Microbial quality and safety of table eggs marketed in commercial channels

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Keywords: microbial contamination; market eggs; preservation; egg coating oil; refrigerated storage; microbial safety; food borne illness

Keeping in view the relative high consumption of eggs and egg products and its association with outbreaks of food poisoning, the bacterial and fungal contamination of table eggs at the farm and in marketing channels was estimated. The initial microbial contamination of table eggs was estimated, as per the procedure recommended by AOAC (2000), immediately after collecting fresh table eggs directly on the farm, where birds were reared in cages. Later, eggs were collected for the same purpose in wholesale and retail markets. Moreover, the effect of the use of an Egg Coating Oil under different storage conditions and periods was also assessed.

Eggs were collected in sterile plastic trays. The sampling operation included collection of 6 eggs under each category. Analysis of egg contents for microbial load was carried out after thorough cleaning of the eggshell surface with surgical spirit. The contents were pooled and homogenized in a sterile beaker before testing.

The microbiological contamination of farm fresh eggs was very low and well within the APHA (1992) recommendations. The level of contamination in market eggs was found to be negligible in the egg contents and hence they were microbiologically safe for human consumption. The Egg Coating Oil application and the refrigerated storage have acted synergistically in keeping the microbial contamination of the eggs within the safety limits.

Introduction

Although, majority of freshly laid eggs are sterile inside, the shells soon become contaminated with litter, droppings, dust and prevailing environment. Food-borne illness caused by micro-organisms is a large and growing public health problem. Most countries with systems for reporting cases of food-borne illness have documented significant increase over the past decades in the incidence of diseases caused by micro-organisms in food, including *Salmonella, Campylobacter jejuni* and Enterohaemorrhagic *Escherichia coli* and parasites such as Cryptosporidium, Cryptospora and Trematodes (WHO, 2005). The increased incidence of food-borne diseases due to microbiological hazards is the result of a multiplicity of factors, all associated with our fast-changing world. Changes in food production result in new types of food that may harbour less common pathogens. Changes in eating patterns, such as a preference for fresh and minimally processed foods, the increasingly longer interval between processing and consumption of foods and the increasing prevalence of eating foods prepared outside the home all contribute to the increased incidences of food borne illness ascribed to micro-organisms.

Numerous microbes may be found on the shell and under conducive conditions may enter the eggs, grow and cause their spoilage. Thus, the egg becomes unfit for consumption and can spread infection to consumers. India is an egg exporting country and there is great potential for expansion of this egg export due to the very low egg production cost, there is an immense need for quality control especially on microbial safety in order to improve its egg exporting potential.

Hence a study was planned to investigate the presence of various pathogens in hens' eggs collected from farm to marketing channels and were compared with APHA (1992) and ICMSF (2002) recommendations. Moreover, some preservative methods were tried to suggest remedial measures for the prevention of food poisoning incidences through eggs.

Materials and methods

SAMPLE COLLECTION

***Experiment 1*:** Eggs were collected during the sampling operations from different cage layer farms, retail and wholesale shops (with a sample size of 6 eggs in each) in and around the Chennai metropolitan city and placed in sterile plastic trays.
***Experiment 2*:** 150 Eggs were collected from a cage layer farm that supplies eggs to many retail shops in the city.

EXPERIMENTAL DESIGN

***Experiment 1*:** The eggs were examined on the day of collection. For the microbiological study 6 eggs under each category were pooled in a sterile beaker.
***Experiment 2*:** 150 Eggs were spray washed using a food grade Chlorine dioxide solution (0.1%), air dried under a fan and were randomly grouped into 4 groups to conduct a 2x2 factorial experiment involving 2 storage temperatures with and without Egg Coating Oil (ECO) spraying.

The 4 treatments were as follows:

1. Preservation at room temperature : without Egg Coating Oil (Control)
2. Preservation at 4^{o}C : without Egg Coating Oil
3. Preservation at room temperature : with Egg Coating Oil
4. Preservation at 4^{o}C : with Egg Coating Oil

Control eggs were not subjected to any preservation method like refrigeration and ECO and were assessed for microbial contamination at weekly intervals up to 4 weeks.

ECO eggs stored at room temperature were also assessed at weekly intervals up to 8 weeks.

The refrigerated eggs with and without ECO were studied at bi-weekly intervals up to 12 weeks.

MICROBIOLOGICAL PROCEDURES

Eggshells were cleaned using cotton swabs moistened with sterile water and wiped with surgical spirit. After thorough disinfection, the eggs were cracked with sterile surgical forceps and the contents of all 6 eggs were dropped into a sterilized beaker. As per AOAC (2000), the egg sample was homogenized and 1g material was added to a test tube containing 9 ml of sterile normal saline solution (10-1 dilution). It was thoroughly mixed and 10 fold serial dilutions were made which served as inoculum for culturing on to different media viz., Plate Count Agar, Brilliant Green Agar, Mac Conkey Agar, Sabouraud's Dextrose Agar, Listeria Selective agar, Yersinia Selective Agar and Campylobacter Selective Agar for appropriate microbial counts. A pour plate technique was performed using 10-5 and 10-6 dilutions for bacterial and fungal counts in duplicates. Tests were carried out within 15 minutes to avoid the growth or death of micro-organisms. All plates were incubated at 37oC for 48 hours excluding Campylobacter, Yersinia and yeasts and moulds. Campylobacter was incubated in a CO2 incubator whereas plates for the enumeration of Yersinia and yeasts and moulds were incubated at ambient temperature. After 48 hours of incubation the bacterial counts were enumerated using a colony counter and expressed as "Number of colony forming units (cfu)/g egg material".

Results and discussion

The results are summarised in Tables 1, 2 and 3. From Table 1, it was inferred that the Total bacterial counts from farm fresh eggs, wholesale shop eggs and retail shop eggs were 1x 10^5, 2x10^5 and 4x10^5 cfu/g respectively. But in all these categories *Coliform-, Salmonella-, Listeria-, Campylobacter-, Yersinia-* and yeasts and moulds counts were found to be <1x10^5 cfu/g (<1x10^5 cfu/g represents plates with no colonies as per APHA, 1992). The initial microbial contamination in both the experiments indicated that the eggs are microbiologically safe for human consumption. These findings are in line with the APHA (1992) recommendations pertaining to the microbial contamination of the eggs. Microbial contamination in eggs collected from retail and wholesale shops in terms of Total bacterial count, *Coliform* count and *Salmonella* count were found to be within the limits set in the ICMSF (2002) recommendations.

Eggs preserved at room temperature without ECO showed an abrupt increase of < 1 to > 200 x 10^5 cfu/g of Total counts, < 1 to 25 x 10^5 cfu/g of Coliform counts and < 1 to 14 x 10^5 cfu/g of *Salmonella*

counts. But *Listeria, Campylobacter, Yersinia* and yeasts and moulds counts remained < $1x10^5$ cfu/g throughout the storage period of 4 weeks (Table 2).

Eggs stored at room temperature preserved with ECO exhibited a gradual increase of < 1 to 51 x 10^5 cfu/g of Total counts, < 1 to 13 x 10^5 cfu/g of Coliform counts and < 1 to 5 x 10^5 cfu/g of *Salmonella* counts, whereas the other specific bacterial counts used in this study remained < 1 x 10^5 cfu/g throughout the 8 weeks storage period.

During the storage of 12 weeks period, the eggs preserved at refrigerated conditions with ECO showed an increase of counts ranging from < 1 to 19 x 10^5 cfu/g of total counts, < 1 to 9 x 10^5 cfu/g of *Coliform* counts, < 1 to 2 x 10^5 cfu/ g of *Salmonella* count and < 1 x 10^5 cfu/g for the remaining specific bacterial and Yeasts and moulds counts. Whereas there was only a slight increase ranging from < 1 to 7 x 10^5 cfu/g of total counts, < 1 to 4 x 10^5 cfu/g of *Coliform* counts and < 1 x 10^5 cfu/g for the remaining specific bacterial and fungal counts as stated by Verma *et al.,* (2003) from the internal contents of eggs preserved without ECO.

Gast and Beard (1992) reported that 3 % of freshly laid eggs, 4 % of eggs held for 7 days at 7.2°C and 16 % of eggs from 25°C held for 7 days were contaminated with *Salmonella* sp., whereas, this study revealed that *Salmonella* sp. was observed in eggs stored at ambient temperatures only after 3 weeks of storage. Saeed and Koons (1993) and Chen *et al*., (1996) noticed minimal or no growth in refrigerated eggs at 4°C and such storage was stated to be necessary to reduce microbial growth and rate of penetration into the egg.

ADAS and MAFF recommend a storage temperature of 12°C for table eggs (SAC, 2005). However, this lies on par to this study that the refrigerated storage eggs with and without ECO remained safe for human consumption even after 12 weeks of storage.

The findings of this study agree with the recommendations of USDA (2003) where fresh shell eggs should be used within 3 - 5 weeks after lay.

This study has revealed that usage of ECO in preservation of eggs at room temperature gives satisfactory results in reducing the microbial contamination during a storage period of 5 weeks, when compared to the eggs stored at room temperature without ECO over a period of 2 weeks. It has also been observed that preservation at refrigerated condition with ECO over a period of 12 weeks showed almost similar bacterial and yeasts and moulds counts with the eggs preserved without ECO over the same period of storage. The ECO application and refrigerated storage has acted synergistically in controlling the microbial contamination in the table eggs up to 12 weeks satisfactorily.

Conclusion

The market eggs of Chennai Metropolitan city and farm fresh eggs were found to be microbiologically safe for human consumption. Combination of refrigerated storage with an Egg Coating Oil spray was found to be more effective in maintaining the microbial safety of table eggs. Indian farm and market eggs are safe, which meet any countries standards and therefore there is a high scope for export potential.

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Table 1 Microbial contamination of farm fresh and market eggs (x 10^5 cfu/g).

Type of microbe	Farm fresh eggs	Wholesale shop eggs	Retail shop eggs
Total bacterial count	1	2	4
Coliform	<1	<1	<1
Salmonella	<1	<1	<1
Listeria	<1	<1	<1
Campylobacter	<1	<1	<1
Yersinia	<1	<1	<1
Yeasts & moulds	<1	<1	<1

Table 2 Effect of storage at room temperature with and without ECO on the microbial contamination of table eggs at various periods (x 10^5 cfu/g).

Preservation method	Period of storage (weeks)	Microbial contamination (x 10^5 cfu/g)						
		Total count	*Coli.*	*Sal.*	*Lis.*	*Camp.*	*Yer.*	yeasts and moulds
Room temperature storage, without Egg Coating Oil	0	<1	<1	<1	<1	<1	<1	<1
	1	13	4	<1	<1	<1	<1	<1
	2	28	7.5	<1	<1	<1	<1	<1
	3	>200	12	9	<1	<1	<1	<1
	4	>200	25	14	<1	<1	<1	<1
Room temperature storage with Egg Coating Oil	0	<1	<1	<1	<1	<1	<1	<1
	1	<1	<1	<1	<1	<1	<1	<1
	2	<1	<1	<1	<1	<1	<1	<1
	3	<1	<1	<1	<1	<1	<1	<1
	4	<1	<1	<1	<1	<1	<1	<1
	5	18	2	<1	<1	<1	<1	<1
	6	25	5	2	<1	<1	<1	<1
	7	34	9	1	<1	<1	<1	<1
	8	51	13	5	<1	<1	<1	<1

Table 3 Influence of refrigerated storage with and without ECO on microbial contamination of table eggs at various periods (x 10^5 cfu/g).

Preservation method	Period of storage (weeks)	Microbial load (x 10^5 cfu/g)						
		Total count	*Coli.* count	*Sal.* count	*Lis.* count	*Camp*count	*Yer.* count	Yeasts and Moulds
Refrigerated storage without Egg Coating Oil	0	<1	<1	<1	<1	<1	<1	<1
	2	<1	<1	<1	<1	<1	<1	<1
	4	<1	<1	<1	<1	<1	<1	<1
	6	<1	<1	<1	<1	<1	<1	<1
	8	6	<1	<1	<1	<1	<1	<1
	10	9	3	<1	<1	<1	<1	<1
	12	19	9	2	<1	<1	<1	<1
Refrigerated storage with Egg Coating Oil	0	<1	<1	<1	<1	<1	<1	<1
	2	<1	<1	<1	<1	<1	<1	<1
	4	<1	<1	<1	<1	<1	<1	<1
	6	<1	<1	<1	<1	<1	<1	<1
	8	3	2	<1	<1	<1	<1	<1
	10	5	3	<1	<1	<1	<1	<1
	12	7	4	<1	<1	<1	<1	<1