A Study Overview of the Effects of Different Packaging Materials and Pasteurization Methods on the Nutritional quality and Microbial Quality of Milk

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Abstract: *Many packaging materials are used today to process, package and store milk products. The Aim of this paper review is to take a holistic view in comparing the effects of milk handling, packaging materials and Pasteurization methods on the nutritional and microbial quality of milk during and after pasteurization using literature.*

Key Words: *Conventional Process, microbial and nutritional quality, milk handling.*

1. INTRODUCTION:

Milk and its individual compounds are of major importance in relation to human nutrition throughout millennia (Schmid, 2003). Milk is highly valued because it is a source of many nutrients essential for the proper development and maintenance of the human body. It is a complex nutritious product containing more nutrients than any other single food (Wattiaux, 1994). Its exceptional nutrient profile includes water, protein, fat, carbohydrates, cholesterol, minerals, vitamins and energy (Anon, 2012).

Raw milk is milk in its natural (unpasteurized) state. Milk harbors a complex microbial community, including microorganisms of industrial importance, that possess health-promoting features and that are of concern from a food quality or safety perspective. Raw cow's milk may contain systems with antimicrobial properties that inhibit the growth of microorganisms in the milk. These systems include enzymes (lactoperoxidase, lysozyme, xanthine oxydase) and proteins (lactoferrin). However, none of these are present at concentrations high enough to eliminate pathogens and their activity is limited at the refrigeration temperatures used to store raw milk (Griffiths, 2010).

2. SOME CONVENTIONAL HEAT TREATMENT EFFECT ON RAW MILK:

Pasteurization is a conventional process applied to milk for the destruction of pathogenic(vegetative) bacteria, yeast and fungi (Kurdra *et al.,* 1991). Ultra-high temperature (UHT or ultra-heat treatment) processing holds the milk at a temperature of 138^0 C (250^0 F) for a fraction of a second (Bylund, 1995). High temperature short time pasteurization had been proven to reduce the microbial loads by many researchers over the years, such include but not limited to the report by Grant *et al.,* (1997) and also seen in Sunmonu *et al.,* (2015). Abd Elrahman, (2013), reported that traditional pasteurization, storage temperature and storage time also affects both the nutritional quality and physical property such as density, significantly at $p<0.001$.

The table 1 adapted from Sunmonu *et al.,* (2015) shows the effect of conventional heat treatment on the microbial quality of milk. The table shows a significant reduction in microbial loads on Aluminium, Stainless and Galvanized steel as a processing material. Sunmonu *et al.*, (2015), reported a reduced microbial count after conventionally pasteurizing irrespective of the pasteurization time and material. Although few anomalies were reported which could have resulted from poor handling and post pasteurization contamination.

Table 1: Significant reduction in microbial loads after pasteurization and reduction comparison among different heating materials (adapted from Sunmonu *et al.,* 2015).

		TVC	CC	FCC	LBC	FC
Materials	Aluminum	4.430a	3.015a	0.337a	0.115a	3.004a
	Stainless steel	2.519b	1.856b	0.000b	0.800b	1.456b
	Galvanized Steel	3.048c	2.270c	0.000b	0.611c	1.952c
Temperature	61	3.256a	2.126a	0.337a	0.582a	1.878a
	66	3.693b	2.848b	0.000b	0.648b	2.096b
	71	3.048c	2.167c	0.000b	0.296c	2.437c
Source	White Fulani	3.778a	2.833a	0.337a	0.333a	2.444a
	New Jersey	3.426b	2.467b	0.000b	0.811b	2.156b
	Mixture	2.793c	1.841c	0.000c	0.382a	1.811c

3. HEAT QUANTITY TRANSFER BY CONDUCTION USING SMALL BATCH PASTEURIZATION:

Batch (or "vat") pasteurization is the simplest and oldest method for pasteurizing milk. Milk is heated to 154.4^0 F (63^0 C) in a large container and held at that temperature for 30minutes. This process can be carried out at home on the stove top using large pot or, for small scale dairies with steam-heated kettles and fancy temperature control equipment. In batch processing the milk has to be stirred constantly to make sure that each particles of milk are heated (Bylund, 1995).

During batch Pasteurization in containers, heat energy is transferred from the heater to the milk enough to cause molecular interactions from the milk surface before moving to the total milk volume based on the shape of the pasteurizer.

The mass of the milk which can also be weighed directly using the mass balance and the volume using a container calibrated in volume or a measuring cylinder.

The following are the heat transfer equation used in the evaluation of heat transfer in batch pasteurizers used in a small-scale design.

$$\text{Mass of Milk (Mm)} = \text{Density of milk}\left(\frac{\text{kg}}{\text{l}}\right) \text{x Volume of milk (l)} \quad (1)$$

When the Pasteurizer is heated, it gained thermal energy which is further transferred to the milk being heated.

Quantity of Heat supplied to Milk (Q_m) = $M_mC_m\Theta_m$ (Joules) (2)

Quantity of Heat supplied to Material (Q_{ma}) = $M_{ma}C_{ma}\Theta_{ma}$ (Joules) (3)

Total heat supplied by the heater (Q_T) = heat gained by material + heat gained by milk sample (4)

$Q_T = Q_{ma} + Q_m$ (5)

$Q_T = M_{ma}C_{ma}\Theta_{ma} + M_mC_m\Theta_m$ (6)

Total heat supplied (Q_T) = power (P) x time of pasteurization (t) for various temperatures (7)

Hence;

Pt = heat gained by any of the material + heat gained by milk (8)

$$\text{Power required (P)} = \frac{\textit{heat gained by any of the materials+heat gained by milk}}{\textit{time}}, \text{W} \quad (9)$$

$$\text{Power required (P)} = \frac{\text{MmaCma}\Theta\text{ma} + \text{MmCm}\Theta\text{m}}{\textit{time}}, \text{W} \quad (10)$$

M_m = Mass of milk, kg, C= specific heat capacity of material or milk, J/kgK, $\Theta_{m\text{ or }}\Theta_m$ = temperature change = (Θ_{m2} - Θ_{m1}) or (Θ_{ma2} - Θ_{ma1}), ^{0}C. The heat transfer to the material includes that of the metallic stirrer.

Necessary parameters such as specific heat, initial and final temperature of milk and pasteurizer can be determined and mathematically plug in to evaluate data needed.

4. MICROWAVE TECHNOLOGY RELATIVE TO OTHER HEAT TREATMENT:

In conventional thermal processing, energy is transferred to the material through convection, conduction, and radiation of heat from the surfaces of the material. The working principle of microwave technology has been explained by Thostenson and Chou (1999).

As microwaves, can transfer energy throughout the volume of the material, the potential exists to reduce processing time and enhance overall quality. In microwave heating, the components of milk are affected to varying degrees by the microwave field as measured indirectly by the outlet temperature of the continuous system. To pasteurize a product, an insulated holding section would be required to obtain the appropriate time/outlet temperature combinations to ensure a proper decrease in microbial load (Kudra *et al.,* 1991).

When the nutritional qualities of the traditional heat treatment methods of milk were compared to the microwave technology, no significant reduction in nutrients value were observed (Albert *et al*., 2009). This result is also supported by Ga´bor, *et al., (2013),* who reported that "there is no difference between the Beneficial Effects of Microwave and Traditional Heat Treatment on the Shelf Life, the Sedimentation of Fractions and the Generation of CO_2 during the Storage of Orange Juice". Microwave technology has a wide applicability on other food products such as apple, potato, meat and onion etc., (Venkatesh, 2004).

The table 2 shows the effects of microwave pasteurization on microbial loads of milk samples. A significant reduction in the microbial load can be seen from the table.

Table 2: Microorganism and Alkaline Phosphates in the milk before and after microwave flash pasteurization (*Adapted from Al-Hilphy and Ali, 2013*).

Microorganisms	Before flash pasteurization	After flash pasteurization
Total count of bacteria	47×10^{5a}	23×10^{1b}
E. coli	9^a	0^b
Alkaline phosphates	+	-

The effect of microwave pasteurization value appear when temperature exceeded 55°C, that means pasteurization analyses "depend on heating and holding stages only" (Halleux, 2005). Al-Hilphy and Ali (2013) reported that as the microwave heating temperature increased, the viscosity and density decreased while thermal conductivity and Specific heat increased with increasing temperature.

5. SOME NUTRITIONAL AND MICROBIAL EFFECTS OF HANDLING AND PACKAGING ON MILK:

Food packaging is one of the stages of food production that enables foods to reach consumers safely. By selecting the appropriate packaging material and technologies for different food products shelf life of food is increased and food quality and freshness can be preserved. While basic function of food packaging is to protect food from contaminants, if food packaging material is not selected properly food may be contaminated by chemicals.

Migration is an important factor affecting the quality and shelf life of food and it also affects the human health. In order to protect the quality and safety of food it is necessary to be careful about properties of selected packaging materials. (*İçöz and Eker, 2016).* Beldì and others studied the effect of fat content and storage temperature on the migration of Irganox 1076 from LDPE to several foods (cheese sauce, chicken, chocolate, margarine, mayonnaise, milk, orange juice, soft cheese, pork, salmon, and wheat flour) and food simulants (distilled water, 3% acetic acid, ethanol 10%, rectified olive oil, isooctane, and 95% ethanol). They found that migration increased as the fat content of the food and storage temperature increased, with the highest level of migration (1413 μg/dm^2) for chocolate (32.1% fat) at 40 °C after 30 days of storage.

For an indigenous milk product, such as kunda for example, Mahalingaiah *et al.,* (2011) reported that 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. This established the fact that "storage temperature and storage material" has a lot to do with prolonging the shelf of milk product.

ÇAKMAKÇI and TURGUT documented the effect of light intensity, exposure time and temperature resulting from the materials used store milk. This report shows the reduction effect of light exposure on the nutritional quality of milk after packaged in transparent and opaque material. This means that, it is not enough to package without considering the overall effect of the environment and light exposure during movement or handling through the chain of demand and supply.

6. CONCLUSION:

It can be inferred from the discussion so far, that different heating materials have different thermal properties which will in turn reduce or increase the overall microbial load depending on the initial and final handling of the milk products, but that which is consistent with food processing standards must be of utmost concern.

Also, physiochemical properties such as color, density, moisture level and acidity etc., of food products such as milk has an important role in milk consumption even before the consumer checks for a sign of spoilage which could be as a result of microbes present in it. Therefore, in order to finally deliver milk products for proper acceptance, compliance has to be made to ensure a quality standard and complete acceptance.

The various pasteurization methods used for processing milk and milk products ranging from the conventional methods to the more sophisticated methods has shown similar results despite increase in research in the area of microwave technology. Also, packaging and proper handling should not be left out of pasteurization processes. A more thorough research should be done to increase the industrial handling and processing capacity of microwave or other no thermal processing of milk products effectively.

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