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Effect of Gamma Irradiation on Hygienic Quality and Chemical Characteristics of Dehydrated Ostrich Eggs

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ABSTRACT

Role of gamma irradiation on improving hygienic quality of dehydrated Ostrich eggs during cold storage was studied. Irradiation with dose level 6 kGy proved to be quite tool to keep quality of ostrich egg components since it decreased their bacterial counts less than 100 cells/g either after irradiation process or during cold storage for 6 months. Total coliform, *E. coli* and *Staphylococcus sp.* were almost eliminated. Twenty one fungi species belonging to eight genera were isolated from the un-treated samples. Most species could not stand cold storage and only five species (*Aternaria clamydospora, Aspergillus niger, Asp. oryzae, Cladosporium cladosporioides & Fusarium oxysporum*) were detected after 6 months of storage at 5°C. Also, five species could endure irradiation with dose level 6 kGy (*Al. alternata, Al. clamydospora, Cl. cladosporioides, Cl. herbarum & F. oxysporum*) and only two species of them could bear cold storage for 6 months (*Al. clamydospora & Cl. cladosporioides*). The effect of cold storage (5°C) on total amino acids either essential or non essential was relatively higher than that occurred by irradiating dried albumen ostrich eggs with 6 kGy. Total amino acids decreased from 272.5 mg/g to 241 mg/g after 6 months of cold storage, while they decreased to 256.2 mg/g after the irradiation process. The same trend was observed in case of dried whole yolk or defatted yolk. The effect of gamma rays and cold storage on the relative percentages of fatty acids composition of dried ostrich eggs yolk was different from each other. After exposing the dried yolk to 6 kGy, the percentages of myristic and palmitic acids increased, while palmitoleic and stearic acids decreased. Mean-while after 6 months of cold storage the percentages of palmitoleic and linoleic acids increased, while stearic and oleic acids decreased.

Key Words: Ostrich eggs; Gamma irradiation; Albumen; Defatted yolk; Whole yolk; Total coliform; *Staphylococcus sp. E. coli;* Amino acid; Fatty acid; Cholesterol

INTRODUCTION

Eggs are a highly nutritious as well as a low cost protein source (Watkins, 1995; Papadopoulou *et al*., 1997; Surai & Sparks, 2001). However, the egg is a highly perishable food product, which could lose its quality rapidly during the period between collection and consumption.

On farms where eggs are produced, the source of bacterial contaminants has been shown to be surrounding environment as well as the chickens (Todd, 1996). Literature furthermore suggests that aerosolization of faecal particles with associated micro-organisms could settle on eggs (Theron *et al*., 2003). Eggs also become infected through a process of either transmission or with moist faeces contaminated with *Salmonella.* Following traversing of the egg shell the associated membrane of the egg becomes permanently contaminated by *Salmonella.* Bacteria on the surface of the shell are able to pass through the pores of the shell to contaminate the interior of the egg, even though the egg shell has physical barriers, and the albumen in the egg white has characteristics to prevent microbial growth (Frazier & Westhoff, 1988; Wang & Slavik, 1998). As a result, Schoeni *et al.* (1994) emphasized the need to remove any faecal contamination rapidly in order to reduce the risk of microbial penetration into the contents of the egg.

In recent years much attention has been given to the role chicken eggs play in the transmission of bacteria such as *Salmonella* to the human population in Canada (Todd, 1996), America (Schultze & Fawcette, 1996; Trepka *et al.*, 1999), Europe (Lee, 2000), Korea (Chang, 2000) and Poland (Radkowski, 2001). Hen egg shells can serve as a vehicle for human pathogenic micro-organisms. *Escherichia coli, Salmonella sp.* (Schoeni & Doyle 1994), *Listeria monocytogenes* (Moore & Madden, 1993) and Y*ersinia enterocditica* (Chiesa *et al.,* 1989) are some of the pathogens isolated from these products.

Food irradiation is an additional food safety tool that serves as a complement to other food safety technologies. A previous research has shown that ionizing energy at medium doses can eliminate non-spore-forming pathogens such as *Salmonella* in food products (Radomyski *et al.,* 1994). Irradiation could cause very little increase in food temperature during application; thus it is termed "Cold processing" these features make the process of irradiation more attractive for eliminating pathogens in heat-sensitive products like eggs. Previous studies on microbial inactivation and functional and chemical egg properties, demonstrates that the process of irradiation can eliminate

pathogens from eggs without adversely affecting egg quality (Narvaiz *et al*., 1992; Tellez *et al.*, 1995; Serrano *et al.*, 1997). Since year 2000, the food and drug administration (FDA) approved the use of up to 3 kGy ionizing radiation dose to reduce the level of the *Salmonella* in eggs' shells (FDA, 2000).

Dried eggs are widely used in food preparations because of their microbiological safety and their reduced volume with respect to un-shelled or liquid eggs (Bergquist, 1995). Moreover, the appeal of dried eggs is their conveniently and long shelf-life; in fact, this product is usually stored without particular care. However, the quality of the raw material, the processing and the storage conditions, strongly influence the quality and safety of egg powder (Galobart *et al.*, 2002).

At present, most of the dried egg products (albumen, defatted yolk & whole yolk) are imported from foreign countries under the Egyptian Organization for Standardization and Quality Control (Egyptian Standard, 1993). Due to the growing poultry farms including ostrich birds, several factories for drying eggs are expected to install. Usually high contamination of microorganisms is occurred during the drying process.

The present work aimed at applying gamma rays for eliminating the bacteria and fungi, especially the pathogens contaminating the components of dried ostrich eggs and its effects on the chemical and nutritional values either immediately after irradiation or during cold storage.

MATERIALS AND METHODS

Sampling. Eggs of the ostrich (*Struthio camelus*) were obtained immediately after laying during laying period from a commercial ostrich production farm (Ostrich farm, Elsaaf, Giza, Egypt). Animals maintained under standard penned conditions in Egypt. In the whole experiment twelve eggs were used. Immediately following collection the yolks were carefully separated from the albumen with an egg separator. Vacuum drying of albumen and yolk was done at temperature 55ºC ± 1ºC until constant weight. The dried albumen was ground using a mill to fine particles. The dried yolk was divided into two groups. The first group (defatted yolk), yolk lipids were extracted by homogenization and refluxing in a suitable excess of chloroform: methanol (2:1 v/v) according to Christie (1984). Thereafter the defatted yolk (protein yolk fraction) was flittered, dried and milted to fine particles. The second group was used as dried, whole yolks. The dried samples were distributed in polyethylene pouches (200 g of dried albumen, 50 g of whole yolk or 25 g of defatted yolk samples for each pouch). The pouches were then sealed and exposed to gamma irradiation. Samples are processed in triplicates.

Irradiation process. Irradiation was carried out with ^{60}Co gamma rays source using Russian Facility Irradiation Model ISSLEDOVATED located at the National Center for Radiation Research and Technology (NCRRT), Nasr City, Cairo, Egypt. The samples were irradiated at the temperature less than 5ºC. Dose rate was 4.72 kGy/h at the time of the experiment. The dried sample received an average absorbed dose of 0, 2, 4 and 6 kGy. The samples were stored at 5ºC ± 0.5ºC and with-drawn periodically for microbiological and chemicals evaluations. Analyses were carried out directly after irradiation (Zero time) and after 2, 4 and 6 months of storage.

Microbiological analysis. Each sample (10 g) was aseptically homogenized for 2 min in a sterile stomacher bag containing 90 mL of sterile peptone water using a stomacher lab blender. The total bacterial counts were enumerated on plate count agar medium (PCA) according to APHA (1992). Molds were counted on Czapek yeast extract agar medium (Pitt & Hocking, 1985). Fungi contaminating samples were isolated and purified. The purified fungal isolates were identified according to their morphological characters and microscopically as the description given by Ellis (1971), Domsch *et al.* (1980) and Samson *et al.* (1995). Coliforms were determined according to WHO (1993) with the most probable number (MPN) technique using MacConkey's broth. Three series of three tubes were incubated at 37ºC for 48 h. The tubes showed yellow tint (acid production) and gas were considered positive. For enumeration of *E. coli*, a loop full of each positive culture was transferred to another tube of MacConkey broth, then incubated at 44ºC for 24-48 h. Confirmation of *E. coli* was carried out by IMViC (Indole, Methyl red, Voges-Proskauar, incubation temperature and Citrate) tests according to APHA (1992). *Staphylococcus sp.* was counted on laboratory prepared Baird-Parker agar medium (IAEA, 1970). Suspected colonies were tested for coagulase activity and confirmed by other biochemical reactions. *Salmonella spp.* was detected in accordance with ISO 6579 (1993) using buffer peptone water, selenite cysteine broth and brilliant green phenol red agar media.

Chemical analysis. Moisture content was determined using vacuum drying oven at 55ºC until reaching to constant weight. Ether extract was prepared by extraction with petroleum ether using soxhlet apparatus and protein was determined using kjeldahl method. Ash content was determined by heating about 5 g of sample at 550ºC in muffle furnace, until gray ash results or constant weight was reached according to the method described in (AOAC, 1990).

Mineral content. The selected minerals were measured as described in the IAEA (1980), Kingstan and Jassie (1988) and AOAC (1990) using Solar System unicam 939 atomic absorption spectrometer. Sample materials were digested after drying for 2 h. at 103ºC. The element concentration in original sample was determined from the following equation:

$$C_2\ (\mu g/g) = \frac{C_1\ (\mu g/g) \times D}{\text{Sample weight}}$$

Where:

C_1 = Metal concentration in solution.
C_2 = Metal concentration in Sample.
D = Dilution Factor

Fatty acid profile. Lipids were extracted according to Bligh and Dyer (1959). Fatty acids profile was determined using a Gas Chromatograph-Mass Selective Detector Instrument "GC-MS" type HP 6890 series.

Condition of Analysis

Column. Capillary HP-Innowax column; 30 m length; 250 μm diameter; 0.25 μm film thickness.

Oven. programmable with initial temperature of 150ºC for one min, then raised in three ramps as follows:

Rateº C/min	Final temp.ºC	Final time (min)
17	235	2
1	242	1
8	255	6

Amino acid determination. Sample of 100 mg of dried and defatted samples were weighed in the screw-capped tubes to which 5 mL of HCl 6.0 N were added. The hydrolysis tubes were attached to a system, which allows the connection of nitrogen and vacuum line without disturbing the sample. The tubes were placed in an oven at 110ºC for 24 h. The tubes were then opened and the content of each tube was filtered and evaporated for dryness in a rotary evaporator. A suitable volume of sodium citrate buffer (pH 2.2) was added to each dried film of the hydrolyzed sample. After complete dissolving of all soluble materials, the sample was then filtered using a 0.2 μm membrane filter, and is ready for analysis (Baxter, 1996). The system used for the analysis was high performance Amino Acid Analyzer, Biochrom 20 (Auto Sampler Version) Pharmacia Biotch constructed at NCRRT. Data analysis of chromatogram was done by Ezchem™ Chromatography Data system Tutorial and user's Guide-version 6.7.

Triglyceride. Triglyceride was determined using Enzymatic, liquid, colorimetric test, GPO-PAP method according to Trinder (1969).

Total cholesterol. Total cholesterol was determined using CHOD-PAP- enzymatic colorimetric method according to Ellefson and Caraway (1976).

High density lipoprotein (HDL). HDL- cholesterol was determined using Phosphotungstic precipitation method according to Friedwald *et al.* (1972).

Low density lipoprotein (LDL). LDL- cholesterol was determined using the Friedwald equation as flows according to Friedwald (1972).

LDL (mg/100 g) = Total cholesterol – Triglycerides/5 – HDL.

RESULTS AND DISCUSSION

The ostrich (*Struthio camelus*), is the world's largest bird living today. Great attentions are carried out nowadays for breeding this economic bird in Egypt. Ostrichs' farms are increasing in Egypt every year. Ostriches are an environmentally friendly animal, of the ratite family, requiring less acreage than other livestock and relatively modest amounts of food and water. Ostriches were first raised for their feathers, but now they are more valued for the low-fat red meat and world renowned leather the birds provide. Ostrich eggs are also fully equivalent to chicken eggs in taste and practical properties. They can be cooked in similar ways. Ostrich eggs are impressive by their sheer size and one ostrich egg (about 1600 g) is equivalent to 24 chicken eggs. The shell, which is resemblance to porcelain, can be turned into objects of art by painting or engraving.

Dried albumin and yolk of eggs are extensively used in various food industries. The main object of the present work was to investigate the efficacy of gamma rays and cold storage on improving the hygienic quality and keeping the distinctive properties of dehydrated ostrich eggs.

Table I presents the chemical composition of the ostrich eggs. It is clear that the edible portion (albumen + yolk) presented more than 80% of the egg, and contains highly percentage of protein either in albumen or yolk (9.56 & 15.19, respectively) indicating the high nutritional value of ostrich eggs. Mean-while yolk contains 29.59% lipids compared with only 0.08 in albumen.

Table II indicates the chemical composition of ostrich and chicken eggs. It is clear that both of total proteins and lipids are almost the same, but there are obvious differences in some mineral salts such as magnesium, selenium and iron, which are higher in ostrich eggs while manganese, zinc and copper are lower in ostrich than chicken eggs.

Since it is well known that ostrich meat is distinguished by its low fats percentage especially the cholesterol and triglyceride, which their increase in blood plasma can lead to heart attacks, brain arteries blocking or blockages of arteries in the legs, it was found interesting to make comparison between their values in ostrichs' eggs yolk and other different kinds of chickens eggs yolk existing in Egypt markets. Table III clearly shows that the total cholesterol and triglyceride are significantly lower in ostrichs' eggs than the other chicken eggs. Total cholesterol value recorded 880 mg/100 g samples compared with 1260, 1400 and 1370 mg/100 g sample in case of balady, red and white eggs, respectively. There is another interesting point in this study, which indicated the high level of High Density Lipoproteins (HDL), which is considered a safety factor for the high level of cholesterol in blood plasma, compared with other chicken' s eggs. Di Meo *et al.* (2003) recorded that the content of cholesterol/g of ostrich eggs yolk was between 10.6 and 10.9 mg. In conclusion, compared with the hen's egg, the ostrich egg has similar chemical and nutritive characteristics, but a higher un-saturated/ saturated fatty acid ratio and lower cholesterol content.

Microbiological investigations. Legislating regulation of Egyptian Standard (1993) dried eggs including the following item: Total bacteria count shall not exceed 1×10^3 cfu/g., Coliforms shall not exceed 10 cfu/g., *E. coli* shall be absent in 1 g of a dried egg., Salmonella organisms shall be absent in 25 g of a dried egg, Yeast and moulds shall not

Table I. Chemical composition of ostrich's eggs

Component %	Albumen	Yolk	Shell egg
Moisture	89.51 ± 0.972	51.21 ± 0.269	1.06 ± 0.033
Total proteins	9.56 ± 0.278	15.19 ± 0.155	-
Total lipids	0.08 ± 4.082^{-03}	29.59 ± 0.506	0.02 ± 4.90^{-03}
Ash	0.88 ± 0.049	2.10 ± 0.082	98.07* ± 0.60
Proportional	57.10 ± 0.702	23.30 ± 0.980	19.60 ± 0.318

* Mainly calcium carbonate

Table II. Comparison between the chemical composition of ostrich eggs and chicken eggs*

Egg's components (albumen + yolk)	Ostrich eggs	Chicken eggs
Moisture %	75.46 ± 0.955	74.88 ± 0.400
Total proteins %	47.21 ± 0.310	47.51 ± 0.604
Total lipids %	44.27 ± 0.376	45.36 ± 0.604
Ash %	5.37 ± 0.245	5.01 ± 0.351
Calcium carbonate %	0.25 ± 0.019	0.24 ± 0.024
Phosphorus %	0.81 ± 0.027	0.82 ± 0.033
Magnesium (ppm)	550 ± 14.697	500 ± 15.513
Manganese (ppm)	9.9 ± 0.220	16.7 ± 0.734
Selenium (ppm)	1.6 ± 0.065	0.71 ± 0.041
Zinc (ppm)	56.6 ± 0.653	64.2 ± 0.408
Iron (ppm)	113.9 ± 1.045	93.9 ± 1.037
Copper (ppm)	1.6 ± 0.057	2.5 ± 0.073

* Values are expressed on dry matter basis except moisture.

Table III. Comparison of total cholesterol, HDL, LDL and triglyceride values among different kind of egg yolks

Fraction	Egg yolk* (mg/100 g sample)			
	Ostrich	Laying hen: variety		
		Fayomy	ISA Brown	Loghorn
Total cholesterol	880 ±14.70	1260 ±14.70	1400 ±22.86	1370 ±12.25
High-Density lipoproteins (HDL)	168 ±7.35	79 ±4.08	83 ±4.08	66 ±2.45
Low-Density lipoproteins (LDL)	320 ±10.61	701 ±14.70	859 ±22.86	840 ±19.60
Triglyceride	1960 ±52.26	2400 ±73.48	2290 ±65.32	2320 ±40.83

* Range of values from 3 different samples

exceed 10 cfu/g. and Pathogenic micro-organisms and their toxins shall be absent.

Data in Table IV clearly showed that the total bacterial counts contaminated the albumen of dried ostrich eggs recorded 1.4×10^5; 1.5×10^5 in yolk and that of defatted yolk were 3.2×10^5 cfu/g. During cold storage at 5°C, the total bacterial counts in all the above products increased gradually reaching 5.1×10^6, 1.1×10^7 and 1.2×10^6 cfu/g after 6 months for albumen, yolk and defatted yolk, respectively indicating the highly percentages of contamination of these products. Application of gamma rays with dose level 2 kGy was not enough to decrease the total bacterial count to the safety level except in defatted yolk, but their counts re-increased gradually during the cold storage. Exposing the products to dose levels 4 kGy decreased their content of bacterial counts to the safety levels especially in case of defatted yolk, which recorded only 81 cfu/g and the counts remained almost un-changed during cold storage. The results proved the role of fats for increasing the resistant of microorganisms against radiation. Application of dose level 6 kGy decreased the bacterial counts contaminated the previous products to less than 100 cfu/g and the counts remained almost constant during cold storage for 6 months as clearly observed in Table IV.

Contamination of foods, especially those of animal origin, with micro-organisms, particularly pathogenic non-spore forming bacteria, parasitic helminthes and protozoa is an enormous public health problem and important cause of human suffering all over the world (Farkas, 1998).

The US Public Health Service estimated that 9000 deaths from 6.5 million to 81 million cases of diarrhea diseases occur in the US each year due to pathogenic bacteria such as *Salmonella*, *Campylobacter*, *Escherichia coli* and V*ibrio*, as-well-as *Toxoplasma gondii* and other parasites (Archer & Kvenberg, 1985; Lee, 1994). Extremely virulent pathogens such as the verotoxin producing *E. coli* 0157: H7 and psychrotrophic pathogenic species including *Listeria monocytogenes*, *Yersinia enterocolitica* and A*eromonas hydrophyla* raise a special concern (Palumbo *et al.*, 1986). *Escherichia coli* 0157: H7 is a major cause of outbreaks of food borne diseases. *E. coli* 0157: H7 is classified in the enterohemorrhagic *E. coli* (EHEC) group of pathogenic *E. coli*, which has major virulence properties, including adherence to the intestinal epithelium and production of verocytotoxin (Shiga-like toxin). *E. coli* 0157: H7 causes a spectrum of diseases ranging from a mild diarrhea to hemorrhagic colitis, hemolytic uremic syndrome (HUS) and, in some cases, death (Padhye & Doyle, 1991).

Although *Salmonella spp.* were not detected in any of the tested ostrich egg products, but other pathogens occurred in counts above the safety level. Total coliform recorded 93, 240 and 150 cfu/g in albumen yolk and defatted yolk, respectively. *Escherichia coli* recorded 43, 93 and 39 cfu/g, while *Staphylococcus sp.* existed as 170, 100 and < 100 cfu/g in the above products, respectively (Table V). Data also showed that the counts of these pathogens increased gradually during the cold storage at 5°C, while gamma irradiation proved to be an effective physical factor to

Table IV. Effect of irradiation and cold storage at 5°C on total bacterial count (cfu/g) contaminating dried ostrich egg products

Storage period (month)	Dried egg products Irradiation doses (kGy)											
	Albumen				Yolk				Defatted yolk			
	0.0	2.0	4.0	6.0	0.0	2.0	4.0	6.0	0.0	2.0	4.0	6.0
0	1.4×10^5	6.8×10^4	9.5×10^2	2.5×10	1.5×10^5	7.0×10^3	2.3×10^2	3.2×10	3.2×10^5	1.8×10^3	8.1×10	0.7×10
2	1.7×10^6	1.2×10^5	2.2×10^3	3.6×10	5.5×10^6	9.0×10^3	4.6×10^2	4.5×10	6.4×10^5	4.8×10^3	5.2×10	2.1×10
4	2.1×10^6	1.5×10^5	4.7×10^3	4.2×10	8.3×10^6	1.9×10^4	5.0×10^2	8.8×10	8.9×10^5	6.1×10^3	6.3×10	3.3×10
6	5.1×10^6	2.5×10^5	7.4×10^3	5.6×10	1.1×10^7	3.8×10^4	5.3×10^2	2.6×10^2	1.2×10^6	8.7×10^3	7.5×10	4.5×10

Table V. Effect of irradiation and cold storage at 5°C on public health concern bacterial counts contaminating dried ostrich egg

Microbiological test	Storage period (month)	Dried egg products: Albumen Irradiation doses (kGy) 0.0	20.	4.0	6.0	Yolk 0.0	20.	4.0	6.0	Defatted yolk 0.0	20.	4.0	6.0
Total coliform	0	93	9	ND	ND	240	15	< 3	< 3	150	11	ND	ND
	2	150	11	ND	ND	460	23	4	< 3	240	15	ND	ND
	4	240	11	ND	ND	460	39	< 3	< 3	240	23	ND	ND
	6	460	23	ND	ND	1100	43	ND	< 3	460	23	ND	ND
Escherichia coli	0	43	9	ND	ND	93	14	ND	< 3	39	9	ND	ND
	2	93	9	ND	ND	150	14	ND	< 3	75	9	ND	ND
	4	93	14	ND	ND	150	20	ND	< 3	75	11	ND	ND
	6	150	14	ND	ND	210	23	ND	< 3	120	11	ND	ND
Staphylococcus sp.	0	1.7×10^2	< 100	ND	ND	1.0×10^2	< 100	ND	< 100	< 100	ND	ND	ND
	2	1.8×10^2	1.8×10^2	ND	ND	1.1×10^2	< 100	ND	< 100	< 100	ND	ND	ND
	4	2.1×10^2	2.0×10^2	ND	ND	1.7×10^2	1.6×10	ND	< 100	1.4×10^2	ND	ND	ND
	6	3.8×10^2	3.1×10^2	ND	ND	2.1×10^2	1.7×10	ND	< 100	1.8×10^2	ND	ND	ND

ND = not detected

Table VI. Effect of irradiation and cold storage at 5°C on mold and yeast counts (cfu/g) contaminating dried ostrich egg products

Storage period (month)	Dried egg products: Albumen Irradiation doses (kGy) 0.0	2.0	4.0	6.0	Yolk 0.0	2.0	4.0	6.0	Defatted yolk 0.0	2.0	4.0	6.0
0	7.0×10^2	7.3×10	1.8×10	1.1×10	2.2×10^3	2.5×10^2	3.2×10	2.1×10	5.0×10^2	1.2×10^2	3.0×10	<10
2	2.2×10^3	1.4×10^2	2.3×10	4.7×10	6.6×10^4	5.1×10^2	2.7×10^2	4.4×10	2.2×10^3	1.8×10^2	4.6×10	<10
4	7.6×10^3	4.3×10^2	3.6×10	6.0×10	7.2×10^4	6.4×10^3	7.6×10^2	7.1×10	6.3×10^3	4.2×10^2	5.5×10	<10
6	9.2×10^3	6.3×10^2	2.2×10^2	6.6×10	3.5×10^5	3.0×10^4	9.1×10^2	9.3×10	8.4×10^3	7.4×10^2	8.3×10	<10

destroy these pathogens from dried ostrich egg products. Exposing albumen, yolk or defatted yolk to 4 kGy was quite sufficient to eliminate the above pathogens from the dried egg products. Radiation treatment at doses of 2 - 7 kGy depending on condition of irradiation and the food can effectively eliminate pathogenic non-spore forming bacteria including both long-time recognized pathogens such as *Salmonella spp.* and *Staphylococus aureus* as well as emerging or "new" pathogens such as *Campylobacter*, *Listeria monocytogenes* or *E. coli* 0157: H7 from suspected food products without affecting sensory, nutritional qualities (Farkas, 1998). Candidates of radiation decontamination are mainly poultry, red meat, egg products and fishery products (Borsa *et al.*, 2004).

In another study, 1 log cycle inactivation of coliforms was achieved at the dose of 0.2 kGy, while for spore-forming bacteria, the dose required was in the order of 5 kGy (Rawat *et al*., 1998). Kamat *et al.* (2003) reported that exposing coriander leaves to low dose of gamma rays (1 kGy) was efficient for bacterial decontamination and elimination of potential pathogens without affecting the keeping quality up to 2 weeks storage at 8 - 10°C.The effectiveness of irradiation for pathogenic microorganism inactivating (*Staphylococcus aureus*, *Llisteria ivanovii*, *Salmonella typhimurium* & *E. coli*) in the prepared foods of animal origin has been also demonstrated by Cheorun *et al.* (2005).

Although total mold and yeast contaminated ostrich egg products was relatively lower than total bacterial counts, but their counts were also above the safety limits (< 200 cfu/g) since they recorded 700, 2200 and 500 cfu/g for dried albumen, yolk and defatted yolk and their counts increased during cold storage (Table VI). The same data show that these fungi contaminated the eggs products were more resistant to gamma radiation than the bacteria and they need 6 kGy to decrease their count to the safety level. It was also observed that highest TFC was found in egg yolk in control and irradiated samples. This could be attributed to the high nutritive value and high lipid content of egg yolk.

It was found interesting to identify these fungi contaminating dried, whole egg and defatted yolk and their resistance to both cold storage and gamma radiation. Tables VII and VIII showed that 21 species of fungi belonging to 8 genera contaminated dried, whole ostrich egg and were identified as *Alternaria(3), Aspergillus(8), Botrytis(1), Cladosporium(2), Fusarium(2), Penicillium(3), Rhizobus(1), Syncephalastrum(1).* Mean-while only 12 species of fungi belonging to 7 genera contaminated defatted yolk. Only genus *Rhizopus (Rhizopus oryzae)* was not evident in defatted yolk beside 8 species of the other genera (*Al. chlamydospora, Asp. candidus, Asp. fumigatus, Asp. oryzae, Asp. terrus, Asp. ustus, Asp. versicolor* & *P. chryzogenum*) indicating the un-suitable of defatted, whole egg product to their growth. During storage at 5°C, several genera and species were un-detected either in dried, whole egg or defatted yolk. After 6 months of cold storage, only 4 species belonging to 3 genera were detected in dried whole

Table VII. Effect of irradiation and cold storage on the survival of fungi species contaminated dried whole ostrich eggs

Time	0 kGy		2 kGy		4 kGy	6 kGy
	Al. alternata	*Botrytis cinerea*	*Al. alternata*	*Clad. cladosporioides*	*Al. alternata*	*Al. alternata*
	Al. brassicola	*Clad. cladosporioides*	*Al. brassicola*	*Clad. herbarum*	*Al. brassicola*	*Al. chlamydospora*
	Al. chlamydospora	*Clad. herbarum*	*Al. chlamydospora*	*Fus. dimerum*	*Al. chlamydospora*	*Clad. cladosporioide*
	Asp. candidus	*Fus. dimerum*	*Asp. candidus*	*Fus. oxysporum*	*Asp. candidus*	*Clad. herbarum*
0 months	*Asp. flavus*	*Fus. oxysporum*	*Asp. flavus*	*Pen. chyzogenum*	*Asp. flavus*	*Fus. oxysporum*
	Asp. fumigatus	*Pen. chyzogenum*	*Asp. fumigatus*	*Pen. expansum*	*Asp. niger*	
	Asp. niger	*Pen. expansum*	*Asp. niger*	*Pen. oxalicum*	*Asp. oryzae*	
	Asp. oryzae	*Pen. oxalicum*	*Asp. oryzae*		*Clad. cladosporioide*	
	Asp. terreus	*Rhizopus oryzae*	*Asp. terreus*		*Clad. herbarum*	
	Asp. ustus	*Syn. racemosum*	*Asp. versicolor*		*Fus. dimerum*	
	Asp. versicolor		*Botrytis cinerea*		*Fus. oxysporum*	
	Al. alternata	*Botrytis cinerea*	*Al. alternata*	*Fus. dimerum*	*Al. alternata*	*Al. alternata*
	Al. brassicola	*Asp. versicolor*	*Al. chlamydospora*	*Fus. oxysporum*	*Al. chlamydospora*	*Al. chlamydospora*
	Al. chlamydospora	*Clad. cladosporioides*	*Asp. flavus*	*Pen. chyzogenum*	*Asp. niger*	*Clad. cladosporioides*
	Asp. candidus	*Clad. herbarum*	*Asp. fumigatus*	*Pen. expansum*	*Asp. oryzae*	*Clad. herbarum*
2 months	*Asp. flavus*	*Fus. dimerum*	*Asp. niger*	*Pen. oxalicum*	*Clad. cladosporioides*	*Fus. oxysporum*
	Asp. fumigatus	*Fus. oxysporum*	*Asp. oryzae*		*Clad. herbarum*	
	Asp. niger	*Pen. chyzogenum*	*Asp. terreus*		*Fus. oxysporum*	
	Asp. oryzae	*Pen. expansum*	*Asp. Versicolor*			
	Asp. terreus	*Pen. oxalicum*	*Clad. cladosporioides*			
	Asp. ustus	*Syn. racemosum*	*Clad. herbarum*			
	Al. alternata	*Asp. terreus*	*Al. chlamydospora*	*Clad. herbarum*	*Al. chlamydospora*	*Al. chlamydospora*
	Al. chlamydospora	*Asp. versicolor*	*Asp. flavus*	*Fus. dimerum*	*Asp. niger*	*Clad. cladosporioides*
4 months	*Asp. flavus*	*Clad. cladosporioides*	*Asp. niger*	*Fus. oxysporum*	*Asp. oryzae*	*Clad. herbarum*
	Asp. fumigatus	*Clad. Herbarum*	*Asp. oryzae*	*Pen. expansum*	*Clad. cladosporioides*	*Fus. oxysporum*
	Asp. niger	*Fus. oxysporum*	*Asp. terreus*		*Clad. herbarum*	
	Asp. oryzae	*Pen. expansum*	*Clad. cladosporioides*		*Fus. oxysporum*	
	Al. chlamydospora	*Fus. oxysporum*	*Al. chlamydospora*		*Al. chlamydospora*	*Al. chlamydospora*
6 months	*Asp. niger*		*Asp. niger*		*Asp. niger*	*Clad. Cladosporioides*
	Asp. oryzae		*Asp. oryzae*		*Asp. oryzae*	
	Clad.cladosporioides		*Clad. cladosporioides*		*Clad. Cladosporioides*	

Table VIII. Effect of irradiation and cold storage on the survival of fungi species contaminated defatted ostrich eggs yolk

Time	Doses			
	0 kGy	**2 kGy**	**4 kGy**	**6 kGy**
	Al. Alternata	*Al. alternata*	***Al. alternata***	***Al. alternata***
	Al. Brassicola	*Al. brassicola*	*Asp. flavous*	*Clad. cladosporioides*
	Asp. flavous	*Asp. flavous*	*Asp. niger*	*Clad. herbaum*
	Asp. niger	*Asp. niger*	*Clad. cladosporioides*	*Fus. oxysporum*
0 months	*Botrytis cinerea*	*Botrytis cinerea*	*Clad. herbaum*	
	Clad. cladosporioides	Clad. cladosporioides	*Fus. dimerum*	
	Clad. herbaum	*Clad. herbaum*	*Fus. oxysporum*	
	Fus. dimerum	*Fus. dimerum*		
	Fus. oxysporum	*Fus. oxysporum*		
	Pen. expansum	*Pen. expansum*		
	Pen.oxalicum	Pen.oxalicum		
	Syn. racemosum			
	Al. Alternata	***Al. alternata***	***Al. alternata***	***Al. alternata***
	Al. Brassicola	*Asp. flavous*	*Asp. niger*	*Clad. cladosporioides*
	Asp. flavous	*Asp. niger*	*Clad. cladosporioides*	*Clad. herbaum*
	Asp. niger	*Clad. cladosporioides*	*Clad. herbaum*	*Fus. oxysporum*
	Botrytis cinerea	*Clad. herbaum*	*Fus. oxysporum*	
2 months	*Clad. cladosporioides*	*Fus. dimerum*		
	Clad. herbaum	*Fus. oxysporum*		
	Fus. dimerum	*Pen. expansum*		
	Fus. oxysporum	*Pen.oxalicum*		
	Pen. expansum			
	Pen.oxalicum			
	Syn. racemosum			
	Al. Alternata	*Asp. flavous*	*Asp. niger*	*Clad. cladosporioides*
	Asp. flavous	*Asp. niger*	*Clad. cladosporioides*	*Clad. Herbaum*
	Asp. niger	*Clad. cladosporioides*	*Clad. Herbaum*	*Fus. oxysporum*
4 months	*Clad. cladosporioides*	*Clad. Herbaum*	*Fus. oxysporum*	
	Clad. herbaum	*Fus. dimerum*		
	Fus. oxysporum	*Fus. oxysporum*		
	Pen. expansum	*Pen. expansum*		
	Asp. niger	*Asp. niger*	*Asp. niger*	*Clad. cladosporioides*
6 months	*Clad. cladosporioides*	*Clad. cladosporioides*	*Clad. cladosporioides*	
	Fus. oxysporum			

egg (*Al. clamydospora, Asp. niger, Asp. oryzae & Cl. cladosporioides*), while 3 species belonging to 3 genera were detected in defatted, whole egg (*Asp. niger, Cl. cladosporioides* & *Fus. oxysporum*) indicating the resistance of these species to cold storage especially *Asp. niger* and *Cl. Cladosporioides*, which existed in both dried whole egg and defatted yolk. Piga *et al.* (2000) maintained the microbiological quality of peeled cactus pear fruits at 4°C for 8 days, while storage at 15°C limited shelf life to 4 days only. Tian *et al.* (2001) found that low temperature inhibited growth and pathogenicity of *Monilia fructicola*. Growth of the fungus on sweet cherries was completely suppressed after 30 days at 0°C. Palou *et al*. (2002) reported that aerial mycelial growth and sporulation of *Monilia fructicola, Botrytis cinerea, Mucor piriformis* and *P. expansum*, were inhibited when stored at 5°C for 4 weeks.

In the mean time, the data in Tables VII and VIII also revealed that exposure of all egg products to 2 kGy of gamma rays was insufficient to eliminate most of the species that contaminated the egg products, since only one species (*Sy. racemosum*) was un-detected either in dried, whole egg or defatted yolk indicating its relative sensitivity to gamma rays compared with other species. On the other hand, only 5 species were detected in dried, whole egg exposed to 6 kGy of gamma rays identified as *Al. alternata, Al. chlamydospora, Cl. cladosporioides, Cl. herbarum* and *F. oxysporum.* The same species except *Al. chlamydospora* were also detected in defatted yolk exposed to the same level of radiation indicating their relatively high resistance to irradiation. Radiation resistance of fungi differs with the genus, species and even within the strains of the same species. Generally, *Fusarium* and *Alternaria* species are more resistant to radiation than *Aspergillus* and *Penicillium* species (Sommer, 1973; Saleh *et al.*, 1988). Chuanyao *et al.* (1993) reported that exposure to radiation dose 0.3 - 0.9 kGy obviously decreased rotting of apple fruits. Aziz *et al.* (1997) reported that the resistance of fungi, isolated from medicinal plants, to gamma radiation was in the following order: *Fusarium solani, F. oxysporum, Aspergillus fumigatus, A. flavus, A. parasiticus and A. ochraceous.* Hegazi *et al.* (2000) found that irradiation dose 3 kGy was required to reduce the growth of *Al. alternata* proving its relative resistance to gamma radiation.

During storage of irradiated egg products at 5°C, some species gradually disappeared and at the end of 6 months of cold storage, only *Al. chlamydospora* and *Cl. cladosporioides* existed in dried, whole egg samples exposed to dose level 6 kGy, while *Cl. Cladosporioides* was the only survival strain detected in defatted yolk samples exposed to the same dose level indicating its relatively high resistance to both radiation and cold storage.

Chemical investigations. Table IX revealed the effect of cold storage at 5°C and gamma irradiation on the amino acids content of dried albumen of ostrich eggs. It is clear that the effect of cold storage for 6 months on total amino acids (either essential or non-essential) of albumen was relatively higher than that occurred by irradiation with 6 kGy. Total amino acids decreased from 272.5 mg/g to 241 mg/g after 6 months of cold storage (11.6%), while they decreased to 256.2 mg/g (6%) after the irradiation process with dose level 6 kGy. Mean-while the irradiated samples decreased to 225.5 mg/g (17.3%) after 6 months of cold storage. The effect of the irradiation process on total amino acids was almost the same in case of yolk (5.8%) or defatted yolk (5.5%) as clearly shown in Tables X and XI. The effect of cold storage on total amino acids of whole yolk was relatively higher (19.1%) than that occurred in albumin or

Table IX. Effect of irradiation on amino (mg/g sample on dry basis) of albumen ostrish eggs

Amino acid (mg/g)	Zero time		After 6 months (5°C)	
	Control	6.0 kGy	Control	6.0 kGy
Essential amino acid				
Theronine	16.5 ±0.286	15.0 ±0.212	14.2 ±0.253	13.5 ±0.261
Valine	15.3 ±0.343	13.8 ±0.196	12.9 ±0.278	12.0 ±0.188
Methionine	3.0 ±0.098	2.4 ±0.147	2.2 ±0.057	1.6 ±0.057
Isoleucine	12.6 ±0.139	12.6 ±0.180	12.0 ±0.237	11.0 ±0.286
Leucine	25.8 ±0.196	24.6 ±0.343	23.1 ±0.327	21.5 ±0.367
Phenylalanine	12.6 ±0.220	12.3 ±0.237	11.4 ±0.073	10.9 ±0.269
Histidine	7.2 ±0.122	6.0 ±0.090	5.7 ±0.049	5.1 ±0.041
Lysine	19.2 ±0.237	18.1 ±0.212	16.5 ±0.229	15.3 ±0.335
Total EAA	112.2 ±1.765	104.8 ±1.617	98.0 ±1.502	90.9 ±1.804
Non Essential amino acid				
Aspartic acid	24.6 ±0.408	23.7 ±0.490	21.6 ±0.367	20.4 ±0.327
Serine	22.5 ±0.139	21.6 ±0.572	19.2 ±0.163	18.4 ±0.114
Glutamic acid	41.7 ±0.563	39.9 ±1.470	38.7 ±0.760	36.3 ±0.351
Proline	17.2 ±0.204	17.1 ±0.041	16.8 ±0.384	16.5 ±0.294
Glycine	9.9 ±0.122	8.7 ±0.114	8.4 ±0.204	8.0 ±0.147
Alanine	13.2 ±0.302	12.9 ±0.318	12.3 ±0.229	10.9 ±0.196
Cystine	6.6 ±0.065	5.1 ±0.073	4.8 ±0.057	4.2 ±0.098
Tyrosine	13.2 ±0.302	11.4 ±0.327	10.8 ±0.212	10.2 ±0.163
Arginine	11.4 ±0.229	11.0 ±0.229	10.5 ±0.114	9.7 ±0.057
Total non-EAA	160.3±2.335	151.4±3.633	143.1±2.490	134.6±1.747
Total amino acid	272.5±4.099	256.2±5.250	241.1±3.993	225.5±3.552

Table X. Effect of irradiation on amino (mg/g sample on dry basis) of whole yolk ostrish eggs

Amino acid (mg/g)	Zero time		After 6 months (5°C)	
	Control	6.0 kGy	Control	6.0 kGy
Essential amino acid				
Theronine	7.8 ±0.073	6.6 ±0.082	5.4 ±0.245	5.4 ±0.033
Valine	6.6 ±0.065	6.6 ±0.098	5.4 ±0.139	4.8 ±0.302
Methionine	0.6 ±0.024	0.6 ±0.041	0.4 ±0.016	0.4 ±0.057
Isoleucine	6.0 ±0.131	6.0 ±0.090	5.4 ±0.180	4.8 ±0.204
Leucine	11.4 ±0.229	10.8 ±0.196	9.8 ±0.114	9.0 ±0.114
Phenylalanine	5.4 ±0.065	5.4 ±0.147	4.2 ±0.073	4.2 ±0.073
Histidine	3.6 ±0.073	3.6 ±0.073	3.0 ±0.090	3.0 ±0.286
Lysine	10.0 ±0.188	10.2 ±0.163	9.4 ±0.327	9.2 ±0.163
Total EAA	52.2±0.849	49.8±0.890	43.0±1.184	40.8±1.233
Non Essential amino acid				
Aspartic acid	12.0 ±0.229	11.2 ±0.188	10.8 ±0.196	10.2 ±0.253
Serine	12.0 ±0.302	10.8 ±0.204	9.0 ±0.302	8.4 ±0.237
Glutamic acid	16.8 ±0.261	15.0 ±0.310	12.0 ±0.269	12.0 ±0.188
Proline	0.0	0.0	0.0	0.0
Glycine	4.2 ±0.073	4.2 ±0.024	3.0 ±0.237	3.0 ±0.73
Alanine	6.6 ±0.082	6.6 ±0.106	5.4 ±0.114	4.8 ±0.098
Cystine	0.6 ±0.033	0.6 ±0.016	0.6 ±0.049	0.6 ±0.024
Tyrosine	4.8 ±0.139	4.2 ±0.057	4.2 ±0.033	3.6 ±0.114
Arginine	8.4 ±0.229	8.4 ±0.188	7.2 ±0.163	6.8 ±0.188
Total non-EAA	65.4±1.347	61.0±1.094	52.2±1.363	49.4±1.176
Total amino acid	117.6±2.205	110.8±1.984	95.2±2.547	90.2±2.409

defatted yolk (9.8%). The effects either due to radiation or cold storage were mainly on theronine, leucine, lysine, glutamic acid and sereine. At very high radiation dose levels, Rhodes (1964) found differences between the mean values for each amino acid before and after irradiation at dose levels of 50 to 200 kGy. On the other hand, Krishna *et al.* (1988) reported that no significant change in amino acid composition when proteins in foods were irradiated in the range below 50 kGy. The effect of ionization radiation of ^{60}Co was studied by Hajos *et al.* (1990) on egg-white proteins. The effect of radiation on the protein structure was investigated in the dose range of 0 - 12 kGy. The effect of the treatment was compared in fresh, frozen, and freeze dried sample and in a 1% aqueous solution of egg-white. In aqueous solution electrophoretic investigation suggested the formation of radiation induced aggregates induced by radiation at doses of 1.5, 6.0 and 12.0 kGy whereas their effects in fresh egg-white were much smaller. The effect of radiation was found to be much smaller in the freeze-dried and frozen samples. Diehl (1995) reported that a large portion of the energy deposited in an irradiated protein goes into protein denaturation, i.e. changes in secondary and tertiary structure, rather than into destruction of constituent amino acids. These changes are similar to those that occur as a result of heating, but are far less pronounced. Degradation of proteins to smaller polypeptides can occur as a result of the splitting of carbon-nitrogen bonds and disulfide bridges. He added that radiation damage to the amino acids in proteins is limited, with little change in amino acid composition generally being observed at doses below 50 kGy.

The effect of gamma rays and cold storage on the relative percentages of fatty acids composition of dried ostrich yolk eggs is presented in Table XII. It is clear from the data that the effect of irradiation and cold storage was different from each other. After exposure of the dried yolk to dose level 6 kGy, the percentages of myristic C 14:0 and palmitic C 16:0 acids increased, while palmitoleic C 16:1 and stearic C 18:0 acids slightly decreased. Non-pronounced increase or decrease in the relative percentage of the other fatty acids, were observed due to the radiation process. Mean-while, after 6 months of cold storage at 5^{o}C the relative percentages of palmitoleic C 16:1 and linoleic C 18:2 acids increased, while stearic C 18:0 and oleic C 18:1 acids decreased. Fatty acid C 12:0 was not detected after the cold storage period, but the relative percentages of other fatty acids remain almost un-changed. These results are in agreement with most previous investigators, who have dealt with fatty acids existing in different oils or food. Hammer and Wills (1979) mentioned that irradiation dose of 10 kGy had little effects on the fatty acids compositions of lard and coconut oil. Also, Hafez *et al.* (1985) observed no changes in the fatty acids (C 16:0 C 18:1 & C 18:2) at different radiation doses (20, 40, 60, 80 & 100 kGy) but negative correlation was found between linolenic acid and radiation dose. This high negative correlation indicated that a high radiation dose caused a decrease in linolenic acid.

Table XI. Effect of irradiation on amino (mg/g sample on dry basis) of defatted yolk ostrish eggs

Amino acid (mg/g)	Zero time		After 6 months (5°C)	
	Control	6.0 kGy	Control	6.0 kGy
Essential amino acid				
Theronine	12.0 ±0.106	12.0 ±0.196	10.8 ±0.082	10.8 ±0.196
Valine	10.8 ±0.114	10.2 ±0.163	10.2 ±0.073	9.0 ±0.188
Methionine	3.0 ±0.090	2.4 ±0.082	1.8 ±0.065	1.7 ±0.057
Isoleucine	10.8 ±0.302	10.2 ±0.082	9.6 ±0.073	9.6 ±0.131
Leucine	19.8 ±0.384	18.6 ±0.196	17.4 ±0.327	16.0 ±0.359
Phenylalanine	10.2 ±0.163	9.6 ±0.131	9.0 ±0.098	8.4 ±0.327
Histidine	6.6 ±0.057	6.6 ±0.180	6.0 ±0.204	5.4 ±0.147
Lysine	17.4 ±0.065	16.2 ±0.163	16.2 ±0.237	15.0 ±0.278
Total EAA	90.6±1.282	85.8±1.192	81.0±1.159	75.9±1.682
Non Essential amino acid				
Aspartic acid	19.2 ±0.237	18.6 ±0.278	18.0 ±0.367	16.8 ±0.294
Serine	18.6 ±0.212	17.4 ±0.057	17.4 ±0.114	16.8 ±0.139
Glutamic acid	28.2 ±0.302	26.8 ±0.645	25.2 ±0.327	24.6 ±0.400
Proline	18.6 ±0.310	18.0 ±0.637	17.4 ±0.229	17.2 ±0.188
Glycine	7.2 ±0.073	6.6 ±0.114	6.6 ±0.082	6.0 ±0.073
Alanine	10.8 ±0.212	10.2 ±0.082	9.6 ±0.131	9.6 ±0.220
Cystine	3.6 ±0.082	3.0 ±0.041	2.4 ±0.065	1.8 ±0.024
Tyrosine	9.6 ±0.131	9.0 ±0.98	9.0 ±0.073	7.8 ±0.196
Arginine	15.0 ±0.212	13.8 ±0.294	13.2 ±0.163	13.0 ±0.212
Total non-EAA	130.8±1.772	123.4±2.245	118.8±1.551	113.6±1.747
Total amino acid	221.4±3.054	209.2±3.437	199.8±2.711	189.5±3.429

Table XII. Relative percentage of fatty acid composition of irradiated ostrish yolk egg at beginning and end of storage period

Fatty acid	Relative % at zero time			
	0 kGy	2 kGy	4 kGy	6 kGy
Lauric C12:0	0.2 ±0.016	0.2 ±8.165^{-03}	0.3 ±0.024	0.4 ±0.024
Myristic C14:0	1.0 ±0.057	1.0 ±0.065	1.3 ±0.033	1.9 ±0.098
Palmitc C16:0	3.9 ±0.098	4.2 ±0.163	5.6 ±0.294	6.1 ±0.408
Palmitoleic C16:1	33.3 ±0.898	33.4 ±0.735	32.7 ±0.653	31.7 ±0.735
Stearic C18:0	8.9 ±0.735	8.3 ±0.327	7.6 ±0.490	7.5 ±0.327
Oleic C18:1	37.4 ±0.900	37.6 ±0.653	37.3 ±0.490	37.5 ±0.898
Linoleic C18:2	14.6 ±0.572	14.4 ±0.408	14.5 ±0.408	14.2 ±0.572
Linolenic C18:3	0.8 ±0.057	0.8 ±0.033	0.8 ±0.016	0.8 ±0.033
Relative % after 6 months of storage (5°C)				
Lauric C12:0	ND	ND	ND	ND
Myristic C14:0	0.9 ±0.049	0.9 ±0.057	0.9 ±0.054	0.9 ±0.030
Palmitc C16:0	3.6 ±0.163	3.9 ±0.163	4.4 ±0.122	6.2 ±0.465
Palmitoleic C16:1	39.7 ±0.735	39.4 ±0.980	38.2 ±0.980	38.1 ±0.939
Stearic C18:0	5.2 ±0.408	5.9 ±0.327	6.2 ±0.245	6.6 ±0.286
Oleic C18:1	32.1 ±0.735	32.2 ±1.388	32.1 ±0.996	31.7 ±1.266
Linoleic C18:2	16.7 ±0.653	16.1 ±0.245	16.4 ±0.694	15.0 ±0.547
Linolenic C18:3	1.8 ±0.073	1.7 ±0.065	1.7 ±0.073	1.6 ±0.065

Trotter (1999) reported that after a post-irradiation storage period of 28 days, little effect on the lipid content in egg yolk was observed. Increasing radiation doses up to 3 kGy resulted in no significant changes in the levels of the individual fatty acids in egg yolk lipids compared to the non-irradiated control. Also, Jo *et al.* (2002) found that irradiation of sausage sandwiches prepared with soy bean oil did not change the fatty acid composition of the products. Mohamed (2003) analysed the fatty acids of non-irradiated and irradiated ready-to-eat meat and found that exposure to gamma radiation at dose levels 1.5, 3, and 4.5 kGy induced very little changes in the quantities of the various fatty acids.

On the other hand Hassan *et al.* (1988) observed a decrease in un-saturated fatty acids with the increase in irradiation dose and prolongation of storage period. Singh *et al.* (1991) mentioned that the most susceptible site for free radical attack in a lipid molecule is at a double bond. The most affected lipids during irradiation are thus the poly un-saturated fatty acids that bear two or more double bonds available for reaction. They concluded that each additional double bond in a fatty acid increases its rate of oxidation by a factor or two.

CONCLUSION

It could be recommended that irradiation dose level 6 kGy is a promising treatment for decontamination of dried ostrich egg products. This treatment is enough to eliminate food borne pathogens and keep the products nutritive value and hygienic quality within safe levels as recommended by food and health organizations, either directly after irradiation or during cold storage.

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