Efficacy of Ginger Extract (*Zingiber Officinale*) and Gamma Irradiation for Quality and Shelf-Stability of Processed Frozen Beef Sausage

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Abstract: The present work deal with improving safety of sausages besides introducing trials for decreasing the microbial load without affecting on sensory properties. Survey local processed sausages samples from eleven local markets proved high contamination with microbes as *Escherichia coli(19.71%), Listeria monocytogene (18.82%), Salmonella* (16.47%), Lactobacilli *(14.11%)* and *Staphylococcus aureus* besides total molds (17.94%). Sausages beef was prepared with recommended raw materials containing fresh ginger extract (GEX) at two concentration (0.5%, 1.0%) besides using γ-irradiation of at 3.0 kGy and 5.0kGy to study the efficiency of these treatment on the microbiological, chemical and sensory characters during frozen storage (90 days). Using irradiation and GEX (1.0%) treatments were sufficient to keep samples even 90 days with safe levels of microbes but not eliminated completely.The values of Thiobarbituric Acid Reactive Substance (TBARS) were less than 2 at zero time but started increased gradually during storage. After two months, most of treatments increased 2 values of TBARS except Ginger extract (1.0%), which was the best treatments even end of storage (90 days of frozen storage). A linear relationship resulted between storage period and TBARS of treated samples with high significant values of coefficient (R^2). Irradiation and untreated samples contained high values more than 2 at end of storage. According ,these data GEX (1.0%) was the best treatment to keep samples with good quality rancidity free even 90 days during frozen storage, whereas γ-irradiation increased rancidity values of TBARS rapidly comparing with control samples during frozen storage. Furthermore, sensory properties were more affected with TBARS changes, which were in parallel with the results of sensory evaluation, especially at end of storage. The obtained results showed that it is possible to produce safe and high-quality fresh sausage using natural antioxidants source as GEX 1.0% to improve the quality and stability of frozen sausages .

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Key words: ginger, Sausages, Radiation, sensory properties, frozen storage, Microbiological character.

1. Introduction

Foodborne pathogens have been estimated to cause >6 million illnesses and approximately 9000 deaths each year (Mead *et al.,* 1999). Bacterial pathogens contribute in more than 60% of the foodborne illnesses that lead to hospitalization and account for nearly two-thirds of the estimated number of foodborne pathogen-related deaths especially through beef or beef products. *Salmonella spp., Listeria spp., Campylobacter spp Escherichia coli* caused various foodborne illness-related hospitalizations and deaths (Mead *et al.,* 1999).Recently, there has been an increase in consumer awareness regarding the use of chemical additives in food and food products (Tiwari *et al*., 2009). This has resulted in an increase in research on natural additives, such as using plant and animal derivatives (Ennajar *et al.,* 2009).

Contamination of meat or meat products with pathogenic microbes are still a major problem in the World, even in well-developed countries (Anonymous, 2002, Pohlman, 2006).The development of new antibiotics and plant based antimicrobial compounds are effective against the resistant organisms. Ginger a common substance found increasingly in the diets of the global population, have known antibacterial effects and are commonly used together in teas. It has strong antibacterial and antifungal properties. *In vitro* studies have shown that active constituents of ginger inhibit multiplication of colon bacteria. It inhibits the growth of *Escherichia coli, Proteus sp, Staphylococci, Streptococci and Salmonella* (Gugnani and Ezenwanze, 1985). The ginger extract has antimicrobial action at levels equivalent to 2000 mg/ml of the spice. Ginger inhibits *Apergillus,* a fungus known for production of aflatoxin, a carcinogen (Nanir and Kadu, 1987; Meena, 1992). Fresh ginger juice showed inhibitory action against *A.niger, S.cerevisiae, Mycoderma SPP. and L. acidophilus* at 4, 10, 12 and 14% respectively at ambient temperatures (Meena,1992). Many studies have implicated *Staphylococcus aureus and*

Streptococcus pyogene as leading causative agents of both community and hospital acquire infections (Amita *et al.,* 2003).

Irradiation of food became more easily and application on a commercial scale on more than 40 countries for decontamination purposes especially to control pathogens, spoilage microorganisms, and pests without compromising the nutritional and sensory properties of foods refrigerated or frozen uncooked meat, meat byproducts, and certain other meat food products to reduce concentrations of foodborne pathogens and to extend shelf life (U.S. Department of Agriculture, Food Safety and Inspection Service, 1999). Such treatments may lead to the development of off-odors and can affect flavor. But low-dose, can solve that problem ,US Food and Drug Administration (FDA) permitted irradiation up to 4.5 kGy for refrigerated and 7.0 kGy for frozen red meats ,irradiation of processed meats has not yet been approved (U.S. FDA, 1997; Molins *et al.,* 2001).

The purpose of this study was to evaluate alternative natural preservatives in producing natural sausages, as ginger rhizome extracts comparing using recommended low doses of γ- irradiation to reduce the effect of fat oxidation, off-flavor to get high quality of sausages for storage frozen long time with high quality .Besides, the evaluation of the consumer acceptance, evaluation the quality ,quantity microbe load to avoid the microbial contaminated pathogen which are present extremely in located samples.

2. Material and Methods

A-Survey samples from local markets:

Sampling :

Eleven ready samples of sausage were purchased from local stores in Egypt produced from different companies. Sausage samples were chosen randomly and within validity date and stored at -7°C until use for analysis.

B-Preparation of beef sausage:

1-Meat source:

Frozen beef lean trim (local markets). Samples were thawed at 4 to 5°c for 4 hours, and then visible bone and connective tissue were removed. Samples were cut separately into small pieces before processing into value added products.

2-Spices mixture:

Spices were obtained from local markets from Giza, Egypt. Each spice was powdered in the laboratory in an electric mill. Spices mixture was prepared according to El-Dashlouty (1978) as shown in Table 1. As previously reported by Moawad and Hameida (2002). Replacement of lean trim by 20% organs in beef sausage was in this study, such percentage achieved the best chemical, physical, functional and sensory properties. Beef lean trim (as seen in table 1) were minced twice with 10% water as ice flakes, aiming to keep the mixture smooth as well as to minimize temperature rise and microbial growth during shopping. The other ingredient in Table 1 were then added and mixed together, then meat mixture was ground for 10 minutes using a meat grinder. The obtained emulation was than stuffed into previously cleaned and prepared natural mutton casings. All sausages were packed in polyethylene bags, placed in cooler 4 to 5°c for 6 hours then part of sausage was examined (zero time analysis), while the rest of samples were frozen at -20°c for different time intervals up to 90 days before analysis. The total fat in tested samples were 16 %.

Table (1)Constituents of beef sausages and spices mixture

Ingredient	g/kg	Percent(%)
Beef lean	680	68
Beef fat	150	15
Ice	100	10
Sodium chloride	18	1.8
Skimmed milk	43	4.3
Powdered rusk	0.4	0.04
Sodium tripolyphosphate	11	1.1
Fresh garlic	0.3	0.03
Sodium glutamate	1.0	0.1
Ascorbic acid	1.0	0.10
Powdered spices mixture	9.3	0.93*
Total	1000	100

* Powdered spices mixture{fennel(59.76%),coriander(27.99%),cubeb(3.42%),black pepper (3.42%),clove(3.42%),laurel leaves(1.99%)}.

C- Preparation of ginger extract:

Ginger was obtained from retail spice seller in Saudi Arabia Kingdom (KSA). The taxonomic identification was performed; the outer covering was peeled off. 20 g of sample was kept in closed containers after being chopped into small pieces. For the preparation of extract, the method as reported by Mohsen and Ammar (2009) was used for this purpose. Ginger rhizomes were minced to a size of 1 mm. ,then extracted at a relation 10:1 using water: Extraction was approved out using a shaking incubator at room temperature for 24 hours, followed by filtration through Whatman No.1 filter paper. The residues were re-extracted in the same method and the two filtrates were combined. The extract was concentrated using a rotary evaporator (BUCHI-Rota vapor R-205 Switzerland) at 55ºC to near dryness (Mohsen and Ammar, 2009). The final extract contained %25 TS .Two concentrations were used as 5% and 10 % by volume respectively.

D-Microbiological analysis

25g of each sample (2 replicates) were homogenized in 225 ml of sterile peptone saline (1 g of peptone and 9 g of NaCl per liter water). After shaking, the suspension was serially diluted in triplicate (1:10) in peptone saline, and 1 ml dilutions were inoculated on MacConkey Agar (MCA) to obtain the *E. coli* count, Baird-Parker Agar (BPA) for the determination of *Staphylococcus aureus*, Brilliant Green Agar (BGA) for the determination of *Salmonella typhimurium*, Columbia Agar Base (CAB) for the determination of *Listeria monocytogenes* and finally Potato Dextrose Agar (PDA) for the determination of total moulds and for LAB. Plates were incubated for 48 hrs at 37°C for pathogenic bacteria. and for 5 days at 25°C, for moulds.. Colonies growth was calculated. Selected and Processed sausage samples were tested for microbiological examinations according to ICMSF (1996). Samples were examined for total fungal count, *Staphylococcus aureus, E coli, Listeria monocytogenes and Salmonella spp*. count (CFU/g.), according to American Public Health Association (APHA, 1992).

E- Preliminary general chemical analysis:

Proximate analysis of sausage were measured for untreated samples by the methods of AOAC (1995), results were expressed as moisture %, protein %, fat % and ash % contents. Feder Value was calculated as moisture/ protein ratio, according to Pearson (1981). Whereas, all tested samples were analysis for lipid oxidation was assed by TBA methods of Vyncke (1975). Thiobarbituric acid reactive substances (TBARS) Values were expressed as mg MA/kg sample.

D-Sensory evaluation:

For sensory analysis, panelists were recruited based on interest and availability .All of the twenty panelists at NRC had experience in sensory testing. Group sessions were held to orient the panelists and determine the terms to include on the ballot for sensory testing of cooked sausage. A complete-block design was used for panel sessions and samples were presented in a random order independently determined for each panelist. For data analysis, categories were assigned values from one to nine (none = one, extreme = 9). Data was subjected to analysis of variance, with treatment and panelist as the main effects. When main effects were significant at $P<0.05$, treatment means were compared by using Duncan test and treated samples were labeled with alphabetic letters .Treated and non treated beef burger samples were evaluated for organoleptic properties by a ten qualified different member sensory panel for the following attributes: aroma, texture, colour, taste and overall according to the method of Wattsg *et al.* (1989).

F- Irradiation process and storage conditions:

The irradiation process was carried out at National Centre for Radiation Research &Technology (NCRRT). Some prepared sausage samples were irradiated with γ-rays with different doses 3.0 and 5.0 k Gy. The irradiation process were performed at cold temperature (3-5 ^{0}C) by using Co^{60} γ-source with dose rate of ~ 3.52 kGy.h $^{-1}$. The irradiation source had been calibrated by the National Physical Laboratory (NPL, Teddington, UK) using the dichromate dosimetry system. All the treated samples were store at -18^{0}C even end of storage in three replicates. At intervals periods, samples were used directly from frozen storage .

G-Statistical analyses:

All data are expressed as mean values ± standard deviation (S.D).Statistical differences between experimental groups were assessed by analysis of variance (ANOVA), using the COSTAT software package (Cohort Software, CA, USA). The main values were compared with LSD test ($P < 0.05$).

3. Results and Discussion

Survey the natural contamination levels in local produced sausages:

The microbiological analysis of eleven collected fresh samples randomly from local markets (store -7^{0}C) during validity period in Egypt proved high load of contaminated pathogenic bacteria and moulds as in Table (2) and fig.(1). The major types of microorganisms were *Escherichia coli (19.71%), Listeria monocytogene (18.82%), Salmonella* (16.47%), Lactobacilli *(14.11%)* and *Staphylococcus aureus*

(12.94%) besides the total molds 17.94%. Same findings were obtained by Farber *et al*. (1988) and Eisel *et al.* (1997).

Escherichia coli occupied the first one with high percentages ,whereas, the values of contamination was(6.7 Log cfu/g±3.90). Its often use as hygiene indicators of foods of animal origin. There is a highly recognized food pathogen that causes gastro-intestinal diseases in humans, its presence on processed food may give a better indication than coliforms of inadequate treatment or post-process contamination from the environment, and may help to indicate the extent of faecal contamination (Nel *et al.*, 2004, Crowley *et al.,* 2005, MacDiarmid & Cook, 2009). Nel *et al*. (2004) has stated that the maximum limit of *E. coli* in meat and meat products should not be more than 10 cfu/g as proposed by the National Department of Health (DoH) of South Africa (Mathenjwa, 2010).

The second one was *Listeria monocytogene (18.82%)*, presence with average (6.4Log cfu ±1.96). Also, the presence of *Listeria monocytogenes* is recognized as a human pathogen, which is a gastrointestinal food infection that leads to bacteremia and meningitis in humans (Gombas, *et al.,* 2003, Madigan *et al.,* 2003).This organism has been detected in a variety of ready-to-eat food products (Huffman, 2002, Gombas *et al.*, 2003, Madigan *et al.*, 2003). The levels of this organism that has been detected in food is not clear, but it has been suggested that levels of > 10^3 cfu/g *L. monocytogenes* may result in listeriosis (Gombas *et al.*, 2003).

The third percentage was occupied by *Salmonella*(16.47%),in average present (log cfu 3.3/g±1.05). The presence of *Staphylococci*- in average values (1.7 log/g ±4.4) - in local markets in sausages are good alarm for food-poisoning outbreaks due to produce harmful enterotoxins as proved by many workers (Shale *et al.*, 2005). Same author showed that a maximum count of 10^2 cfu/g in meat is acceptable in South

Africa. Also, The amount of *Staph. aureus* required for production of toxin is 10^5 – 10^8 cfu/g (Farber *et al.,* 1988; Nel *et al*., 2004; Shale *et al*., 2005).

Also, the total mold occupied high percentage (17.94%) for contamination of sausages .But ,usually Lactic acid bacteria (LAB) occupied 18.82%, as starter in culture mainly for fermented sausages, due to its abilities to lower the pH of the product and produce bacteriocin (Kim, 2006). Bacteriocins are antimicrobial peptides produced by lactic acid bacteria. Nisin and pediocin are well known bacteriocins. Nisin is produced by *Lactococcus lactis* and pediocin is produced by *Pediococcus acidilactici*, which have been shown to be effective against *L. monocytogenes* and other Gram-positive pathogens on meat surfaces (Siragusa, *et al.,* 1999).

According to the United States Department of Agriculture (USDA, 1999), sausage makers should ensure that their products are not contaminated by pathogens such as *Listeria*, *E. coli* O157, *Salmonella*, *Trichinae* and *Staphylococcus* enterotoxin.

Escherichia coli is a highly recognized food pathogen that causes gastro-intestinal diseases in humans, especially *E. coli* O157:H7, which is frequently detected in the intestinal tracts and hide of cattle and pigs. This pathogen is also associated with ground beef products and other bovine products. The consumption of food and water contaminated with faecal matter of animals sometimes result in infections caused by *E. coli* strains (Li *et al.,* 2006). Aerobic colony counts range from 1.5 x 10^3 – 2.1 x 10^8 cfu/g for fresh sausage and for frozen sausage from 1.4 x 10^3 – 3.1 x 10^7 cfu/g (Farber *et al.,* 1988).

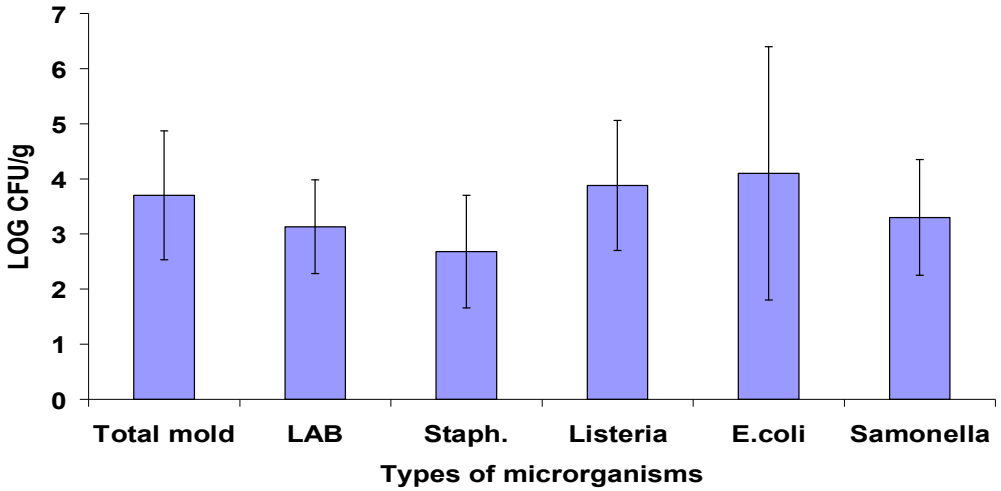

Fig.(1): Mean population of eleven collected samples from Egyptian local Markets (log cfu/g.)

Effect of ginger extract and γ- irradiation on the microbiological load during frozen storage:

As shown, in Figs (2-5), the obtained results of this study demonstrated that the microbial quality of sausages were more affected by used treatments mainly with ginger 1% and irradiation doses. In the same time ,low concentration of ginger (0.5%) and irradiation (3.0,5.0 kGy) reduced all the pathogenic microbe load even two and three months of frozen storage .But, irradiated sausage at 5.0 kGy samples extend free from most microbes even three months. Only , Staph ,was present due to low irradiation dose for decontamination. Also, after two month re-generation phenomenon raised for some microbes ,its observed and extend to the third month on frozen storage. In the same ,time ,after three months only ginger extract at 1.0 % was sufficient to prevent the growth of the microbes .These differences were significantly as shown in Fig(5), Irradiation doses prevented completely the microbes even three months as happened by 3.0 kGy which decreased only 3.0 Log cycle even end of frozen storage. Whereas, the ginger extract (1.0%) has the same effects like irradiation after two and three months in decreasing the 3.0 Log cycles or more of all micro organisms. Irradiation doses inactivation were more affective as ginger extract (1.0%), to reduced most the pathogenic and molds by more than 3.5 log CFU/g.

The re-generation phenomenon of growth some microbes in most treatments started again as observed after 2-3 months during frozen storage. These results may be due to low doses of irradiation which activate the spores or injured cells of microbes to reclaim or repair the injured DNA-cells as showed by some workers, but this trend was limited or not harmful to cause spoilage. (Sweetie *et al.,* 2005, 2006). Besides the permeability of packaging materials for water and air which activate the re-growth after two or three months..The obtained results by irradiation doses are similar found by workers (Pallas & Hamdy, 1976, Mattimore & Battista, 1996, Sweetie *et al.,* 2005, 2006). Who showed that low doses better to avoid the off-flavor of fat content.

Ginger extracts have antibacterial effects against both gram positive and gram negative bacteria such as Clostridium, Listeria, Enterococcus, and Staphylococcus species, but some of this effect is destroyed by heating as cooking. (Mascolo *et al.,* 1989, Chen *et al.,* 1985, James *et al.,* 1999). The antibacterial, antifungal properties of ginger extract were reported by workers who showed that due to presence of sesqui-caryophellene and limonene (Belantine *et al.,* 2006; Martínez *et al.,* 2007, El-Baroty *et al.,* 2010).

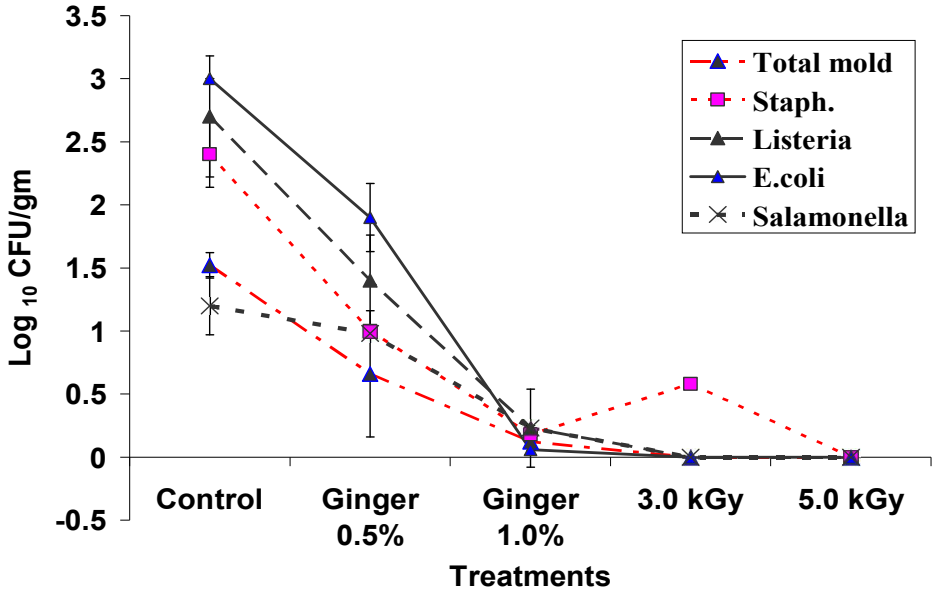

Fig.(2): Effect of ginger extract and gamma irradiation on load of microorganisms at processed sausage at zero time log CFU/g

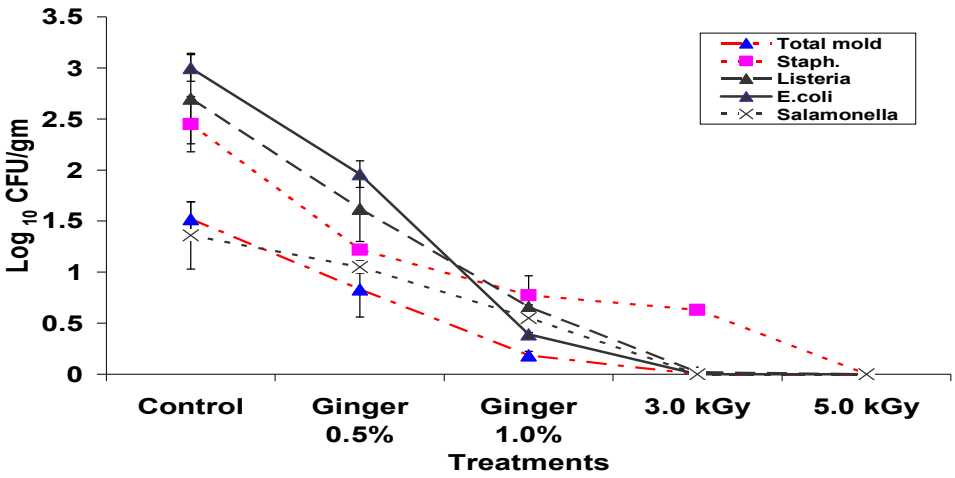

Fig.(3): Effect of ginger extract and gamma irradiation on load of microorganisms at processed sausage after one month of storage frozen.(log CFU/g)

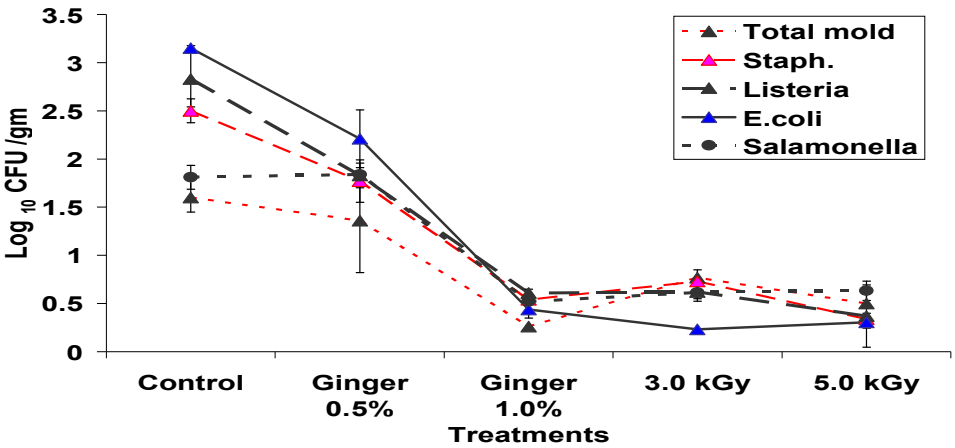

Fig.(4): Effect of ginger extract and gamma irradiation on load of microorganisms at processed sausage after two months of frozen storage(log CFU/g)

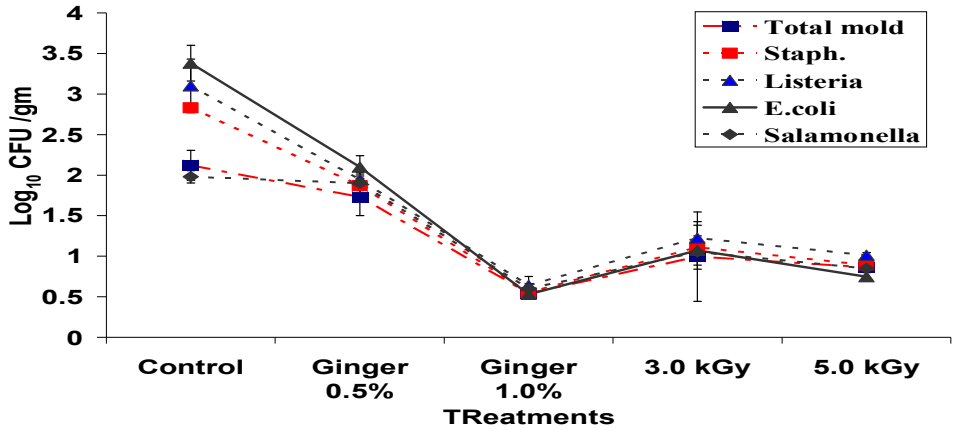

Fig.(5): Effect of ginger extract and gamma irradiation on load of microorganisms of processed sausage stored three month on freezing

Lipid stability

Lipid oxidation is one of the main parameters that affect the quality of meat and meat products. Lipid oxidation results in the development of unacceptable organoleptic characteristics such as rancid flavour, colour, texture and odour deterioration. Products produced from the oxidation reactions may also pose health risks (carcinogenic, low absorption of fat soluble vitamin), whereas microbial growth causes spoilage and foodborne diseases (Georgantelis *et al*., 2007). The primary determination of fat in tested samples showed presence low fat content (16- 17 %). Controlling both lipid oxidation and preventing microbial growth will have an increase in shelf-life. The use of natural preservatives or additives in food products can provide beneficial effects to consumers and also to the food industry.

The results of the lipid stability of sausages treated with different treatments are presented in Figure (6). The values of Thiobarbituric Acid Reactive Substance (TBARS) were less than 2 at zero time but started increased gradually during storage .After two months, most of treatments increased 2 values of TBARS except Ginger extract (1.0%),which was the best treatments even end of storage (90 days of frozen storage). To prevent the rancidity in samples. Recent studies in meat such as beef, however, indicate that TBARS values of 2 or greater are considered to be rancid (Suman *et al.,* 2010).

A linear relationship resulted between storage period and TBARS of treated samples with high significant values of coefficient (R^2) ,as shown in Fig.(5).The rate of rancidity can calculate per every treatments as (MDA mg /kg fresh weight).These values can descending order as 0.37,0.36,0.35,0.34,,0.29 for 5.0 kGy,3.0 kGy ,control, 0.5% GE and 1.0% GE respectively. According ,these data ginger extract (1.0%)was the best treatment to keep samples with good quality rancidity free even 90 days during frozen storage ,whereas irradiation increased rancidity values of TBARS rapidly comparing with control samples during frozen storage.

When comparing the treatments stored at -18°C for the period of 90 days, the ginger extract (1.0%) treatment maintained the TBARS values from day 1 – 90 less or near 2. These effects of ginger extract (1.0%) may be are the suitable concentration which contain the effective levels of antioxidants and phenols to prevent rancidity besides its antibacterial agent. Whereas, less concentration (0.5%) failed to do same effects, due to lack of that affective levels of antioxidant properties. Ginger contain active phenolic mainly sesquiterpene hydrocarbons, including β-sesquiphellandrene, aryophyllene ,zingiberene, *α*-farnesene, and *ar*-curcumin besides its effect on significant inhibitory activity against selected strains of bacteria and pathogenic fungi. (El-Baroty *et al.,* 2010). These properties of ginger extract prevent the rancidity of fatty content during long storage period. Georgentelis *et al.* (2007) also observed similar trends whereby the fresh pork sausage preserved with rosemary had lower oxidation products of 0.16 mg malonaldehyde (MDA)/kg meat to that of chitosan of 0.37 MDA/kg meat treatment after 20 days storage at 4°C. Same results were obtained on rosemary (Rižnar *et al.*, 2006, Mirshekar *et al.*, 2009).

Increasing values of TBARS of irradiated samples was clear as in Fig (6). These results show irradiation due to presence of water content (58%) and low content of lipids (16-17%) in spite of using freezing storage for 90 days. But these trend of rancidity by irradiation usually done, these effect via lipid oxidation in animal muscles, were observed with increasing doses in irradiated lamb liver as proved by Sweetie *et al.,* 2006. Also, at cold storage, same trend was observed by workers (Sommers *et al*., 2001, Shams El din, 1949, Emam, 1990). In addition, close relationship was observed between oxidative state and sensory during cold storage by (Shults *et al.,* 1977 and Piccinni *et al.,* 1986).

Concerning increasing TBARS values in control samples, may be due to further oxidation of MDA to other organic products of lipid oxidation (alcohol & acids) which are not determined by the reaction with TBA (Soultos *et al.,* 2008). Another possible reason may be due to the decomposition of MDA by bacteria such as pseudomonad's and *Enterobacteriaceae*, which posses the ability to selectively attack and utilize carbonyl compounds, including MDA (Soultos *et al.,* 2008). Another possible reason may be due to the decomposition of MDA by bacteria such as pseudomonad's and *Enterobacteriaceae*, which posses the ability to selectively attack and utilize carbonyl compounds, including MDA (Soultos *et al.,* 2008). Other factors such as temperature have an effect on the oxidation rate of meat and meat products. For example, during the cooking process there is a significant increase in the TBA values because the cooking method disrupts the muscle membrane system, thereby exposing the lipid component to oxygen and/or other reaction catalysts such as iron (Kamil *et al.,* 2002).

The role of ginger extract to keep sausages (1.0%) during long storage at frozen conditions due to presence high content of antioxidants as phenols or like which have been high antioxidant and antibacterial activity properties which prevent oxidation of hemoglobin.

In sausage preserved with ginger extract(1.0%) stored for a period of 90 days at -18 °C, the ginger extract (1.0%) showed lower TBARS values when compared to those irradiated or with ginger extract (0.5%). Ginger extract (1.0%) extract was significantly

the best treatment; its observed to reduce or maintain the TBARS in samples even towards the end of storage (90 days).

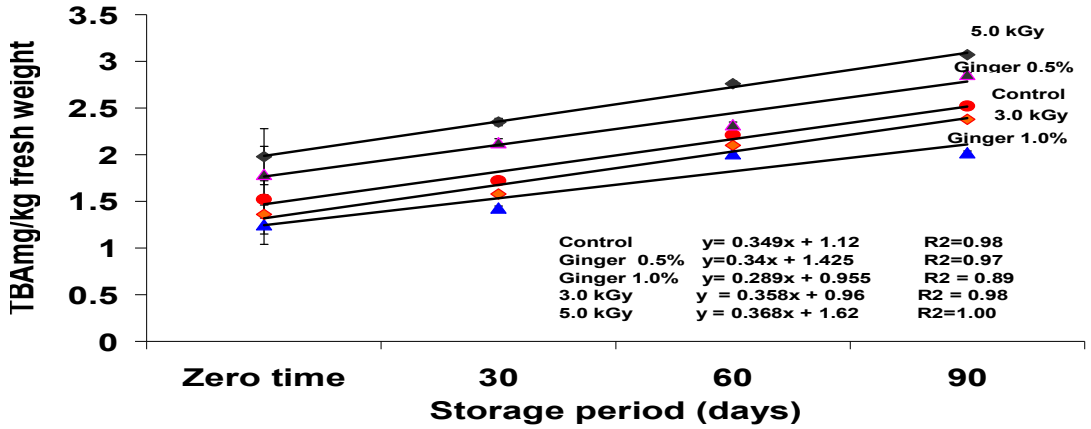

Fig.(6):Changes of TBA (MAmg /kg. fresh weight basis) of treated sausage during frozen storage.

Effect of treatments on sensory of sausage:

According to the means given by the panelists of cooked samples either at zero time or end of storage as shown in figs 6-10,the addition of ginger extract especially at 1.0 % concentration promoted stability most of sensory properties like fresh samples of sausage at zero time even after storage frozen three months .These effects of roles of ginger extract may be due to presence of antioxidants and phenols which prevent lipids oxidation consequently then keeping redness color , flavor, taste and texture like fresh samples.

These results as evidenced by statistical difference in relation to the control treatment at zero time or third month of freezing. The treatments with addition of ginger extract (1.0 %) always had the highest notes regarding change of color (Fig 6).

The redness of meat is an important aspect which consumers use to purchase meat and meat products (Boles *et al.,* 1998). This has major economic consequences that cause an annual loss of 1 billion USD to the meat industry (Smith *et al.,* 2000). Reclaiming profit via improved colour stability relies on the proper application of the fundamental principles of myoglobin chemistry, including two often overlooked factors: oxygen consumption and NADH regeneration as they impact metmyoglobin reduction The redness colour originates when meat myoglobin is exposed to oxygen resulting in the formation of red myoglobin.

Ginger extract (GE) was the best color especially at 1.0 % keep the original color after treatment directly. Whereas all the other treatments were like control at zero time in color significantly as shown in Fig.(6). At end of storage low levels of ginger (0.5%) keep the color as control but irradiation decreased these values dramatically. As shown in Fig (6), the highest value of color was significantly recorded with ginger extract (1.0%) these results may be due to high content of antioxidants and phenols which prevent the oxidation of hemoglobin. These results are highly significantly for keeping redness of sausages naturally on frozen (-18^{0}C) for 90 days. The explanation of ginger extract roles to improve color, depend on NADH regenerating besides releasing radicals as antioxidants consequently prevent oxygenated process of myoglobin or darkening tissues as showed by previous workers. (Hunter and Mancini, 2009). Whereas, irradiation activated the oxygenating and darkening process then decreased color ranks for consumers. Most of the past studies were in limited period for cold storage, as observed in modified packaged fresh pork sausage, using rosemary with ascorbic acid whereby the redness colour of the product was maintained for 12 days (Martínez *et al.,* 2007). Also, the redness of 1% chitosan preserved beef patties packaged in an oxygen permeable film (PVC) and stored at refrigerated temperatures has been shown to have greater redness than that of control packages in the same material at days 3 – 5 (Suman *et al.,* 2010).

Our findings, results are more significant, economically for keeping stability of color during long storage at frozen even three months with same red original color of hemoglobin of meat products naturally without any harmful additives or chemicals comparing irradiation treatments.

The results of cooked sausage texture as present in Fig.(7), showed no significant differences were obtained between treatments and control samples at zero time. Whereas, GE (1%) recorded the highest rank after three months at frozen storage. Also, GE (0.5%) was the second one. Less significantly ranks were recorded for irradiated samples as control samples,

irradiated samples results were near control samples. These data were significantly recorded as shown in Figs.(7). Decreasing texture ranks by irradiation may be due to activation enzymes at low applied doses during irradiation process. The solubility of the collagen in intact beef sausages muscle was increased by irradiation. The solubilisation of collagen was considered to be the result of an indirect action of radicals formed in water. (Bailey and Rhodes, 1964). Whereas, same changes in collagen were in slow rate in control samples .

Aroma and taste properties are related to volatile oil products due to lipid oxidation and rancidity products. Besides roles of microbial growth causes spoilage and off flavour (Rižnar *et al.*, 2006; Georgantelis *et al.*, 2007). Controlling both lipid oxidation and preventing microbial growth will have an increase in shelf-life of sausage as proved by GE especially at 1% which was the best treatment. The results of aroma and, taste showed the priority of GE especially (1.0%). Whereas, irradiated and control recorded lower values either at zero time or end of storage. Over all acceptance of sausage proved the preferability of GE (1.0%) then 0.5% whereas the other treatments recorded less significant ranks for all accepted samples especially irradiated samples.

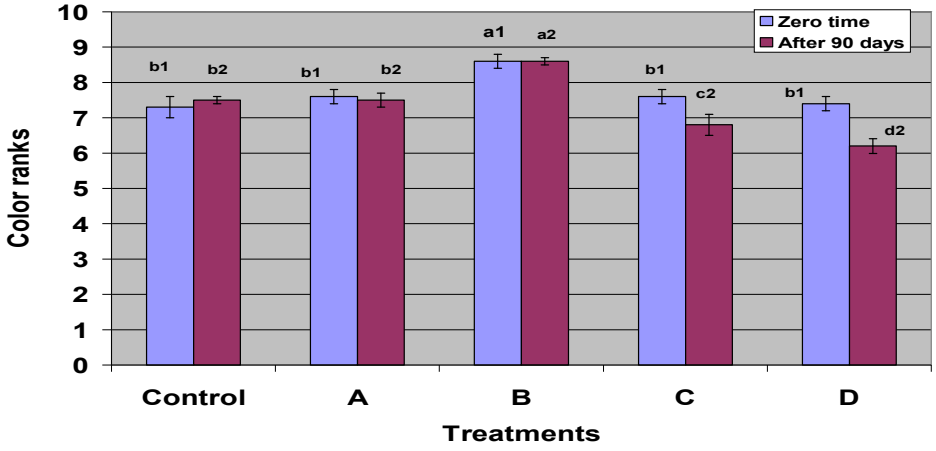

Figure (7): Effect of ginger and irradiation at zero time and end of storage on the color of sausages stored at –18°C. Results with different superscripts are significantly different. Error bars represent standard deviations (A,B=0.5%,1% ginger extract, D=3.0 kGy, 5.0 kGy). $LSD_{0.05}$ = 0.3 at zero time, 0.43 after 90 days of storage.

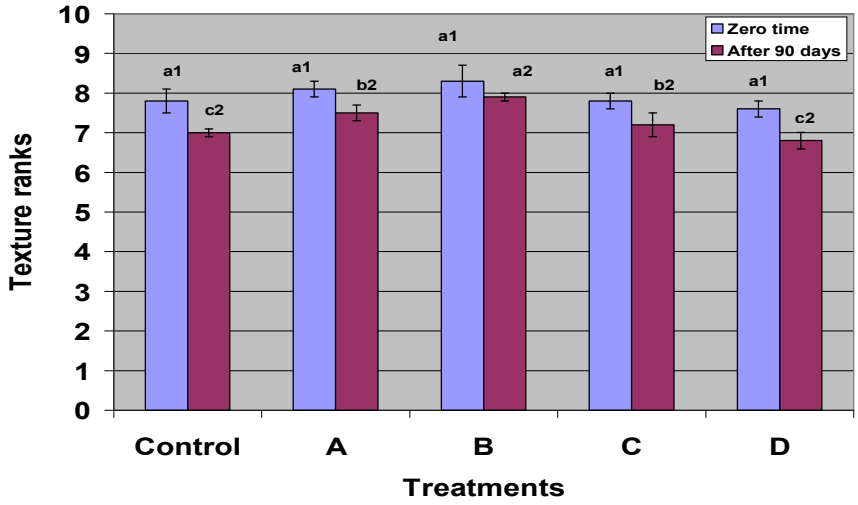

Figure (8): Effect of ginger and irradiation at zero time and end of storage on the texture of sausages stored at –18°C. Results with different superscripts are significantly different. Error bars represent standard deviations (A,B=0.5%, 1 % ginger extract, C, D=3.0 kGy, 5.0 kGy). $LSD_{0.05}$=not significant at zero time, 0.06 after 90 days of storage.

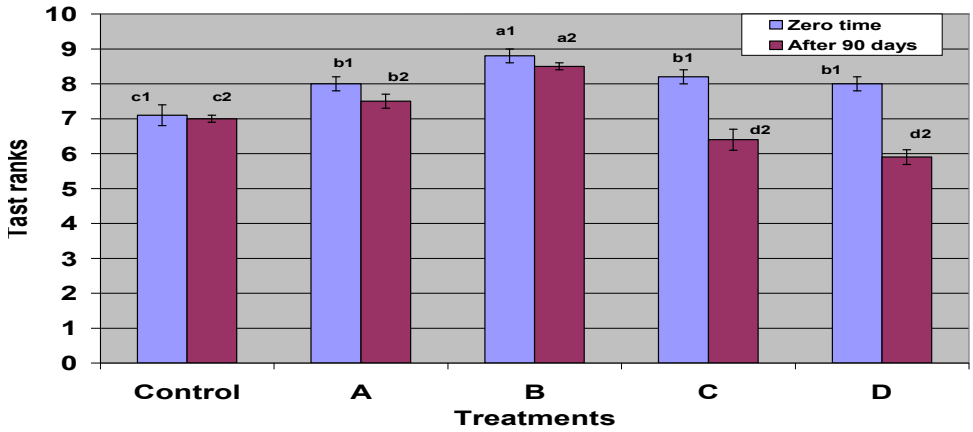

Fig. (9): Effect of ginger and irradiation at zero time and end of storage on the taste of sausages stored at –18°C. Results with different superscripts are significantly different. Error bars represent standard deviations (A,B=0.5%,1% ginger extract, D=3.0 kGy, 5.0 kGy). LSD $_{0.05}$=1.09 at zero time, 0.52 after 90days of storage.

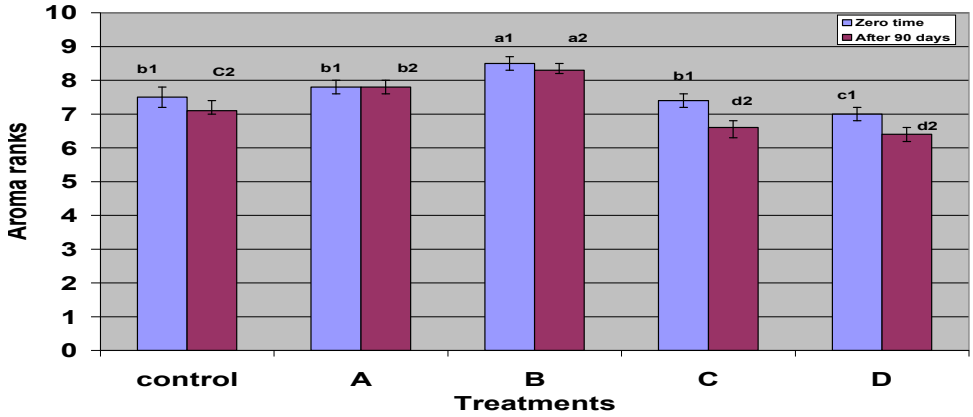

Fig. (10): Effect of ginger and irradiation at zero time and end of storage on the Aroma of sausages stored at –18°C. Results with different superscripts are significantly different. Error bars represent standard deviations (A,B=0.5%,1% ginger extract, D=3.0 kGy,5.0 kGy). LSD $_{0.05}$=0.02 at zero time, 0.01 after 90 days of storage.

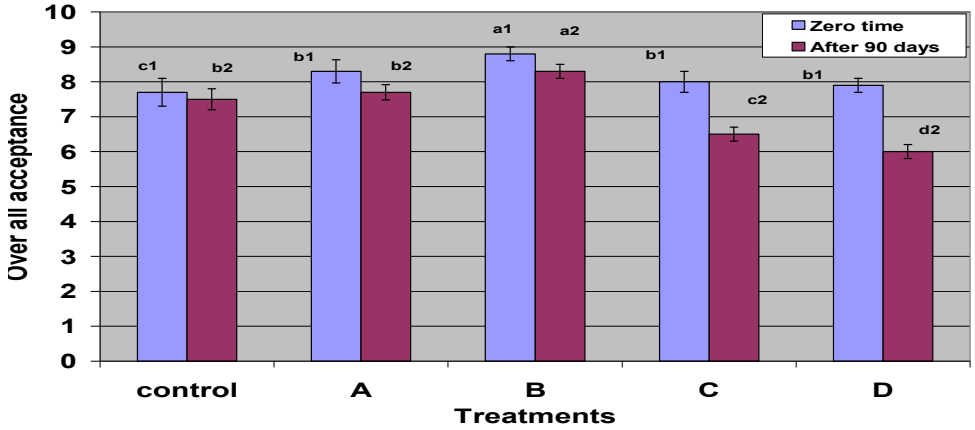

Fig. (11): Effect of ginger and irradiation at zero time and end of storage on over all Acceptance of sausages stored at –18°C. Results with different superscripts are significantly different. Error bars represent standard deviations (A,B=0.5%, 1% ginger extract, D=3.0 kGy, 5.0 kGy). LSD $_{0.05}$=0.02 at zero time, 0.01 after 90 days of storage.

4. Conclusion

According to our results, the addition of ginger extract as natural additives improved the quality and storage stability of sausages. Ginger extract results were satisfactory effect in protecting against lipid oxidation in processed, cooked and frozen beef sausages. Besides were more affective as antimicrobial agent comparing with irradiation treatments. In the same time, the treatment with ginger extract more effective than irradiation in maintaining the oxidative stability of samples. As for sensory acceptance, the addition of ginger extracts was effective in maintaining the sensory properties of the sausages even after 90 days of storage at -18^{0}C .

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