Effect of microwave on chemical characteristics of raw milk

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Abstract

Milk and milk products are the most popular food all over the world especially for infants and almost the high level of life most recently use the microwave in preparing the food especially the milk. So, the purpose of this paper was to evaluate the effect of microwaves on the chemical characteristics of raw milk especially on the protein content. The obtained results showed that the average of fat, protein and lactose concentrations decreased during the microwave exposure especially at 120 and 180 seconds. Also, the currently results showed high levels of aldehyde (butanal – hexanel – octanal – total aldehde) at 60, 120 and 180 second corresponding to levels of all in the raw and boiled milk.

Key words: Raw milk, microwave, milk protein, chemical characteristics.

Introduction

Milk can be considered a fat emulsion in an aqueous solution containing many other substances, some in colloidal form (protein substances) and other in dissolved state (lactose, minerals, water soluble vitamins and enzymes).Quantitatively, the predominant component of milk is water 87.5% and total dry matter is 12.5% which is the nutritious milk. If one liter of milk is heated at 100 ˚C until all water evaporates it will remain a yellow brown residue. The chemical composition of milk varies according to animal species and other factors including breed, diet, age etc. ***(Constantin and Csatlos, 2010)***. Heat treatment of milk can be achieved through the use of microwave technology, the inhomogeneity of electromagnetic fields leads to an uneven distribution of temperature in the food products, therefore precluding their use in industry ***(*peter korzenszky *et al., 2013)***.

Microwave heating is a common and fast procedure for food preparation and manufacturing. Milk and milk products usually undergo different changes during their preparation which may include moderate or severe heat treatment that can lead to undesirable changes. As decreased fat, protein and lactose concentrations of raw milk collected from local farm in Romania. **(Dumuta *et al., 2011)***

Although the microwave oven is widely used as a mean of food preparation, insufficient information is available on the sequences of microwave heating on the composition and nutritional quality of food .Meanwhile ,**Albert *et al. (2009)*** analyzed the effect of microwave treatment on the amino acids, free amino acids content compared to the conventional heat treatment technique. They established that the total free amino acids content of the raw milk reduced in the milk pasteurized in the traditional way. Also, vitamin C content of milk hardly changed after mild pasteurization while during microwave pasteurization, it decreased to less than its third value. Moreover, **Inchingolo *et al. (2013)*** studied the effect of microwave heating on edible oils and lipids containing food. Although the risk of cholesterol oxidation in fresh milk is low due to fat organization into micelles, the heating could favor cholesterol oxidation.

The microwave treatment could have a thermally effect on the kinetics of the ß-lactoglobulin folding process. Also, some of the hypotheses behind a thermal effect of microwave heating suggest that microwave radiation may change the solvent properties of water **(Ashar Shazman *et al*., 2007).**

Protein content can also decrease during the microwave exposure due to the fact that protein can be involved in the Maillard reaction together with the lactose .Among the proteins, the lysine is the most implicated in this reaction and its diminution in time become a nutritional indicator for the appreciation of the heat treatments effects on food **(Florea and Chimia , 2001)** .

The aldehyde and ketone compounds can be generated from auto-oxidation reactions of the unsaturated fatty acids of milk as hexanal and 3-octen-2-one could originate from linoleic acid, while octanal could originate from oleic acid by auto-oxidation. The spontaneous decomposition of hydroperoxides could also promote the formation of these compounds **(yanhua *et al.,* 2012).** The oxidative stability of dairy products is the result of a delicate balance between the anti- and pro-oxidative processes in milk **(Smet *et al*., 2008).**

The toxicity of low molecular weight carbonyl compounds, such as aldehydes, to humans and animals is well-known. Both the International Agency for Research on Cancer (IARC) and the US Environmental Protection Agency (US EPA) classified formaldehyde as "carcinogenic to humans" in group 1. The US EPA sets the acceptable daily intake (ADI) of formaldehyde to 0.2 mg kg-1 body weight and warned of potential adverse health effects resulting from intakes of formaldehyde at levels higher than ADI. Acetaldehyde is also toxic, an irritant and a probable carcinogen **(Kim *et al*., 2011).**

Material and Methods

1. Collections of milk samples:-

The raw cows milk samples were collected from different groceries and supermarkets. In order to evaluate the effect of microwave on milk chemical characters, 25 samples of 250 ml milk were sent to laboratory without delay and kept in refrigerator at 4°.

2. Preparations of milk samples and adapted methods:-

Every milk sample was divided into four parts: three parts were exposed to different intervals 60, 120 and 180 seconds in microwave in unclosed vessels, the fourth part exposed to home boiling for one moment then cooled at 4°c. Microwave heating was carried out using LG microwave oven (Model MH6344W) at electrical power 1250w. All samples analyzed via Frank Gerber 98 Lacto star Milk Scan apparatus in Animal production Department, Faculty of Agriculture of Mansoura Universty to determine the concentrations of protein.

3. Determination of aldehydes groups in milk:-

All milk samples prepared to be analyzed by HPLC to determine the aliphatic aldehydes in milk according to **Hiroaki, *et al*.(1997)** as follow: An ethanolic sample solution was prepared by mixing 10g of a milk with 50 ml of ethanol. A reaction mixture was prepared by mixing 90 ml of ethanol, 2 ml of hydrochloric acid, 50 mg of DNPH and 8 ml of water. One milliliter of the sample solution was added to 1 ml of the reaction mixture. The mixture was allowed to stand at 45°C for 30 min to form aliphatic aldehydes-DNPH derivatives. Twenty microliters of the reactant were injected into an HPLC system and separated in a reversed-phase column with an aqueous solution of acetonitrile (water: acetonitrile=80:25). Aliphatic aldehydes-DNPH was completely separated in 25 min by HPLC. The detection limits, monitored at 365 nm, were about 0.040.2µg for each of the aliphatic aldehydes in 1 g of sample. The reproducibility of the HPLC measurements was 0.54.9% (RSD).All prepared milk samples analyzed by HPLC Animal Health Research Institute, Dokky, Cairo. The results were then statistically analyzed.

4-**. Statistical analyses**:-

Data obtained were statistically analyzed using **SPSS 11 (1997**)

Results and Discussions

The results in table (1) showed that the percentage of protein , fat and lactose were decreased significantly(P ≤ 0.05) when used the microwave treatment specially at time 120 & 180 seconds . These may be due to the effect of microwave on physico-chemical characteristics of raw milk & altrated these characters which agreed with **(Kheder *et a.*, 2014).**

As the decreases in the percentage of protein was due to the fact that the whey protein sulfhydryl groups , typically buried within the core of protein structure , are exposed to the surface because of heating. Furthermore , protein sulphydryl groups may be formed because of hydrolysis or β-elimination of disulfide bonds during thermal treatments **(Clere *et al.*, 2005)**

Hexanal and 3-octen-2-one could originate from linoleic acid while octanal could also promote the formation of these compounds **(Ullrich and Griosch, 1987)**.

2-Heptanone , a main methyl ketone in dairy products is formed by β-oxidation of saturated fatty acids followed by decarboxylation or by decarboxylation of β-ketoacids naturally present milk fat **(Nursten, 1997).**

table (2) showed that there was markedly increase in the total aldehyde level which came to high level (26.32 mg/100 g DM) at 180 seconds in microwave and decreased to 1.9 mg/100 DM at raw milk.While the level of hexanal reached to (16.47 ± 0.9 mg/100 g DM) at 180 seconds, (12.52 ± 0.8 mg/100 g DM) at 120 seconds and 9.43 ± 0.01 at 60 seconds in contrast to the level in raw milk which not exceed than 0.5 ± 0.01 mg/100g DM). Also, the level of Octanal reached to 0.6 ± 0.001 , 0.4 ± 0.002 , 0.2 ± 0.001 , in microwave treatment at 180 , 120 and 60 seconds , but not detected in boiled for one minute and raw milk samples respectively. These results agreed with (**Clare *et al.*, 2005) , (Ashar shazman *et al.*, 2007) , (Annib *et al* ., 2011**). **(Michael *et al* ., 2013)** and **(Mandic *et al.*, 2014) ,** These increase in the percentage and level of aldhydes either total or hexanal which is the most frequently used marker that indicates the level of lipid oxidation **(Arato *et al*., 2009)**.

Also the change in the type of protein which occur due to the microwave treatment from the whey protein contain cysteine $\propto -$ and β-casein which normally found in raw milk and boiled one , to the volatile compounds which being formed by use of the microwave , these volatile compounds protein and aroma were found by **(Carunchia *et al.*, 2005).**

Table 1 :mean value of chemical composition of raw and thermal treated milk samples.

component	Raw	Boiled one min,	Microwave at 60 sec.	Microwave at 120 sec.	Microwave at 180 sec.
Protein %	3.71 ± 0.018 ^{a}	3.65±0.08 ^{a}	3.65 ± 0.029^{a}	3.51 ± 0.022^{b}	3.41 ± 0.028 ^{c}
Fat %	3.52 ± 0.08 ^{a}	3.47±0.05 ^{a}	3.5 1 ± 0.05 ^{a}	3.42 ± 0.05 ^{b}	3.46 ± 0.02 ^{a}
Lactose %	4.9 ± 0.08 ^{a}	4.8 ± 0.08 ^{a}	4.6 ± 0.007 ^{b}	4.5 ± 0.06 ^{b}	4.4 ± 0.01 ^{c}

- **Data are expressed as mean ± SE of 25 samples.**
- **Values with the same small letter in each raw are not significantly different at $P \leq 0.05$.**

Table 2 : mean content of volatile aldehydes compounds of milk samples using HPLC (mg/100g of dry matter) .

component	Raw	Boiled one min	Microwave at 60 sec.	Microwave at 120 sec.	Microwave at 180 sec.
Total aldehyde	1.9 ± 0.2 ^{a}	3.8 ± 0.3 ^{b}	16.23± 1.11 ^{c}	21.18 ± 1.21 ^{d}	26.32 ± 1.13 ^{e}
Hexanal	0.5 ± 0.01 ^{a}	1.25 ± 0.2 ^{b}	9.43 ± .0.01 ^{c}	12.52 ± 0.81 ^{d}	16.47 ± 0.9 ^{e}
Octanal	0.0±0.0 ^{a}	0.0 ± 0.0 ^{a}	0.2 ± 0.001 ^{b}	0.4 ± 0.002 ^{c}	0.6 ± 0.001 ^{d}
Buitanal	0.02 ± 0.001^{a}	0.09± 0.001 ^{b}	1.05 ± 0.01 ^{c}	1.9 ± 0.2 ^{d}	2.01 ± 0.3 ^{e}

- **Data are expressed as mean ± SE of 25 samples.**
- **Values with the same small letter in each raw are not significantly different at $P \leq 0.05$.**

Fig.1:Mean Protein % in raw milk and microwave treated milk samples.

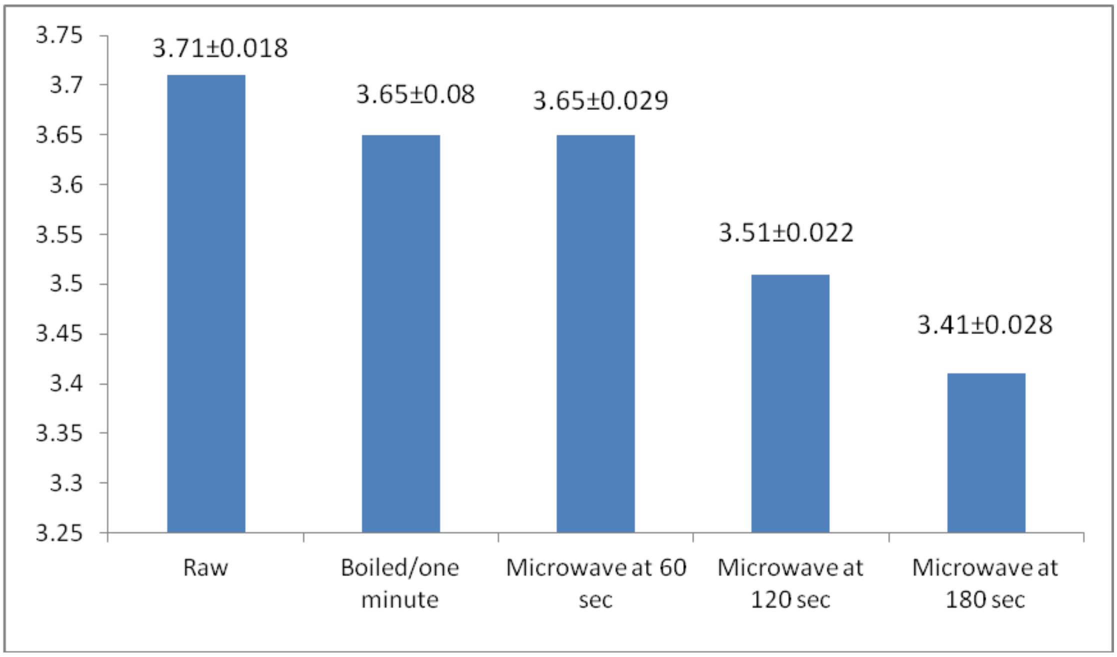


Fig.2 :Mean Fat % in raw milk and microwave treated milk samples.

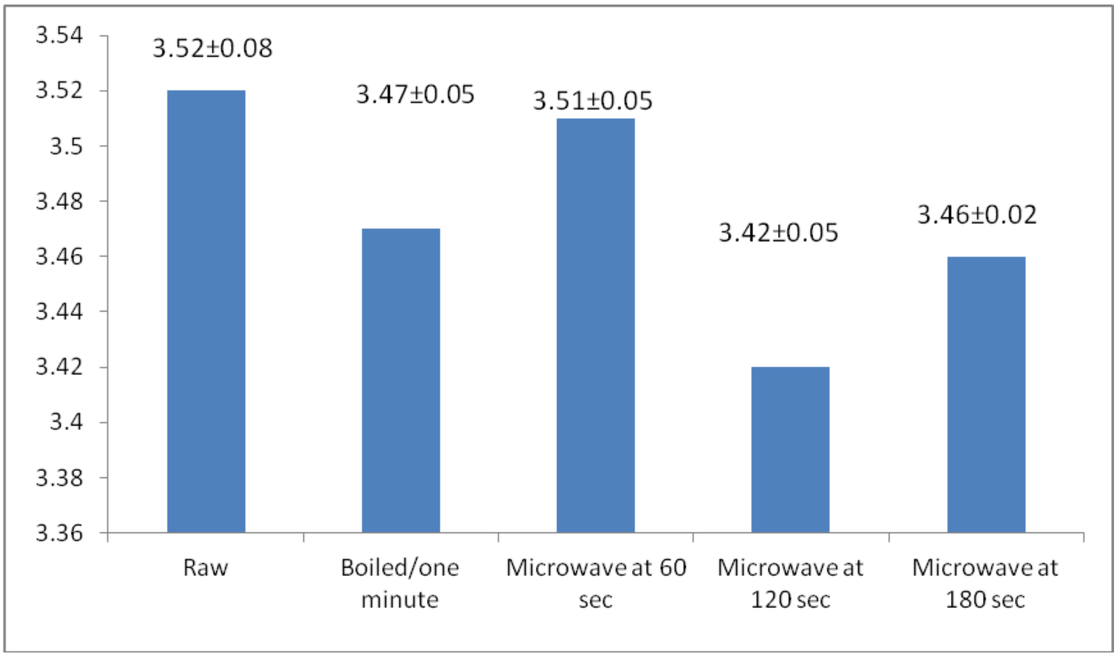


Fig.3 :Mean Lactose % in raw milk and microwave treated milk samples.

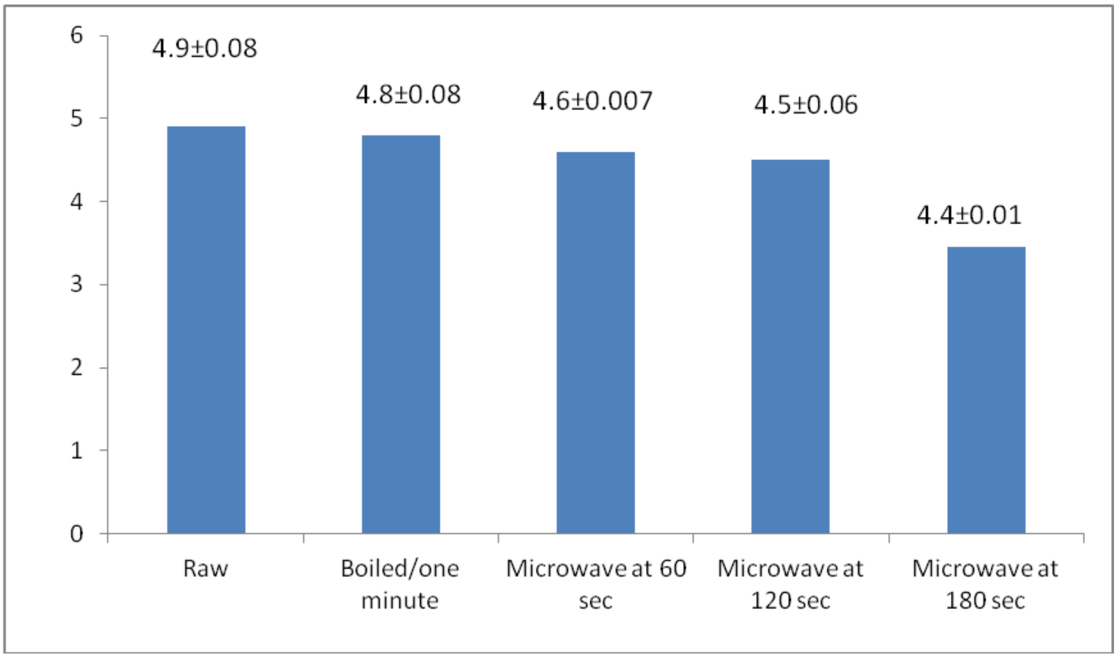


Fig.4 :Mean Total aldehyde in raw milk and microwave treated milk samples.

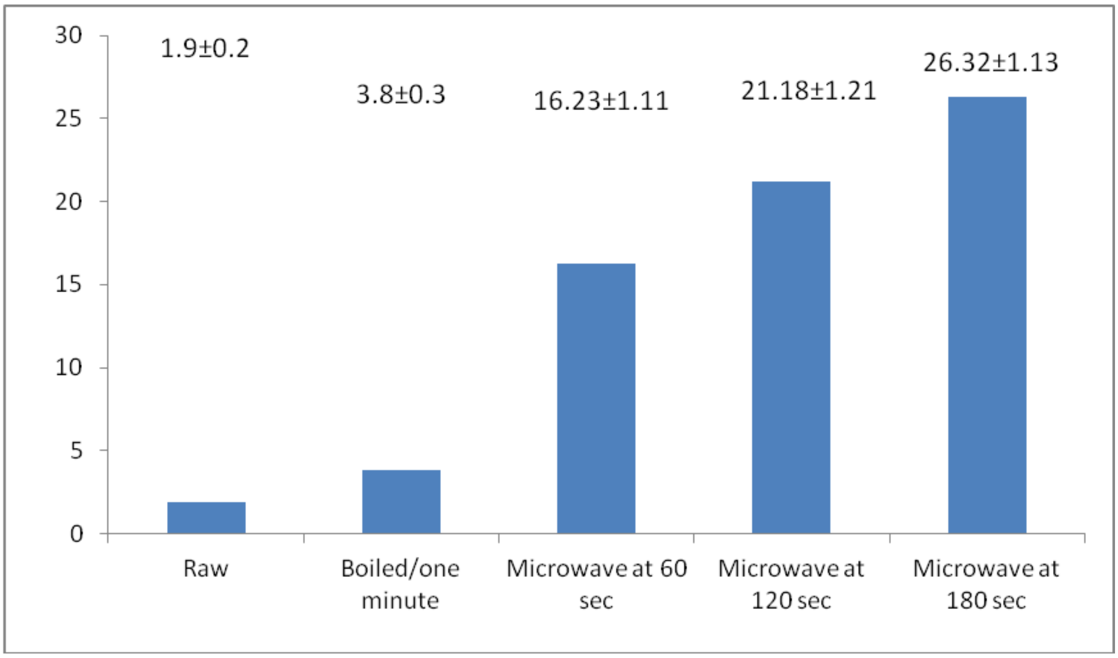


Fig.5 :Mean Hexanal % in raw milk and microwave treated milk samples.

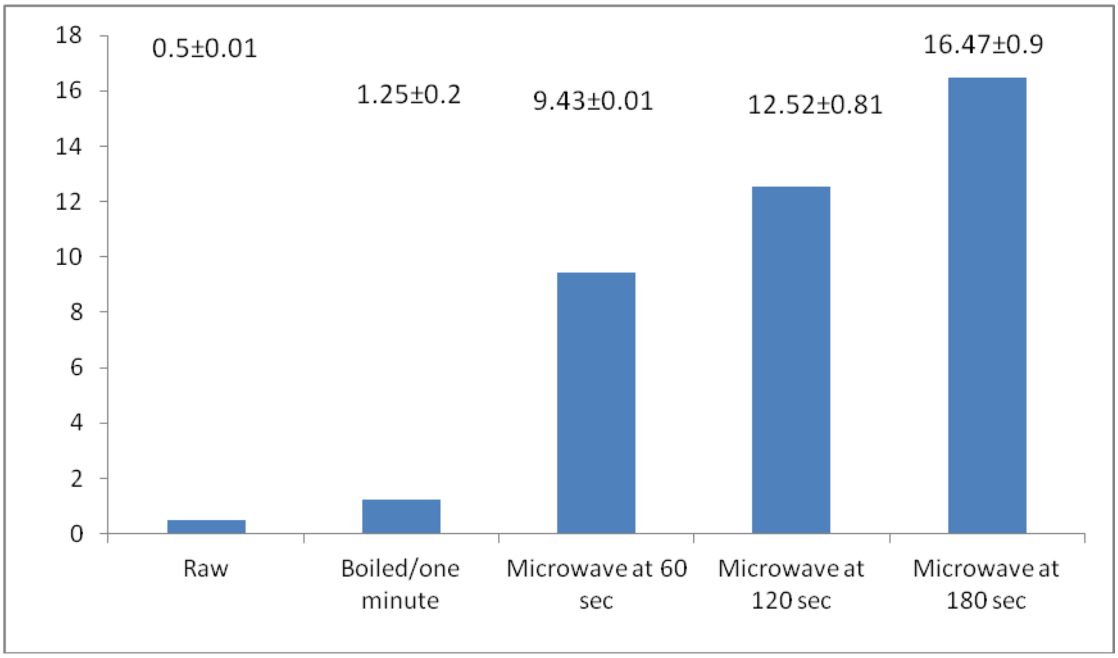


Fig.6 :Mean Octanal in raw milk and microwave treated milk samples.

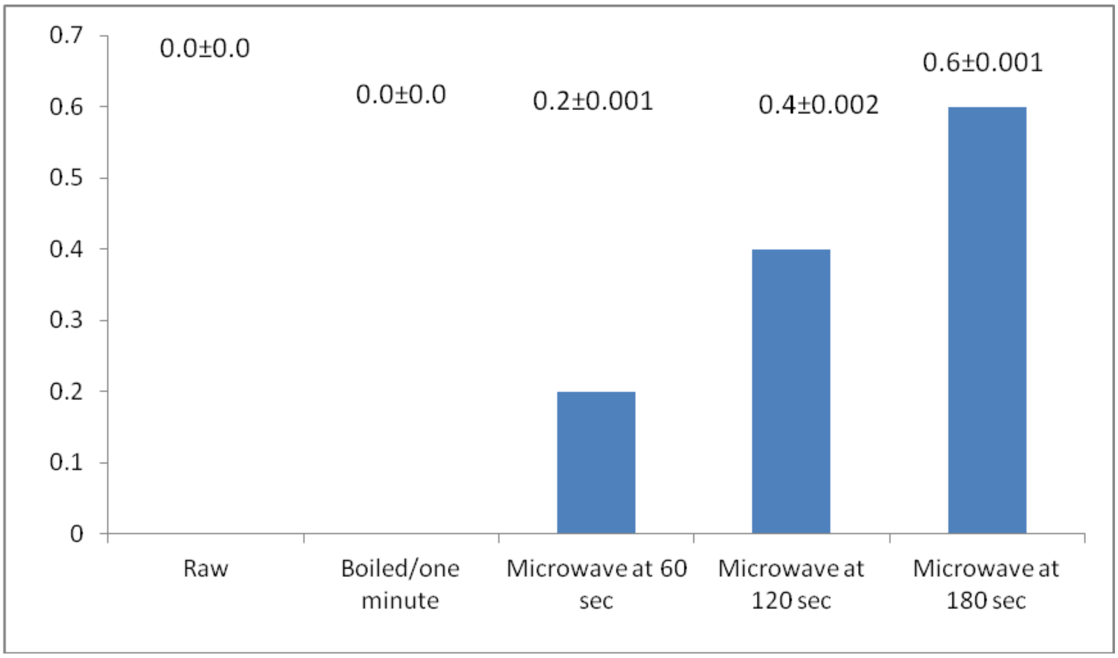
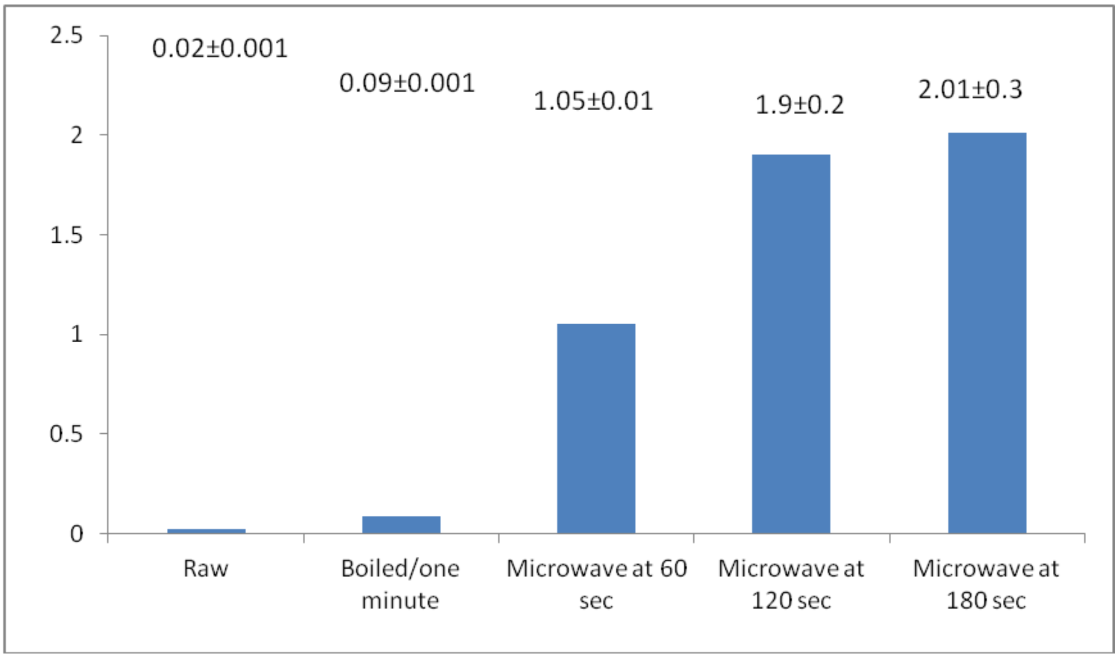


Fig.7 :Mean Butanal in raw milk and microwave treated milk samples.



Conclusions

Referring to the obtained results, the using of microwave in preparing milk is a harmful instrument as it lead to presences of aldehydes and the adehydes content raised in these way more than the raw and boiled one

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