, Conventionally and Ohmically heated milk

Tests performed (%)	Untreated	Conventionally heated	Ohmically heated
Acidity(% lactic acid)	0.066±0.003	0.075±0.005	0.063±0.03
Fat (%)	5.833±0.01	6.267±0.06	6.033±0.01
SNF (%)	8.557±0.006	7.643±0.003	5.840±0.0
Protein (%)	4.137±0.006	3.513±0.003	2.777±0.003
Total solids (%)	14.390±0.006	13.910±0.003	11.840±0.003

Figure 6. Experimental setup of ohmic heating

observation. The average values are given in table 4. Acidity remains almost constant. There is slight increase in acidity during processing. Acidity of conventionally heated milk is more than ohmically heated. Though the increment is insignificant but it will consider as advantage of ohmic treatment. Fat is decreasing in ohmic heated milk where as in conventionally heated milk it remains constant. This decrement may be due to handling issues as it is difficult to handle milk in a lab ohmic setup. Protein is decreasing in both ohmic heating and conventional heating. In ohmic heating protein is reduced significantly. There can be a predictive reason i.e. Protein is susceptible to electrical field. As field intensity increases protein loss decreases (Asaad Rehman, 2013). This is due to for higher field intensity, protein is exposed for less time hence protein denaturation retards. But here with low field intensity more exposure time leads to significant denaturation of protein hence protein content reduces. SNF reduces as protein reduces. Because protein is reducing and it is an integral part of SNF. As SNF decreases, total solids decreases as fat remain constant.

Conclusion

It is concluded from the above study by concerning the chemical analysis that ohmic heating provides better performance as the operation time is concerned. It is also indicated that ohmic heating provides the products with chemical properties similar to those of conventional heating. These findings are very important because ohmic heating can be replaced by the conventional heating.

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