Effect of pasteurization of shell egg on its quality characteristics under ambient storage

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Abstract Three thermal processes viz. dry (55°C, 2 h), moist (57°C, 5 min) and microwave (power 9, 20 sec) were studied to determine their efficacy for the pasteurization of intact chicken eggs based on the extent of inactivation of artificially inoculated *Salmonella typhimurium* (ST) in the yolk of shell eggs and alteration in albumen protein solubility (APS). Moist heat treatment was superior to others as it brought about 2 log cfu/ml reduction of inoculated ST in much less time than dry heating but changes in APS were not significant. Subsequent quality evaluation of normal (uninoculated) eggs subjected to moist heat pasteurization during 15 days of ambient (35°C, 36% RH) storage revealed no significant effect on percent loss in egg weight, albumen pH, viscosity of albumen and yolk and thiobarbituric acid values between pasteurized and unpasteurized eggs. Pasteurization had no adverse effect on foam volume and foam stability of albumen during storage in comparison to those of raw eggs. Naturally occurring aerobic mesophilic bacteria, coliforms, staphylococci, yeast and moulds on the egg shell surface and in egg contents got markedly reduced by pasteurization of shell eggs and their multiplication also retarded during storage. Both pasteurized and raw eggs remained fairly acceptable sensorily up to 10 days of storage at ambient conditions.

Keywords Shell egg · Pasteurization · *Salmonella typhimurium* · Inactivation

Introduction

Microbial contamination of eggs, particularly with pathogenic bacteria is of increasing concern globally. As a result, the research on the shell egg pasteurization has drawn the attention of researchers in the recent past so as to provide wholesome table eggs to consumers (Hou et al. 1996, Stadelman et al. 1996, Hank et al. 2001). Although the major causes of spoilage of eggs are microbial contaminants and alteration in their chemical constituents during storage, incidence of contamination of eggs with pathogenic bacteria, especially *Salmonella* serotypes *S. typhimurium* (ST) and *S. enteritidis* (SE) has been of great concern from egg borne human salmonellosis viewpoint (Humphrey 1994, Henzler et al. 1998, Krishnamoorthy et al. 2003, Suresh et al. 2006, Messens et al. 2007). Attempts to eliminate these egg-borne pathogens from laying flocks to overcome vertical transmission have not been very successful. This has led to an alternative approach to explore the application of liquid egg pasteurization systems to intact shell eggs. Stadelman et al. (1996) subjected chicken eggs artificially inoculated with high levels of SE cells to thermal treatments to obtain yolk temperature of 55°C followed by holding at this temperature for varying times and found a drastic reduction of this pathogen without a significant change in egg albumen functional property. In a similar study carried out by Hank et al. (2001), no adverse effect was observed in the albumen quality between pasteurized (55°C, 3 h) and unpasteurized egg during 8 weeks of refrigeration (4°C) storage. In view of very limited information on shell egg pasteurization, and wide variation in the type and level of microbial contaminants (Bajaj et al. 2003, Reu et al. 2008) owing to variation in the egg production, handling and storage practices between developed and developing countries, attempts were made to optimize pasteurizing treatment for chicken shell eggs and evaluate its effect on their quality.
Materials and methods

Fresh chicken eggs were cleaned using 0.5% sodium carbonate solution (pH 11.8, 43 ± 0.5°C) followed by sanitizing in 100 ppm sodium hypochlorite solution prior to drying under fan. The cleaned eggs were candled to remove damaged eggs with hairline cracks.

Artificial inoculation: ST (E 2391) having resistance against nalidixic acid (NA) was procured from National Salmonella Centre, IVRI, Izatnagar. Hektoen enteric agar media containing NA (30 mg/l) was used to culture the resistant isolate to inhibit the growth of other bacteria. The broader end of clean intact shell eggs was gently perforated using 18-G needle. An inoculum of ST containing 10^7 cells in 100 μl was injected into the centre of yolk of each egg through the perforation using 25G needle. After inoculation, the holes were sealed with paraffin and the eggs were subjected to three pasteurizing treatments viz. dry heat (hot air oven) at 55°C for 2 h, moist heat (circulating water bath) at 57°C for 15 min and radiant energy (microwave oven) at power 9 for 20 sec. The yolk core temperature was measured by inserting a portable digital probe thermometer (Model ST-9269 Hwa Tai Tech. Co., Ltd, Taiwan) in the centre of the yolk through the perforation made into the broad end of thermally treated eggs. The heat treated and unheated (control) eggs were broken aseptically, yolk was separated from albumen, cultured, incubated (37°C, 18–24 h) and dark green colonies with light green colloidal zone having bull’s eye appearance were counted and the counts were expressed as log cfu/g yolk.

Storage quality evaluation: Based on the magnitude of destruction of inoculated ST and egg albumen protein solubility assay as an indicator of its denaturation, moist heat (water bath) pasteurizing treatment was selected for keeping quality study. Both unpasteurized (control) and circulating water bath (57°C, 15 min) pasteurized eggs were stored for 15 days at ambient conditions (35 ± 0.5°C, 36 ± 2% RH) and evaluated at 5 days intervals for physico-chemical, microbiological and sensory quality.

Analysis: The loss in egg weight during storage was expressed as % of initial weight. Egg albumen pH was determined as per AOAC (1995). The distillation procedure of Tarladgis et al. (1960) was followed for measuring thiobarbituric acid (TBA) value in egg yolk whereas albumen protein solubility was measured as per Morr et al. (1985). Interior quality of eggs viz. Haugh unit (Haugh 1937), albumen index (Heiman and Carver 1936), yolk index (Funk 1948) and functional property viz. foam volume and foam stability (Baldwin 1977) were measured. Albumen and yolk Viscosity was determined directly, using a Brookfield Viscometer (Model DV-II PRO Viscometer USA). Aerobic plate count, coliforms, staphylococci, yeast and moulds counts were determined as per APHA (2001). All these measurements were done in triplicates, except egg weight loss and interior egg quality for which 10 eggs were utilized per treatment. Sensory evaluation for appearance, texture, flavour and overall acceptability was performed using 7-point Hedonic scale ranging from 7 (like very much) to 1 (dislike very much) by seven in-house semi-trained panelists. The data were analyzed statistically (Snedecor and Cochran 1994).

Results and discussion

ST inactivation: Application of dry heat (55°C, 2h) and moist heat (57°C, 15 min) brought about reduction (p <0.05) in ST counts by 2.1 log and 2.0 log cfu/ml yolk, respectively while the same in eggs subjected to microwave heating (power 9, 15 sec) was found to be merely 1.2 log cfu/ml yolk (Table 1). Such variability observed in the reduction of ST counts might be due to variable yolk core temperature attained with different thermal treatments. Inoculated ST was not destroyed completely in any of these heat pasteurization treatments possibly due to non-attainment of critical temperature of 55 to 56°C necessary for maximum inactivation of salmonellae without denaturation of egg white proteins (Stadelman et al. 1996). Heat resistance of salmonellae is pH dependent and is maximum in the pH range of 5 to 6. This could be one of the reasons for heat resistance exhibited by ST in the yolk (pH 6.0–6.1) of fresh eggs as also reported by Cunningham (1977). In an earlier study, immersion of eggs in water for 30 min at 57°C also did not cause complete destruction of ST and prolongation of holding time at this temperature resulted in the coagulation of egg albumen proteins (Van Lith et al. 1995). However, in present study, water bath heating appeared more practicable than hot air oven as the former process required much less time due to faster heat transfer than the latter while both these pasteurization treatments exerted almost similar ST inactivation (Table 1).

Table 1 Effect of shell egg pasteurization on inactivation of inoculated Salmonella typhimurium in egg yolk and changes in albumen protein solubility

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yolk core temp, °C</th>
<th>S. typhimurium count, log cfu/ml</th>
<th>Albumen protein solubility, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated (Control)</td>
<td>-</td>
<td>5.9 ± 0.09^a</td>
<td>87.5 ± 2.49</td>
</tr>
<tr>
<td>Microwave oven, * 20 sec</td>
<td>50</td>
<td>4.6 ± 0.59^b</td>
<td>82.4 ± 1.36</td>
</tr>
<tr>
<td>Water bath, 57°C, 15 min</td>
<td>53</td>
<td>3.9 ± 0.50^b</td>
<td>84.6 ± 1.29</td>
</tr>
<tr>
<td>Hot air oven, 55°C, 2 h</td>
<td>54</td>
<td>3.8 ± 0.86^b</td>
<td>83.3 ± 0.93</td>
</tr>
</tbody>
</table>

*Power (9) Means ± SE with different superscripts in a column differ significantly (p <0.05)