FABRICATION AND PERFORMANCE STUDY OF A SOLAR MILK PASTEURIZER

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Milk borne diseases in developing countries leads to millions of deaths and billions of illnesses annually. Milk disinfection is one of several interventions that can improve public health, especially if part of a broad program that considers all disease transmission routes and sustainable involves the community. A solar milk pasteurizer (SMP) was fabricated to investigate the potential of using solar energy to pasteurize naturally milk. The milk samples from different animals were collected and were used for the inactivation of microbes. This experimentation was done on temperature ranging from 65°C to 75°C. During present research the maximum ambient air temperature was 40°C .The base and inner space temperature were recorded and they were found to have values 85°C and 75°C respectively. The SMP was easily attained pasteurization temperature. This solar milk pasteurizer was also use for water pasteurization. It provides a practical, low-cost milk pasteurizer for the improvement of drinking milk quality in developing countries like Pakistan.
Keywords: Pasteurizer; phosphatase enzyme; reflectors; solar energy

INTRODUCTION

The amount of solar energy intercepted by the Earth every minute is greater than the amount of energy that the world used in fossil fuel each year. A solar box cooker traps the dun's energy in an insulated box such boxes have been successfully used for cooking and pasteurization. Solar energy is pollution free during use (Wegelin *et al*., 1994).

Today use of modern fuel is so expensive and even count as one of the major pollution source. In areas where sunlight is plentiful the use of sunshine to cook and pasteurize contaminated water and milk require our more concentration on industrial level to develop cheap and pollution free technology (Wegelin *et al*., 1994) among available alternatives solar pasteurization is a cheap, energy-efficient, robust and adoptable technique in sun-rich areas (Black, 1999).

Different techniques have been developed to make use of solar radiations such as solar milk pasteurizer and it is possible to pasteurize milk using solar energy with careful operation (Pandey and Gupta, 1983).

Simple and reliable methods could be used in developing countries to pasteurize milk and water with solar energy (Safapour and Metcalf, 1998).

Milk, a natural liquid food, is one of our most nutritionally complete foods. Milk contains bacteria when improperly handles create conditions where bacteria can multiply Antibiotic residues in milk due to use of antibiotics widely in food producing animals, supposed problems for the both dairy industry and consumers (Zorraquino *et al*., 2008).

Most of the bacteria in fresh milk from a healthy animal are either harmless or beneficial but rapid changes in the health of an animal, or the milk handler, or contaminants from polluted water, dirt, manure, vermin, air cuts and wounds cab make raw milk potentially dangerous. Raw milk contains Alkaline phosphate (ALP) is an enzyme naturally present in raw milk which is responsible for intra-abdominal bacterial infection when milk use for drinking purposes (Ylva *et al*., 19999; Sandeep *et al*., 2003; Fenoll *et al*., 2002).

The actual definition of pasteurization is; the heating of milk to a specific temperatures for a specific time to reduce undesirable enzymes and bacteria to negligible levels. It is important that pasteurization is function of time and temperature not just temperature (Pandey and Gupta, 1983). Pasteurization destroys most of the disease producing organisms and limits fermentation in milk, beer, and other liquids by partial and complete sterilization. The enzyme bovine alkaline phosphate (ALP) is present in milk and is destroyed during pasteurization (Sandeep *et al*., 2003). The check for the presence of residual ALP activity in milk is a good indication of proper pasteurization (Fasken and Mcclure 1940). The determination of residual alkaline phosphate activity in milks subjected to temperature treatments can be performed by various optical methods. The microbes form endospores such as Bacillus and Paenibacillus spp. even can exist at high temperature short time pasteurization (Huck *et al*., 2008). In case of incomplete inactivation of enzymes, proteolysis and lipolysis can occur and affect the quality of milk and dairy products (Villamiel *et al*., 1997) to destroy organisms that grow slowly or produce spores. Proper time and temperature must be applied (Zorraquino *et al*., 2008).

Raw milk can also be pasteurized on the stovetop. Microwaving raw milk is not an effective means of pasteurization because of uneven heat distribution. Some potentially dangerous microorganism may exist when we use conventional method for milk pasteurization (Smith *et al*., 2002).

To pasteurize water and milk a silver coated card board reflector is used to focus sunshine on to black jar containing milk or water heated to pasteurizing temperatures in several hours. By using some indication methods pasteurization will have been conformed (Safapour and Metcalf, 1998).

The present research deals with the fabrication and performance study of solar milk pasteurizer (SMP) for proper pasteurization and handling will greatly increase the storage life of milk by avoiding uneven heat distribution and destroy organism that grow slowly or produce spores that responsible for spoilage. Our concentration to fabricate a cheap solar milk pasteurizer whose fabrication helpful to remove uneven heat distribution and destroy organism that grow slowly in milk (by creating a proper time and temperature) to increase the storage life of milk. Solar pasture was also constructed to investigate the potential of using solar energy to pasteurize milk .The milk samples of different animals from different dairies were collected and use for the inactivation of microbes. this experimentation was done on temperature ranging 65°C to 75°C .It provides a practical low–cost milk pasteurizer for the improvement of drinking milk quality in developing countries like Pakistan.

MATERIALS AND METHODS

The solar milk pasteurizer was fabricated from standard appliance shipping cardboard. The SMP was made of some basic components which were insulated with a large cardboard box which contained the rectangular area. A removable glass window and the main insulating material of the SMP were made of multiple layers of the regular aluminum foil glued onto cardboard. The outer box has volume (75×38×39.5) cm and aluminum foiled on the inner side only.

The inner box having volume (52.5×24×36) cm covered on both sides with aluminum foil. The inner box rested of foiled cardboard support piece and it was supported by four stacks (8×8) cm of card board 3.5 cm high glued to the bottom of the outer box. The side insulator covered with aluminum foil on both sides are placed diagonally extending from the inside bottom of the outer box to the outside top of the inner box. The resulting cooking chamber has volume (50.5×23×35) cm. A metal tray painted black with toxic paint on the outside only is placed in the bottom of the cooking area. This tray absorbed sunlight and converted it to infrared heat rays.

Heating Procedure in SMP

Milk heated in the solar pasteurizer was added in the tray which was painted black from outside (Safapour and Metcalf, 1998). The tray was filled with raw milk and was placed in the bottom of inner box. Temperature was recorded by mercury thermometer every 10 minutes. The lid of solar pasteurizer was placed over the top carefully and can be easily removed. For the duration of all SMP experiments, the solar pasteurizer was positioned towards the sun. The pH of those samples which were collected before the pasteurization was determined by pH meter. The pH of different samples which is noted before pasteurization was 6.75.after pasteurization to confirm that it had been done properly the phosphate test as an indicator of pasteurization of milk applied (Sharma *et al*., 2003).

Test Procedure

Taken 10ml distilled water in six test tubes. Put Lactognost 1 and then Lactognost 2 in each of the test tubes, dissolve both Lactognost 1 and 2 in distilled water in test tubes .Then added 1ml raw milk in each of three test tube and 1ml pasteurized milk in other each of three test tube. After this incubate both test tubes at 37°C to 38°C for an hour (Sharma *et al*., 2003). Now after passing through this process pour one spoon of Lactognost 3 which was in powdered form in each test tube, now remain these tubes at room temperature for ten minutes. After ten minutes these test tubes gave three types of colour namely blue, light brown and greenish. Blue colour for raw milk indicated that phosphatase enzyme was present. Light brown colour indicated that milk has been pasteurized perfectly and greenish color indicated that normal pasteurization of milk has been occurred. The light brown and green colors show phosphatase enzyme is destroyed during pasteurization. The colour of pasteurized samples was light brown. The pH of raw milk had also been checked with pH meter which was 6.75 and it was normal (Fasken and McClure, 1940).

This confirmatory test was performed in the laborites of Haleeb Food Limited, 62 km Multan Road Lahore (Bhai Pheru).

Statistical Analysis

The data so collected had been statistically analyzed. The polynomial regression was applied on the data (Steel and Torrie, 1980). The independent variable was taken along x axis and dependent variables were taken along y axis. The base and side temperature were increased with increase in time and these are nearly

Table 1. Polynomial regression analysis of different temperatures (°C) versus Time (minutes)

Temperature of different parts of SMP	Constant	Linear	Quadratic	Cubic	R^2
Day -1 Temperature					
Base Temerature	45.70	0.370	-0.001	0.000002	98.1%
Inner Space Temerature	36.97	0.816	-0.004	0.000006	94.8%
Milk Temerature	22.91	0.557	-0.001	0.0000009	98.7%
Day -2 Temperature					
Base Temerature	50.38	0.2295	_	_	98.1%
Inner Space Temerature	39.44	0.744	-0.004	0.000007	99.6%
Milk Temerature	15.10	0.513	-0.001	_	99.5%
Day -3 Temperature					
Base Temerature	25.50	0.856	-0.003	0.000003	97.9%
Inner Space Temerature	30.42	0.753	-0.004	0.000008	99.6%
Milk Temerature	19.67	0.326	-0.001	-0.000006	98.8%

equal. The milk temperature was also increased with increase in time but it was remain small as compared to base and side temperature.

RESULTS

Simple and reliable methods could be used in developing countries to pasteurize milk and water with solar energy (Safapour and Metcalf, 1998).

The main parameters for this study under local climatic conditions were Ambient Temperature, Base Temperature of inner box, Inner Space Temperature of inner box, hot milk Temperature and Time Period.

Working of solar Pasteurizer was dependent upon the availability of the sun shine therefore; it is evident that it can be used only during bright sunny days and not in a hazy or cloudy day.

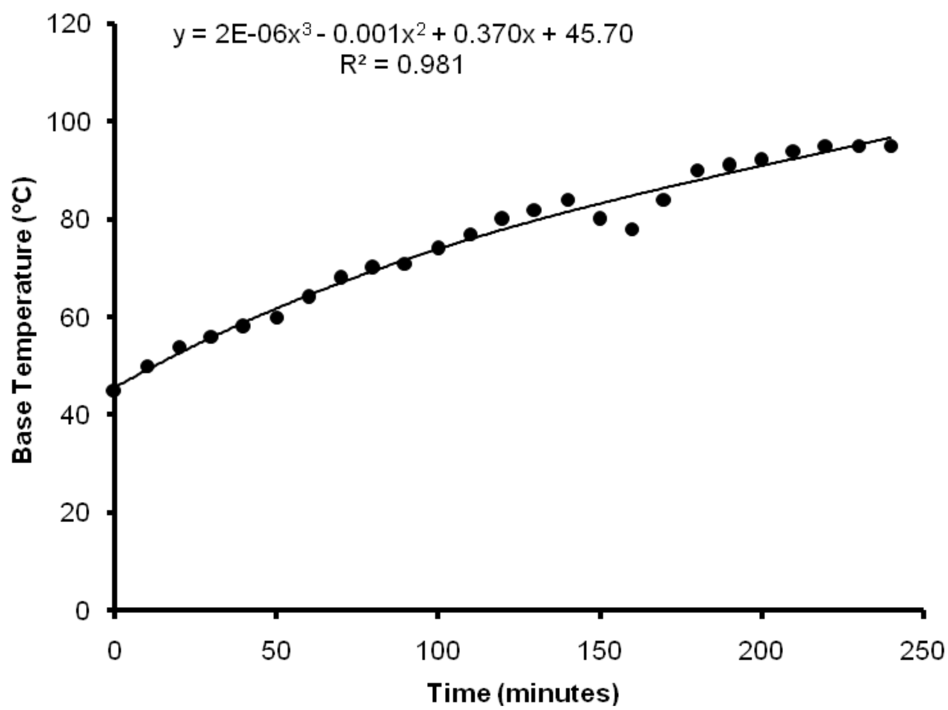

Fig. 1.1 Base Temperature of solar milk pasteurizer verses Time

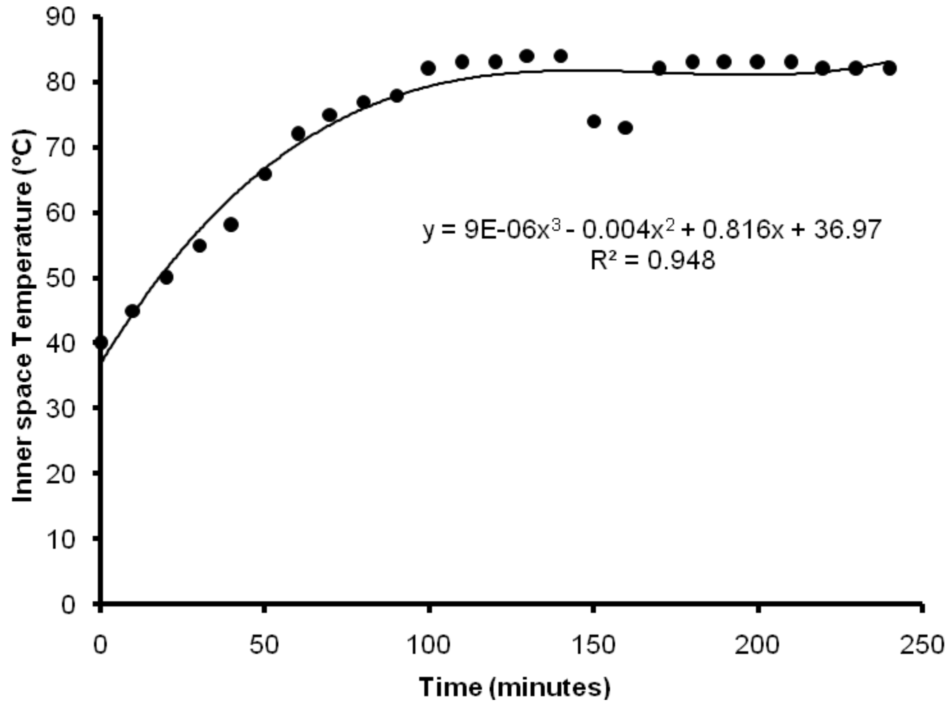

Fig. 1.2. Inner space Temperature of solar milk pasteurizer verses Time

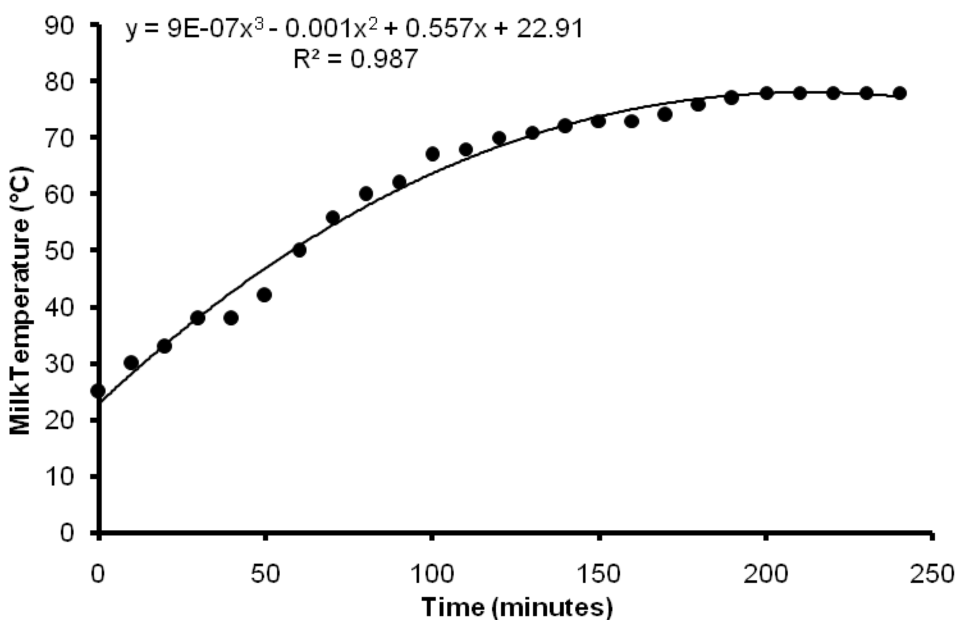

Fig. 1.3. Milk Temperature of solar milk pasteurizer verses Time

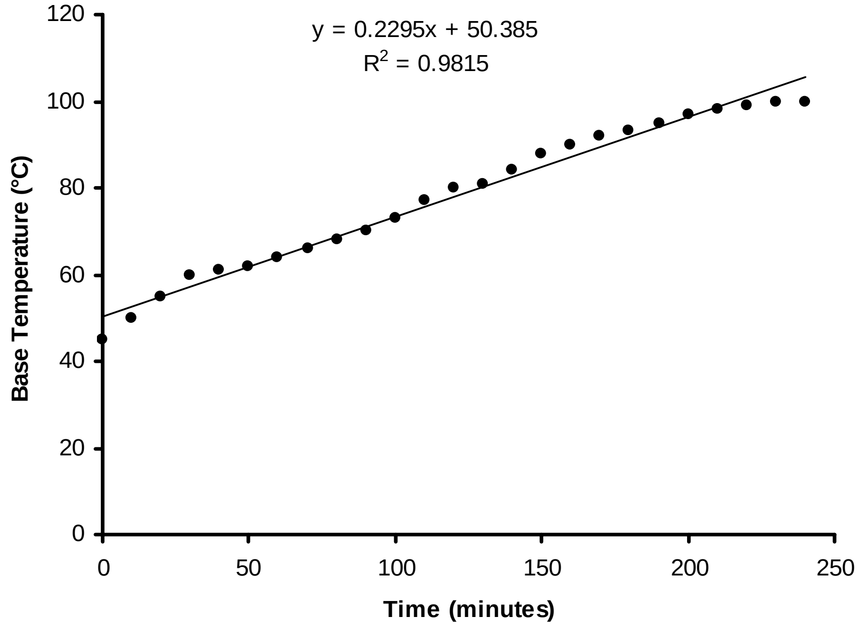

Fig. 2.1. Base Temperature of solar milk pasteurizer verses Time

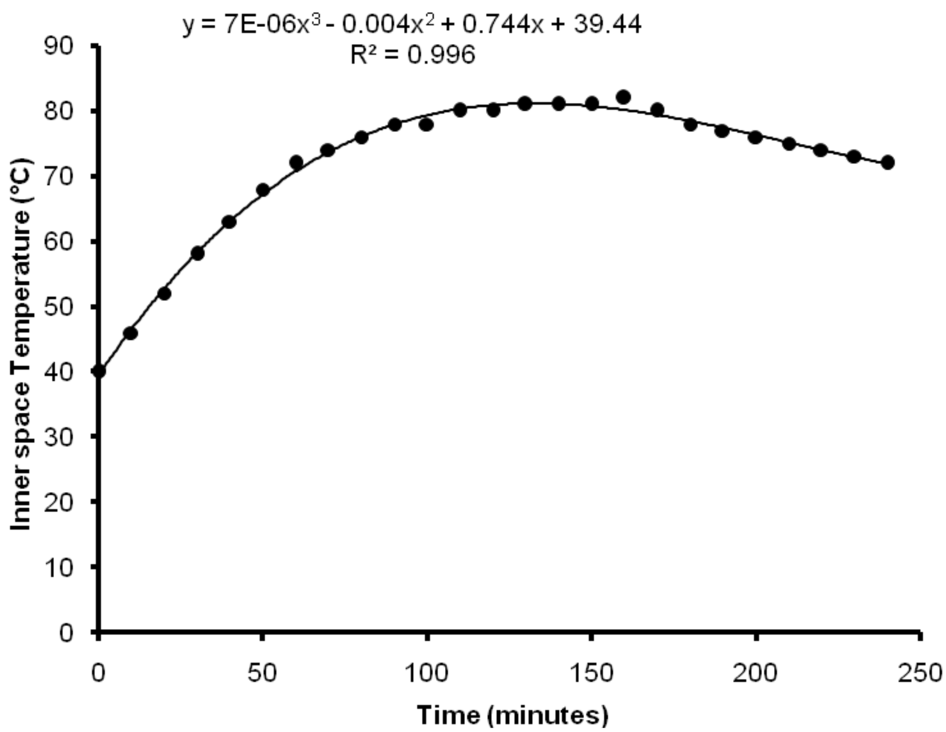

Fig. 2.2. Inner space Temperature of solar milk pasteurizer verses Time

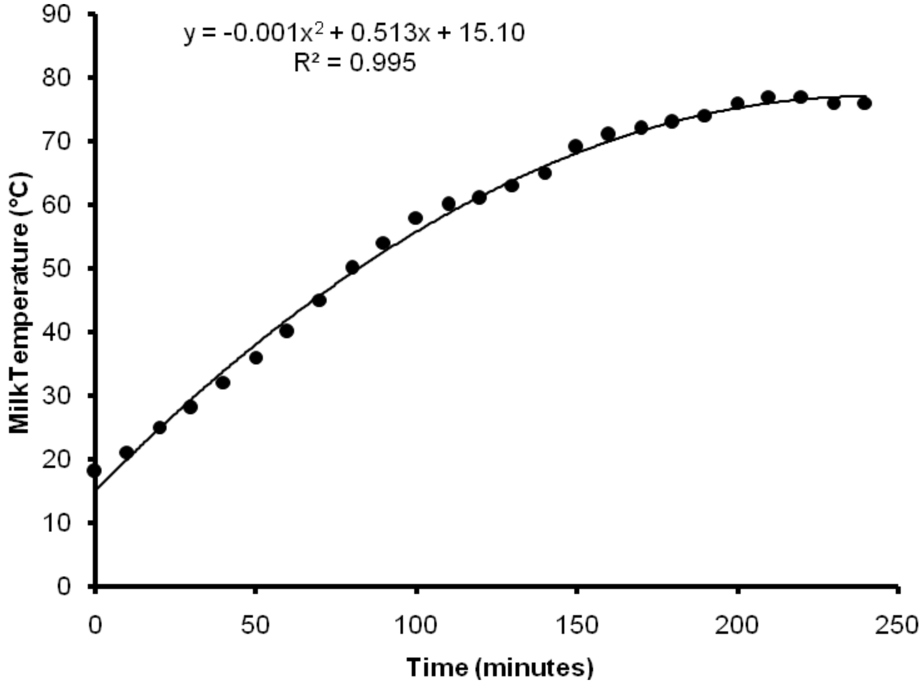

Fig. 2.3. Milk Temperature of solar milk pasteurizer verses Time

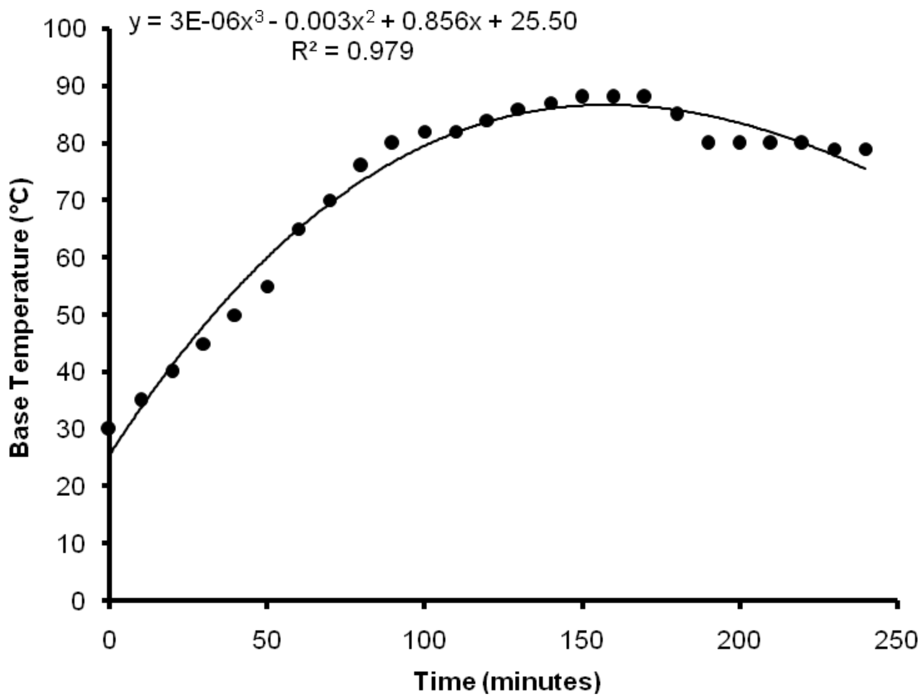

Fig. 3.1. Base Temperature of solar milk pasteurizer verses Time

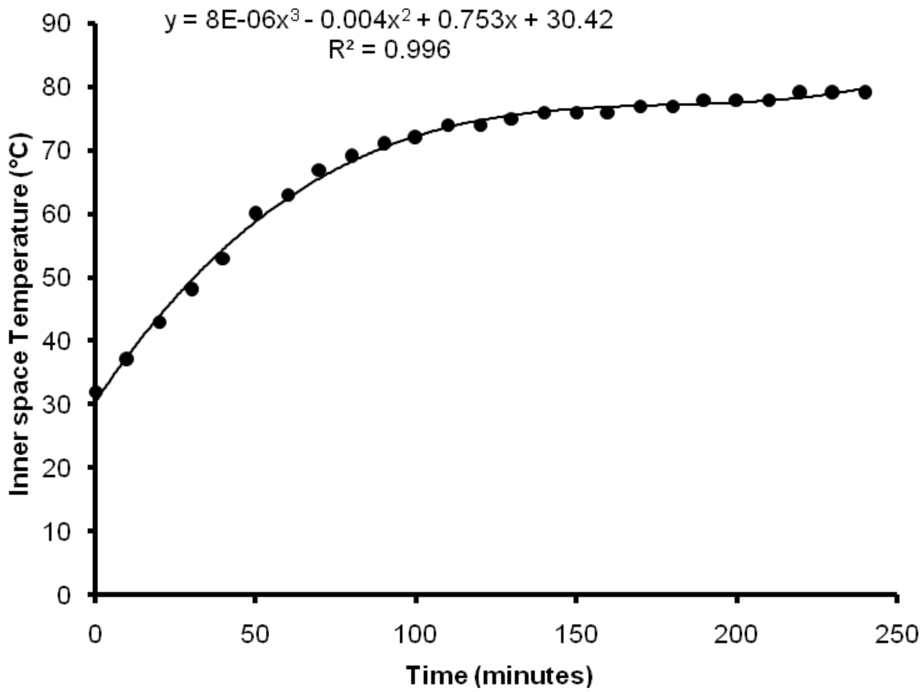

Fig. 3.2. Inner space Temperature of solar milk pasteurizer verses Time

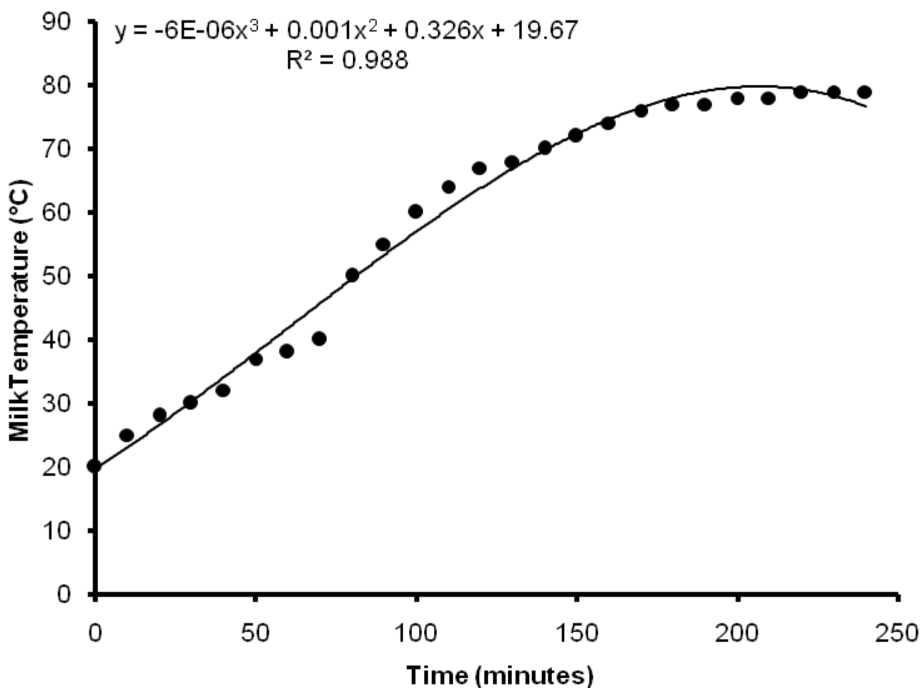

Fig. 3.3. Milk Temperature of solar milk pasteurizer verses Time

Solar milk pasteurizer was observed fifteen days from 10:00 to 14:00. The data was collected during the summer season under the local weather conditions of Faisalabad. The solar radiations passed through glass window and heated the milk. The temperature of solar milk pasteurizer was recorded at ten minutes intervals. For measuring temperature, mercury thermometers were used.

The ambient air temperature was almost same. The minimum value of ambient temperature was 31°C and the maximum ambient air temperature recorded during this research was 40°C.

Base temperature was noted by the mercury thermometer which was placed in the base of inner box. From the data it was observed that the maximum base temperature of a solar milk pasteurizer was reached at 100°C. The regression lines for base temperature in the Figures (1.1, 2.1, and 3.1) show that base temperature increases with increase in time. Base temperature was increased as we increase time one minute then on the average temperature will increased by 0.370°C, 0.2295°C and 0.856°C respectively as shown in Figures 1.1, 2.1 and 3.1. There were decrements in temperatures also observed which were due to change in weather. R2 value is 97.9% to 98.1% which describes the amount of variation in the observed response values.

Inner space temperature was noted by a mercury thermometer which was present in the inner box. The maximum inner space temperature attained was 90°C. The regression lines for inner space temperature in the Figures 1.2, 2.2 and 3.2 shows that it increased with increase in time and nearly equal to the base temperatures. Slopes of regression lines were at 0.816°C, 0.744°C and 0.753°C.

Milk temperature was noted by a mercury thermometer which was placed in an aluminum tray in which milk was present. The milk temperature was reached the maximum value of 85°C. In most of the experiments the temperature of milk was reached 72°C in two to three hours and this temperature was sufficient for pasteurization of milk. After heating, the milk was maintained above 72ºC for 15 seconds (Pandey and Gupta, 1983). From Figures 1.3, 2.3 and 3.3 it was observed that milk temperature was increased as if we increase time 1 minute then on the average temperature will increase by 0.557°C, 0.513°C and 0.326°C. On cloudy days, the rise of temperature was not high as that on hot and bright days.

Fifteen samples of raw milk were pasteurized and were tested in the Haleeb Food Limited 62 km Multan Road Lahore (Bahi Pheru) using phosphatase test as an indicator of pasteurization of milk (Fasken and McClure, 1940) which confirmed that pasteurization of milk has occurred.

DISCUSSION

A direct method adopted for obtaining pasteurization by using solar energy as the heat source for obtaining a minimum and maximum pasteurization fluid temperature of 63°C to 78°C. Liquid milk has been pasteurized by using this process. Thermal and biological tests of the pasteurized milk showed very successful results (Razzak *et al*., 1985).

The results had shown that there was tremendous scope of utilizing solar energy in dairy processes such as pasteurization of milk (Reddy and Verma,1986).

The dairy products studied undergone heating and cooling during processing. To heat the water required the medium temperature which could be easily achieved using solar energy. The results had shown that there was tremendous scope of utilizing solar energy in dairy processes such as pasteurization of milk (Reddy and Verma, 1986). People in sun-rich areas of developing countries often cannot afford modern fuels and suffer from ever-increasing fuel wood shortages. The use of sunshine to cook and pasteurize contaminated water and milk could provide a new approach to these debilitating problems (Wegelin *et al*., 1994).

Pasteurization of milk is time and energy consuming and therefore it might be difficult for poorer households to apply it. Gathering or buying firewood, charcoal or other types of fuel has an economic price.

Villamiel *et al*., 1997 had been derived a model that describes the inactivation of bovine milk catalase during heating in a high temperature in short time pasteurizer.

The solar milk pasteurizer attained pasteurization temperature in 1 to 1.5 hours so it should be commercially used. The time interval can be reduced by using mirror reflectors (Black, 1999).

The milk was pasteurized successfully by heating with solar energy using aluminum foil on card board. The glass window on SMP increased the performance of pasteurizer. The change in intensity of solar radiation had a direct impact on solar milk pasteurizer. The heat gain and temperature rise with the increase in solar intensity (Pandey and Gupta, 2004).

It is an effective method of pasteurizing raw milk using card board box glued by multiple layers of aluminum foil covered with glass could be copied at low cast by individuals in many sun rich areas around the world and possibly contribute to improved health among the poorest citizens.

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