EFFECT OF GAMMA RADIATION ON MICROBIAL AND CHEMICAL CHARACTERISTICS OF SOME FOODS

By

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B.Sc. Agric. Sci., (Food science), Fac. Agric., Cairo Univ., 2006

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ABSTRACT

Gamma irradiation technology is one of the most effective food preservation methods used alone or in combination with other techniques for microbial decontamination and pathogen elimination. It has positive effects in destroying the pathogenic microorganisms as well as improving the safety and shelf stability of food products without compromising the nutritional or sensory quality. In the present study, the effect of gamma irradiation on microbial load and physicochemical characteristics of minced beef meat and concentrated mango juice has been evaluated. Samples of minced beef meat and concentrated mango juice were irradiated using a $Cobalt^{60}$ irradiation source at doses (0, 2, 4, 6, 8 and 10 kGy) of gamma irradiation. Irradiated and non-irradiated samples were kept in a refrigerator (4–5 ^{o}C) during storage periods. Microbiological and physicochemical analyses were done immediately after irradiation and throughout the storage periods at 7 days intervals. The results indicated that all doses of gamma irradiation reduced the total bacterial count, spore forming bacteria, total fungi, *Staph. aureus, Salmonella, Shigella,* total coliforms, and fecal coliform in all irradiated samples. Thus, the microbiological shelf-life of all samples of beef meat and mango juice, except a sample with 2 kGy was significantly extended more than 4 weeks in meat and 12 weeks in mango juice. No significant differences in moisture, protein content, fat content, ash values, and total acidity of beef meat were observed due to irradiation. However, pH values decreased significantly with increasing irradiation doses in comparison with control. On the other hand, total soluble solids, total sugars, total phenols, total flavonoids, antioxidant activity and pH values increased due to irradiation in mango juice, but total acidity and ascorbic acid values decreased significantly. While, no significant differences in moisture and ash values were observed with increasing irradiation doses in comparison with control.

Key words: Gamma irradiation, Minced beef meat, Concentrated mango juice, Microbial load, Physicochemical characteristics, Shelf-life, Storage periods.

DEDICATION

I dedicate this work to whom my heartfelt thanks; my father, my mother, my grandmother and my Sisters for their patience and help, as well as to my brothers for all the support they lovely offered along the period of my post graduation.

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ARABIC SUMMARY

INTRODUCTION

Fresh and processed meat provides high biological value proteins and important micronutrients so that it provides the human body with energy, protein, long chain fatty acids, essential trace elements, vitamins and other micronutrients (McAfee *et al*., 2010; Millward and Garnett, 2010; Rooke *et al*., 2010 and De Smet and Vossen, 2016).

Therefore, spoilage microorganisms and food-borne pathogens can easily grow on nutrient components of meat which need preservation methods to maintain meat products safety and quality (Aymerich *et al*., 2008 and Zhou *et al*., 2010).

Quality and shelf life of meat can be influenced by controlling storage temperature, oxygen, endogenous enzymes, moisture, light and, most importantly, microbial growth, which can delay changes in color, odor, texture and flavor of meat (Lambert *et al*., 1991; Zhou *et al*., 2010 and Farkas *et al.*, 2014).

Meat preservation methods based on storage temperature and moisture as well as microbial reduction processes such as ionizing radiation can achieve microbial and organoleptic quality as an effective method to reduce and eliminate pathogenic and spoilage microorganisms in meat and poultry (Farkas, 2006; Lawrie and Ledward, 2006; Brewer, 2009 and Feliciano, 2018).

Mango (*Mangifera indica* L.) is one of the most popular tropical fruits in the world because of its excellent flavor, beautiful color, sweet

taste and nutritional properties. In addition, it is a good source of provitamin A carotenoid, vitamin C (ascorbic acid), carotenoids, polyphenolic compounds, and traces of vitamins E, K and B. These bioactive compounds are good antioxidants and their daily intake in the diet has been related to prevention of degenerative process such as cardiovascular diseases and cancer (Liu, 2003 and Naresh *et al.,* 2015 b). Thus, consumption of mango juice can provide significant amounts of health protective bioactive compounds to the diet. Fresh mango juice as natural extract from mango fruits enjoys high consumer acceptance as account of its taste and nutritional benefits. As mango is a seasonal fruit, it is processed into various forms like frozen and canned slices, puree, jam, nectar and mango powder (Varakumar *et al.,* 2011). During production or processing the fruits are exposed to conditions such as instance irrigation or washing waters or sick workers which are prone to contaminate the product. Fruits can host foodborne pathogens that may constitute a serious threat, causing gastrointestinal diseases when ingested. These biological agents, some of which are pathogenic to humans and animals, may be able to survive preservation treatments and pose health risks to humans (Naresh *et al.,* 2015 a).

Food irradiation is a physical process that uses gamma rays or accelerated electrons as ionizing radiation to destroy pathogens and spoilage microorganisms in foods (Sajilata and Singhal, 2006; Alfaia *et al*., 2007; Abedi *et al*., 2014 and Hwang *et al*., 2015). International health and safety authorities such as Food and Agriculture Organization (FAO), International Atomic Energy Agency (IAEA) and World Health Organization (WHO) reported that, medium doses up to 10 kGy of

radiation can control and destroy pathogenic and spoilage bacteria such as *Escherichia coli*, *Salmonella*, *Campylobacter* and *Listeria* in food products. These are considered safe for human consumption as well as a good manufacturing practices (GMPs) in food production plants (Maghraby, 2007; Gumus *et al*., 2008; Gecgel, 2013 and Ayari *et al*., 2016).

This study aimed to determine effects of gamma radiation on the microbial groups of raw minced beef meat and concentrated mango juice and its effect on the quality, physicochemical and shelf life during storage under refrigeration (at 4-5 ^{o}C).

REVIEW OF LITERATURE

Despite substantial efforts in avoidance of contamination, an upward trend in the number of outbreaks of foodborne illnesses caused by non-spore forming pathogenic bacteria are reported in many countries. Good hygienic practices can reduce the level of contamination, but the most important pathogens cannot presently be eliminated from most farms nor is it possible to eliminate them by primary processing, particularly from those foods which are sold raw. Several decontamination methods exist but the most versatile treatment among them is the processing with ionizing radiation. Decontamination of food by ionizing radiation is a safe, efficient, environmentally clean and energy efficient process. Irradiation is particularly valuable as an end product decontamination procedure (Farkas, 1998).

The desire to assure food safety for consumption requires better food preservation techniques. The presence of parasites, insects, mites, and micro-organisms is an important source of problems. In this regard, irradiation is an interesting alternative to be considered to satisfy quarantine requirements, to control severe losses during transportation and commercialization, and to insure food safety (Lacroix and Ouattara, 2000).

A Joint FAO/WHO Expert Committee on Food Safety concluded as early as 1983 that "illness due to contaminated food is perhaps the most widespread health problem in the world and an important cause of reduced economic productivity" (WHO, 1984). Data published since then by various countries confirm this statement and

indicate that the problem has been on the increase for the last two decades (Sockett, 1993 and WHO, 1997).

Yearly, losses during storage have been estimated to be 10 % for cereal, 40% for vegetable and fruits, 75 % for peas and beans, and much more for meats, poultry and fish due to their particular sensitivity to enzymatic and microbial attacks. These losses are being shouldered by the customers who are faced with price increases for the products. Furthermore, society has to cope with many food-borne diseases as a result of the development of pathogenic micro-organisms such as *E. coli* O157:H7, *Campylobacter, Listeria, Toxoplasma*, *Trichinella etc.* and production of toxic substances like enterotoxin, mycotoxin and histamine (Cassin *et al.,* 1998 and IFT, 1988).

The time has come to find ways to reduce losses in food products, enhance their shelf life and assure their innocuousness. Irradiation technology is the answer to these expectations, since it creates the possibility of putting foods on the market that are glowing with freshness and exempt of pathogens. This technology was approved in 1981 by the FAO/IAEA/WHO joint committee on the wholesomeness of irradiated food. It was stated that, irradiation of food at doses up to 10 kGy introduced no special nutritional problem. Thus, more than 26 countries are using the process on a commercial scale (Stevenson, 1994).

1. The history of food irradiation

Food irradiation has about 100 years of history and it was developed as a scientifically established technology and safe food process during the second half of the 20th century (Molins, 2001). The

first half of the last century could be called as the age of inventors (Diehl, 2002) because in that period radiation facilities were not of suitable capacities for practical applications. However, from the middle of the 20th century, systematic research efforts, several national research programmers and international cooperation's together with technical developments established a solid scientific and technical background for the utilization of this technology. Due to its uniqueness, lack of application history and experience, it was important and necessary to also clarify the wholesomeness (toxicological and microbiological safety and nutritional adequacy) of irradiated food. This required an unprecedentedly careful and wide-ranging effort of such testing, which was beyond even the capability of the most developed countries. Therefore, specific research programmers and international projects supported by specialized agencies of the United Nations such as the Food and Agricultural Organization (FAO), the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) were important partners in assisting progress. The most extensive one of such international cooperation's was the International Project in the Field of Food Irradiation (IFIP, Karlsruhe) with the involvement of up to 24 countries between 1970 and 1982. (Farkas and Farkas, 2011).

Historical milestones of food irradiation were:

1905: J. Appleby and A.J. Banks: British patent: "to bring about an improvement in the conditions of foodstuffs" and in "their general keeping quality by radiation of radioactive substances."

1921: B. Schwartz (US): published use of X-rays for inactivating trichinae in raw pork.