

STORAGE STUDIES ON PULSED ELECTRIC FIELD PROCESSED MOTHER'S MILK

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ABSTRACT

This paper investigates the shelf life of mother's milk at refrigerated storage (5°C) processed by pulsed electric field technology (PEF), which is one of the novel, non-thermal methods of processing. Mother's milk was processed using PEF technology by applying voltage gradient 35kV with different treatment times (3000 µs and 4500 µs). The processed samples were collected in sterile bottles and stored at 5°C. The physico – chemical parameters (pH and acidity) of the PEF treated samples were analyzed at regular intervals and the results were compared with the pasteurized (62.5°C for 30 minutes) mother's milk samples. Mean value for pH and acidity (°D) was observed as 6.8±0.07 and 5.84±0.48 respectively during the 19th day of storage at 5°C when the samples were treated at 35kV with a PEF treatment time of 4500 µs (T₂). For pasteurized samples, mean value for pH and acidity (°D) was observed as 6.75±0.09 and 6.17±0.61 respectively during the 7th day of storage at 5°C. The results revealed that PEF treated samples stored at 5°C remained shelf stable for 19 days whereas pasteurized milk samples stored at 5°C remained shelf stable for 7 days.

Keywords: Mother's milk, Pasteurization, Pulsed electric field, Shelf life

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Mother's milk is considered as a natural and sustainable food and is recognized as the ideal food for infants' nutrition (Boquien, 2018). When mother's own milk is not available for the sick or hospitalized newborn or due to

preterm delivery, pasteurized donor milk from mother's milk bank is the only alternative (Ewaschuk *et al.*, 2011). Human milk banking practice involves the process of collecting breast milk from the lactating mothers and processing it and storing it with the main aim of feeding it to the infants of other mothers (Leaf and Winterson, 2009). Pasteurization (62.5°C for 30 mins) is recommended in all mother's milk bank to preserve milk as it

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inactivates all the bacterial cells in the milk (Kim and Unger 2010).

Pulsed electric field (PEF) technology is an emerging novel non – thermal food preservation technique which is often considered as an alternative or replacement to traditional thermal pasteurization. PEF technology involves the application of short pulses of high voltage (in the order of 10 – 80 kV/cm) with a duration of microseconds to milliseconds to the foods placed between two electrodes (Zhang *et al.*, 1995).

The objective of this study was to investigate PEF technology as an alternative treatment method for processing donor human milk and to evaluate the shelf life of PEF processed milk at refrigerated storage (5°C).

Collection of mother's milk

Mother's milk samples were collected from mother's milk bank attached to hospitals in Chennai and also from donor mother's in and around Koduveli village, Chennai. Sterilized stainless steel (SS) containers were used for mother's milk collection.

PEF processing of mother's milk

The collected milk samples were subjected to PEF treatment using a lab model PEF equipment which comprises of two stainless steel circular, parallel plate electrodes. The distance between electrodes in PEF chamber was adjusted to 0.5 cm. Mother's milk samples were subjected to PEF processing by applying voltage gradient 35kV with different treatment times (3000 μ s and 4500 μ s). Microbial inactivation of PEF was governed by the strength of the applied

electric field and total treatment time (Sale and Hamilton, 1967). PEF treatment of 35 kV/cm was applied to the milk samples and observed log reduction of the selected microorganisms and no significant difference in color, pH, proteins, moisture and particle size were observed in PEF treated milk samples (Michalac *et al.* 2003).

Treatments	PEF treatment parameters
T ₁	35 kV, 3000 μ s
T ₂	35 kV, 4500 μ s

Voltage gradient in Kilovolt (kV); Treatment time in microseconds (μ s)

Shelf life and quality assessment

pH and acidity of the stored samples were analyzed at regular intervals during the storage period. pH was measured using digital pH meter and acidity was measured and expressed in Dornic degrees (°D).

Statistical analysis

Statistical analysis was performed using one way analysis of variance (ANOVA).

Research findings

The shelf life studies were conducted for a period of one month for the PEF treated samples and the results were compared with the pasteurized milk samples. Physico-chemical parameters viz., pH and acidity were determined at two day intervals for PEF treated samples stored at 5°C and the results were compared with the pasteurized mother's milk samples.

Table 1. pH during storage at 5°C (n=6)

	0 th Day	3 rd Day	5 th day	7 th Day	9 th Day	11 th Day	13 th Day	15 th Day	17 th Day	19 th Day
T ₁ (35 kV, 3000µs)	7.09±0.05 ^a	7.09±0.04 ^a	7.07±0.03 ^a	7.05±0.03 ^b	7.04±0.03 ^a	7.07±0.03	7.02±0.02	6.77±0.09	6.7±0.09	6.3±0.05
T ₂ (35 kV, 4500µs)	7.14±0.08 ^a	7.1±0.04 ^a	7.09±0.04 ^a	7.07±0.04 ^b	7.05±0.04 ^b	7.04±0.03	7.04±0.03	7.05±0.04	7.01±0.03	6.8±0.07
Pasteurized sample	7.05±0.03 ^a	7.04±0.03 ^a	7.04±0.03 ^a	6.75±0.09 ^a	6.34±0.06 ^b	-	-	-	-	-
F value	.731 ^{NS}	1.327 ^{NS}	1.061 ^{NS}	11.747 ^{**}	106.294 ^{**}	1.250 ^{NS}	0.385 ^{NS}	9.698 ^{**}	11.211 ^{**}	41.667 ^{**}

NS – Non Significant (P>0.05); ** Highly significant (P<0.01); * Significant (P<0.01)

^a - loss of stability

Mean bearing similar superscripts do not differ significantly (P>0.05)

Table 2. Acidity during storage at 5°C (n=6)

	0 th Day	3 rd Day	5 th day	7 th Day	9 th Day	11 th Day	13 th Day	15 th Day	17 th Day	19 th Day
T ₁ (35 kV, 3000µs)	2.67±0.22 ^a	3.17±0.31 ^a	3.34±0.22 ^a	3.5±0.23 ^a	3.67±0.22 ^a	3.34±0.22	3.67±0.22	6±0.64	6.5±0.670	8.84±0.17
T ₂ (35 kV, 4500µs)	3.17±0.31 ^{ab}	3±0.37 ^a	3.17±0.31 ^a	3.34±0.34 ^a	3.5±0.35 ^a	3.67±0.22	3.67±0.22	3.5±0.35	3.83±0.30	5.84±0.48
Pasteurized sample	3.67±0.22 ^b	3.84±0.17 ^a	3.84±0.17 ^a	6.17±0.61 ^b	8.67±0.22 ^b	-	-	-	-	-
F value	4.091	2.283 ^{NS}	2.167 ^{NS}	14.521 ^{**}	125.811 ^{**}	1.250 ^{NS}	0.000 ^{NS}	12.097 ^{NS}	13.061 ^{NS}	35.217 ^{**}

NS – Non Significant (P>0.05); ** Highly significant (P<0.01); * Significant (P<0.01)

^a - loss of stability

Mean Bearing similar superscripts do not differ significantly (P>0.05)

Table 1 shows the pH values of the pasteurized mother's milk and PEF treated milk (T_1 and T_2). It was observed that pH values declined significantly from 7.09 ± 0.05 to 6.3 ± 0.05 for treatment T_1 and from 7.14 ± 0.08 to 6.8 ± 0.07 for treatment T_2 over 19 days of storage at 5°C , whereas the pH of the pasteurized milk declined from 7.05 ± 0.03 to 6.34 ± 0.06 over 9 days of storage at 5°C .

Table 2 shows the acidity of the PEF treated samples and pasteurized samples stored at 5°C . The determination of acidity in donor milk is one of the common controls performed in human milk banks to test the quality of milk. Dornic acidity is an indirect method for measuring the quality of mother's milk and bacterial contamination (Roman *et al.*, 2013). The acidity of milk for treatments T_1 and T_2 increased gradually from $2.67 \pm 0.22^\circ\text{D}$ to $8.84 \pm 0.17^\circ\text{D}$ respectively over 19 days of storage at 5°C , whereas the acidity of pasteurized milk increased from 3.67 ± 0.22 to 8.67 ± 0.22 over 9 days of storage at 5°C .

This is in accordance with the findings of Vieco *et al.* (2016) and Hedeker and Gibbons (2006) who stated that donor mother's milk with acidity of $\leq 4^\circ\text{D}$ and pH ranging between 6.5 - 7.4 is of acceptable quality. They have also stated that mother's milk with acidity ranging between 4 - 8°D is of intermediate quality, whereas acidity $\geq 8^\circ\text{D}$ and pH of 6.57 is of poor quality and should be rejected.

PEF treatment can be used as an effective alternate method for processing mother's milk. The milk treated by PEF stored at 5°C extended the shelf life of mother's milk to 19 days at 5°C whereas pasteurized milk had a shelf life of around 7 to 9 days.

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