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RESPONSE OF PHYSICAL AND ORGANOLEPTIC VARIABLES OF POULTRY EGGS TO GAMMA RADIATION

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Abstract

Although considerable endeavors in prevention of contamination, an increasing tendency in the occurrence of food borne illnesses caused by non spore forming pathogenic bacteria are indicated in many countries. Hygienic and sanitized practices can diminish the rate of contamination however the most key pathogens cannot be currently eliminated from most farms nor is it possible till now to eradicate them by principal practice of sanitation but the most helpful treatment among them is to process the products with ionizing radiation. Gamma irradiation is a plausible tool for the preservation and decontamination of different food stuffs. Current research work was carried out to know physical and organoleptic variables of poultry eggs in response to gamma radiation along with the effect on storage stability of shell eggs. Physical properties parameters like foam density, foam volume, weight contents, volume contents and density did not show any significant alteration except for viscosity which was altered on exposure to gamma radiation. Similarly organoleptic variables also didn’t show any variation. Findings of the study suggest that this method for decontamination of shell eggs is best among all other preservation techniques because with irradiation treatment sensory quality and physical parameters are to a greater extent unaffected or changed up to a suitable range in contrast to other quarantine treatments.

Key words: Pathogenic, Gamma irradiation, Organoleptic variable, Decontamination, Quarantine

Introduction

An egg is amongst the most important nourishment on earth and can be a salubrious component of our diet. Though, it can be easily contaminated just lik raw meat, poultry and fish[5]. Naturally egg has four shielding layers which hinder bacteria from penetrating the yolk: the inner and outer membranes between the shell and the albumen, the albumen, and the vitelline (yolk) membrane. In addition, there is a membrane-like substance called as cuticle.This cuticle shut the pores of the egg-shell and impedes the entry of bacteria into the egg. Nevertheless, the cuticle can be affected in the cleaning process [9]. Bacteria like *Salmonella* Enteritidis *(Salmonella enterica* subsp. *enterica* serovar Enteritidis) has created complications for the poultry industry and this microbe have very harmful effect on human health which can also cause losses economically. Only in the United States of America these disease-causing microorganisms have incurred a fiscal loss of more or less 1.1 billion dollar to their economy and also infected almost 700,00 persons [26]. A large number of methods are commonly used for removal of any fecal contamination present on the shell of eggs. At the moment, detergents and other sanitizing agents are used to diminish the activity of microbes present on shells of poultry eggs. These agents lessen the concentration of such pathogenic microbes by 2-3 $\log_{10}$ when conditions are convenient for the employment of such products [4]. Not denying their beneficial use but, still detergents cannot prevent the entry of *salmonella* species to human population through infected shell eggs. Washing measures can only reduce microbes present on shell of egg but little misappropriation of washing methods can cause access of pathogenic bacteria into egg interior [5]. Research accomplished by different countries shows that this problem is escalating for the last two decades and is big risk for economic stability [11, 25]. Gamma irradiation due to its effective nature is more useful on sensitive food items like poultry eggs and meat. Irradiation is an alternative method used for food storage, processing and preservation. Food irradiation is a technique used for food protection that is used as a balance to other food preservation techniques. Research based data published in 1994 indicated that usage of gamma irradiation at average level can eradicate non sporing bacteria like *Salmonella* in different food items [8].

Food and drug administration (FDA) authority of the United States of America has allowed the exposure of food items to gamma irradiation in the range of up to 3 kGy to lower the intensity of pathogenic bacteria such as *Salmonella* in eggs [21]. Literature studies shows that less work have been done on the effect of irradtion on food safety and preservation and also their findings are contradictory. Further studies carried out by different nutritionists shows that irradiation caused damage in the quality features of shell eggs [16, 19, 20]. But further research showed that an average dose of ionizing irradiation have no considerable damaging role on the sensory characteristics of shell eggs [3]. This study is novel work in this regard in Pakistan which will open new vistas of research into poultry industry because lot of their money and time will be saved by irradiation technique. The main endeavor of food preservation techniques is to maintain the nutritive worthiness of food without altering their organoleptic features.

Methods and Materials

Contemporary investigation was performed on shaver eggs in the Nutrition Labs of the Food Science Division (FSD) of Nuclear Institute for Food and Agriculture (NIFA), Peshawar. Sample consisted of fresh, white-shelled shaver eggs acquired from a nearby poultry farm.

Samples Treatment with Gamma Radiation

Eggs samples were exposed to gamma radiation in triplicate at doses of 0, 1, 2, 3 kGy in the ^{60}Co research irradiator available at NIFA, Peshawar. The control and irradiated samples were evaluated for different functional and organoleptic qualities at the start (0-Day) and their subsequent analysis at day 7, 14, 21 and 28.

Analysis of eggs for functional properties

For measurement of viscosity, an appropriate Ostwald viscometer was selected, typically B or D (U-shaped) viscometer. Viscometer was clamped in a vertical direction. Then distilled water was added by pipette in to arm C of the viscometer until it was above the mark A at the top of the bulb. Time was noted for water as the surface falls between marks A and B. The process was repeated thrice and then average time readings were taken. After this the viscometer was rinsed with sample. The sample was added by pipette into the arm C of viscometer until reached to the arm A. The process was repeated thrice and average time readings were taken. The viscometer was emptied and rinsed with distilled water.

Further for Foam Volume, volume of Irradiated and controlled eggs was determined by measuring 100 grams of egg white mixed in a mixer at maximum speed for 3 minutes. To determine specific density, the foam formed was transferred into a weighing dish and then weighed [24].

Another property called as foam sstability of irradiated and controlled eggs was determined by measuring drainage after 30 min of holding the foam at room temperature. Drainage was collected in a 100-ml graduated volumetric cylinder, and the volume was read [24].

Sensory Evaluation:

Sensory or organoleptic variables like color, appearance, aroma, texture and taste evaluation of shell eggs was determined by boiling the eggs. Taste, odour, color and texture of irradiated and controlled boiled eggs were evaluated by a panel (10 members) of experienced judges. For Boiled eggs, irradiated and controlled boiled eggs were presented to a panel of trained judges for organoleptic evaluation. The sensory criteria especially the taste, odor, color and texture of the eggs products from irradiated and controlled shell eggs were evaluated according to Lavrova and Krilova [13]. Each member independently evaluated the egg products for taste, odor, color and texture on a 10-point hedonic scale (1 = extremely dislike, 10 = extremely like).

Statistical Analysis:

Computer package Statistix of the data was used for statistical analysis. Statistics were performed via completely randomized design (CRD) with 5 (storage intervals) × 6 (Radiation doses) factorial arrangement.

Discussion

Food irradiation technologies have been well acknowledged and explored by the scientific community for five decades such that some researchers refuse to debate the issues of food safety and wholesomeness of the processed product [18]. It is also believed that the peril of vulnerability to diseases contracted by eating contaminated food is significantly reduced with the application of irradiation [6]. Foaming property of shell eggs was enhanced when treated with gamma irradiation between 2-3 kGy which is due to the structural modifications of protein content in white of eggs and an increase in the surface hydrophobic property [14]. Ball and Gardner established that increase in foam quantity of egg white treated with gamma radiations was owing to scission process of protein [4]. However, it was proposed by Min that there was substantial reduction in both foam volume and its stability by rise in dose of gamma irradiation [17]. Ma and Huang argued that chief functional characteristics of shell eggs such as beating, blending, and thermal gelation are enhanced by irradiation doses ranging from 1 to 3 kGy [15, 10].

Wong also observed that irradiated eggs had greater foaming stability and more constant viscosity than eggs treated with heat [23]. Pasteurization is the best method for internal contamination of shell eggs [14]. They proposed that ovomucin crashing is responsible for the lowering of egg white viscosity. But due to sensitive nature of eggs this method has very controlled role because at high thermal treatment its protein content is damaged [22].

In our study only viscosity of poultry eggs was altered which showed varied values while the rest of the variables remain unaffected as can be shown in the tables. Viscosity was influenced by radiation treatment (p=0.0000) and different storage intervals as well (p=0.0029). As evident from Table 1, average viscosity was 2.63 kg/m/s at the beginning and dropped significantly during first week to 1.77 kg/m/s. But Egg Density was not influenced by radiation treatment while storage had significant (P =0.0272) effect. Average Egg Density was 1.05 at the start and dropped insignificantly during the fourth week to 0.99. Radiation doses did not influence this parameter and the value ranged from 1.01 to 1.01 for the control and variously treated eggs (Table 2). Concurrently Foam Volume was also not influenced by radiation treatment while storage had also non-significant (P =0.0006) effect; Average foam volume was 37.25 ml at the beginning and increased significantly during the first week to 46.83 ml. There was non-significant reduction during the subsequent 3 weeks of storage. Radiation doses did not affected this parameter and the value ranged from 48.80 ml to 51.27 for the control and variously treated eggs as apparent from Table: 3.

Furthermore Weight content was not influenced by radiation treatment while storage had significant (P =0.0263) effect. Average Egg weight as 58.82 g at the beginning and dropped significantly during the fourth week to 56.36 g as obvious from Table 4. Alike Egg volume was also not impacted by radiation treatment while storage had also non-significant (P =0.0056) effect. From Table: 5 it is clear that average Egg volume was 55.62 ml at the beginning and fall down to 54.58 ml during the fourth week. Lastly, Foam density was not influenced by radiation doses and the value ranged from 0.12 to 0.12 g/ml for the control and variously treated eggs (see Table 6).

Compounds having sulfur in it are highly sensitive to irradiation, so protein having cysteine and methionine amino acids are very susceptible to ionizing radiations [1]. It is also reported that compounds containing sulfur in its structure are main cause of bad odor in meat treated with ionizing irradiation [2]. For sensory characteristics Appearance of boiled eggs was not influenced by radiation treatment while storage had also non-significant (P =0.5325) effect. Average appearance of boiled eggs was 8.08 at the beginning and dropped significantly during the first week to 7.70 as can be seen from table 7. Similarly odour of boiled eggs was not influenced by radiation treatment as average odour of boiled eggs was 8.04 at the beginning and slightly increased during the first week to 8.00 (Table 8). Texture of boiled eggs was also not influenced by radiation treatment. As can be noted from Table 9, average texture of boiled eggs was 8.12 at the beginning and dropped very little during the first week to 8.08. There were non-significant reductions during the subsequent 3 weeks of storage. Taste of boiled eggs was also not influenced by radiation treatment while storage had also non- significant (P =0.4284) effect. As can be noted from Table 10, average taste of boiled eggs was 7.87 at the beginning and dropped slightly during the first week to 7.67. There was non-significant reduction during the subsequent 3 weeks of storage. Overall acceptability was not influenced by radiation treatment while storage also had non-significant (P =0.8240) effect; interaction of radiation doses and storage time also had non-significant (P= 0.9752) effect on this parameter. As can be noted from Table 11, average Overall acceptability of boiled eggs was 8.01 at the beginning and dropped little during the first week to 7.96. There was non-significant reduction during the subsequent 3 weeks of storage. Radiation doses did not influenced this parameter and the value ranged from 8.00 to 7.82 for the control and variously treated eggs.

Tab:1 Analysis of Variance Table for Viscosity contents in shell eggs

Source	DF	SS	MS	F	P
Replications	2	0.9596	0.47978		
Radiation doses	3	15.8882	5.29605	16.96	0
Storage	4	6.0608	1.51519	4.85	0.0029
Radiation X Storage	12	17.4519	1.45433	4.66	0.0001
Error	38	11.8688	0.31234		
Total	59	52.2292			

Tab: 2 Analysis of Variance Table for Foam volume contents in shell eggs

Source	DF	SS	MS	F	P
Replications	2	160.53	80.267		
Radiation doses	3	556.18	185.394	2.59	0.0672
Storage	4	1797.27	449.317	6.27	0.0006
Radiation X Storage	12	2076.73	173.061	2.41	0.0193
Error	38	2723.47	71.67		
Total	59	7314.18			

Tab: 3 Analysis of Variance Table for foam density in shell eggs

Source	DF	SS	MS	F	P
Replications	2	0.00142	0.00071		
Radiation doses	3	0.00134	0.00045	0.75	0.5274
Storage	4	0.01415	0.00354	5.95	0.0008
Radiation X Storage	12	0.01613	0.00134	2.26	0.0279
Error	38	0.02259	0.00059		
Total	59	0.05562			

Tab: 4 Analysis of Variance Table for Weight contents of shell eggs

Source	DF	SS	MS	F	P

Replications	2	36.044	18.022		
Radiation doses	1	119.014	119.014	14.26	0.002
Storage	3	104.409	34.803	4.17	0.0263
Radiation X Storage	3	2.92	0.973	0.12	0.9489
Error	14	116.819	8.344		
Total	23	379.205			

Tab: 5 Analysis of Variance Table for Volume contents of shell eggs

Source	DF	SS	MS	F	P
Replications	2	72.396	36.1979		
Radiation doses	1	6.51	6.5104	0.74	0.4046
Storage	3	171.615	57.2049	6.49	0.0056
Radiation X Storage	3	7.031	2.3437	0.27	0.8489
Error	14	123.438	8.817		
Total	23	380.99			

Tab:6 Analysis of Variance Table for Density contents of shell eggs

Source	DF	SS	MS	F	P
Replications	2	0.00361	0.0018		
Radiation doses	1	0.02344	0.02344	12.07	0.0037
Storage	3	0.02405	0.00802	4.13	0.0272
Radiation X Storage	3	0.00291	0.00097	0.5	0.6884
Error	14	0.02719	0.00194		
Total	23	0.0812			

Tab:7 Analysis of Variance Table for Appearance of shell eggs

Source	DF	SS	MS	F	P
Replications	2	0.0583	0.02917		
Radiation doses	3	2.0167	0.67222	1.26	0.3018
Storage	4	1.7083	0.42708	0.8	0.5325
Radiation X Storage	12	4.025	0.33542	0.63	0.8045
Error	38	20.275	0.53355		
Total	59	28.0833			

Tab:8 Analysis of Variance Table for Odour of shell eggs

Source	DF	SS	MS	F	P
Replications	2	0.9083	0.45417		
Radiation doses	3	0.8833	0.29444	0.44	0.7257
Storage	4	1.7083	0.42708	0.64	0.6384
Radiation X	12	8.1583	0.67986	1.02	0.454

Storage					
Error	38	25.425	0.66908		
Total	59	37.0833			

Tab:9 Analysis of Variance Table for Texture of shell eggs

Source	DF	SS	MS	F	P
Replications	2	0.1333	0.06667		
Radiation doses	3	1.3833	0.46111	0.53	0.6659
Storage	4	0.8583	0.21458	0.25	0.9105
Radiation X Storage	12	6.4083	0.53403	0.61	0.8191
Error	38	33.2	0.87368		
Total	59	41.9833			

Tab-10: Analysis of Variance Table for Taste of shell eggs.

Source	DF	SS	MS	F	P
Replications	2	0.14427	0.07214		
Radiation doses	3	0.52187	0.17396	1.17	0.3321
Storage	4	0.22292	0.05573	0.38	0.8240
Radiation X Storage	12	0.60833	0.05069	0.34	0.9752
Error	38	5.62656	0.14807		
Total	59	7.12396			

Tab-11: Analysis of Variance Table for Overall acceptability of shell eggs.

Source	DF	SS	MS	F	P
Replications	2	0.4000	0.20000		
Radiation doses	3	1.1500	0.38333	0.62	0.6081
Storage	4	2.4417	0.61042	0.98	0.4284
Radiation X Storage	12	4.5583	0.37986	0.61	0.8187
Error	38	23.6000	0.62105		
Total	59	32.1500			

Results

Physical variables of poultry eggs by exposure to Gamma radiation is shown in the tables below. As evident from the tables that viscosity was influenced by radiation treatment and different storage intervals while others parameters like foam density, foam volume, weight contents, volume contents and density did not show any significant alteration on exposure to gamma radiation.

Table: 1

Storage Intervals (Weeks)	Viscosity (kg/m/s) of shell eggs Radiation Doses (kGy)				Mean
	0	1	2	3	
1	5.17	2.04	1.66	1.67	**2.63A**
2	1.61	1.91	1.9	1.72	**1.78B**
3	2.87	2.09	1.66	1.66	**2.07B**
4	3.17	1.9	2.1	1.68	**2.21AB**
5	2.02	1.75	1.74	1.58	**1.77B**
Mean	**2.97A**	**1.94B**	**1.81B**	**1.66B**	

Table: 2

Storage Intervals (Weeks)	Foam Density of shell eggs Radiation Doses (kGy)				Mean
	0	1	2	3	
1	0.12	0.14	0.16	0.17	**0.15 A**
2	0.12	0.14	0.11	0.09	**0.12 B**
3	0.12	0.09	0.08	0.12	**0.10 B**
4	0.11	0.14	0.1	0.12	**0.11 B**
5	0.11	0.11	0.11	0.1	**0.11 B**
Mean	**0.12A**	**0.12A**	**0.11A**	**0.12 A**	

Table: 3

Storage Intervals (Weeks)	Foam Volume (ml) of shell eggs Radiation Doses (kGy)				Mean
	0	1	2	3	
1	43.33	39	34	32.67	**37.25B**
2	41.33	39.33	47	62.33	**47.50A**
3	42.66	57.66	62.67	51	**53.50A**
4	47.33	37.33	52.33	50.33	**46.83A**
5	46	48	48	60	**50.50A**
Mean	**44.13B**	**44.26B**	**48.80AB**	**51.27A**	

Table : 4

Storage Intervals (Weeks)	Wt. (grams) contents of shell eggs Radiation Doses (kGy)				Mean
	0	1	2	3	
1	56.02	59.4	60.78	59.07	**58.82A**
2	50.43	55.08	57.09	54.84	**56.36B**
Mean	**53.22B**	**57.24A**	**58.94A**	**56.96A**	

Table: 5

Storage Intervals (Weeks)	Volume contents (ml) of shell eggs Radiation Doses (kGy)				Mean
	0	1	2	3	
1	53.33	52.5	60	56.67	**55.62A**
2	51.67	53.33	58.33	55	**54.58A**
Mean	**52.50B**	**52.92B**	**59.17A**	**55.83AB**	

Table: 6

Storage Intervals (Weeks)	Density of shell eggs Radiation Doses (kGy)				Mean
	0	1	2	3	
1	1.04	1.12	1.02	1.03	**1.05A**
2	0.98	1.03	0.97	0.99	**0.99B**
Mean	**1.01B**	**1.07A**	**0.99B**	**1.01B**	

Table: 7

Storage Intervals (Weeks)	Appearance of shell eggs Radiation Doses (kGy)				Mean
	0	1	2	3	
1	7.67	8.33	8	8.33	**8.08A**
2	7.67	7.67	8	7.67	**7.75A**
3	7.67	8.33	8.33	7.33	**7.91A**
4	8.33	8.67	7.67	7.83	**8.12A**
5	7.83	8	7.67	7.33	**7.70A**
Mean	**7.83A**	**8.20A**	**7.93A**	**7.70A**	

Table: 8

Storage Intervals (Weeks)	Odour of shell eggs Radiation Doses (kGy)				Mean
	0	1	2	3	
1	8.67	8.33	8.17	7	**8.04A**
2	8.67	8	8.33	8.67	**8.41A**
3	8.33	7.83	7.33	8.33	**7.96A**
4	7.67	8.33	8	8	**8.00A**
5	8	8	8.33	7.67	**8.00A**
Mean	**8.26A**	**8.10A**	**8.03A**	**7.93A**	

Table: 9

Storage Intervals (Weeks)	Texture of shell eggs Radiation Doses (kGy)				Mean
	0	1	2	3	
1	8.67	7.83	8	8	**8.12A**
2	7.67	8.33	8.67	7.33	**8.00A**
3	7.66	8.33	7.67	8	**7.91A**
4	7.66	7.67	8.17	7.67	**7.80A**
5	8.66	7.83	8.17	7.67	**8.08A**
Mean	**8.06A**	**8.00A**	**8.13A**	**7.73A**	

Table: 10

Storage Intervals (Weeks)	Taste of shell eggs Radiation Doses (kGy)				Mean
	0	1	2	3	
1	7.83	8.33	7.33	8	**7.87A**
2	7.66	8	7.67	7.33	**7.67A**
3	7.66	7.66	7.67	7.33	**7.58A**
4	8.33	7.66	7.83	8.67	**8.12A**
5	7.67	8.33	7.67	8.33	**8.00A**
Mean	**7.83A**	**8.00A**	**7.63A**	**7.93A**	

Table: 11

Storage Intervals (Weeks)	Overall acceptability of shell eggs Radiation Doses (kGy)				Mean
	0	1	2	3	
1	8.2	8.2	7.81	7.83	**8.01A**
2	7.92	8	8.16	7.75	**7.96A**
3	7.83	8.05	7.75	7.75	**7.84A**
4	8	8.08	7.91	8.05	**8.01A**
5	8.04	8.05	7.96	7.75	**7.95A**
Mean	**8.00A**	**8.07A**	**7.92A**	**7.82A**	

Similarly organolptic properties i.e taste, appearance, odour of shell eggs were also not altered which is evident from the tables shown below:

Values are means of 3 replications

Mean values followed by different letters are significantly (P=0.05) different from each other.

Conclusion

In conclusion, irradiation of shell eggs does not cause significant deterioration in functional properties, color, or odor of poultry eggs and it can be used as an alternative to decontaminate shell eggs. There is need of public understanding regarding gamma irradiation because greater part of people confound this term with nuclear energy or harmful rays for human health. Furthermore, there is need of more use of this technique for preservation of poultry products and other food processing industries to save time and energy and also make food safer, healthier and store for a longer period of time without any harmful effect.

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