

Effectiveness of a Wool Based Packaging System on the Abundance of Surface Spoilage Microorganisms on Meat Products

¹Rabya A. Lahmer, ⁴Angela Morris, ³Simon F Curling, ³Graham A Ormondroyd,,
²Davey L. Jones, ²Prysor A. Williams

¹Department of Food Science and Technology, University of Tripoli (UT), Libya

²School of Environment, Natural Resources & Geography, College of Natural Sciences, Bangor
University, UK, LL57 2UW

³ BioComposites Centre, Bangor University, Deniol Road , Bangor, UK LL57 2UW

⁴ Woolcool, Units 11-12, Beacon Road, Walton Industrial Estate, Stone, Staffordshire, UK ST15 0NN

ABSTRACT

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Correspondent Author:
Rabya A. Lahmer
Email: rabyalahmer@yahoo.co.uk

Sheep wool can be used as an eco-friendly type of packaging that, due to its complex physical and chemical composition, can also help control humidity and reduce condensation. Given these properties, the potential of wool to be used as packaging liners for the transport of food products is of interest. The present study assessed the microbiological quality of meat packaged and stored at room temperature for 40 h in conventional EPS (expanded polystyrene) boxes and cardboard boxes lined with wool using standard, approved culturing techniques. The findings suggest that the wool may have potential market value as packaging liners for transporting meat, and possibly other food products. Further research is needed to allow better characterization to real-world conditions, and understanding of how wool used as a packaging liner could help maintain food quality on a larger scale.

KEYWORDS

Contamination, Microbiological
Quality, Packaging, Raw Meat,
Spoilage.

فاعلية نظام التغليف بالصوف على الكائنات الحية الدقيقة المسببة للفساد على سطح اللحوم الطازجة

¹ربيعة عبد القادر الاحمر، ⁴موريس أنجيلا، ³سيمون الضفر، ³غراهام اورموندرويد، ²ديفي جونز، ²برسول يليامز

¹قسم علوم الأغذية، جامعة طرابلس، ليبيا

²كلية البيئة والموارد الطبيعية والجغرافيا، كلية العلوم الطبيعية، جامعة بانجور، المملكة المتحدة

³مركز BioComposites، جامعة بانجور

Woolcool، وحدات 11-12، منارة الطريق، Beacon Road, Walton Industrial Estate, Stone, Staffordshire

المستخلص

قيمت هذه الدراسة الجودة الميكروبيولوجية للحوم المغلفة والمخزنة عند درجة حرارة الغرفة لمدة 40 ساعة في صناديق الـ EPS التقليدية وصناديق الورق المقوى المبطن مع Woolcool® باستخدام تقنيات الزرع القياسية المعتمدة. كما وتمت دراسة نماذج فارغة أيضا من هذه الصناديق معرضة لنفس ظروف الخزن. لجميع التحليل الميكروبي وجد ان EPS كان أعلى في العد الميكروبي مقارنة بـ WCUN و WC باستثناء بكتيريا القولون. بشكل عام، كشفت WCUN أعدادا أقل بكثير من WCUN باستثناء تقدير الفطريات. هذا قد يعني أن المنتج له قيمة تسويقية محتملة لغرض نقل اللحوم، وربما غيرها من المنتجات الغذائية، إلا أن هذا يتطلب دراسة ومعايرة صلاحية النتائج اخذا بعين الاعتبار التكاليف ونتائج، عوامل أخرى مثل التكاليف، ونتائج مقاييس الحرارة والامتثال يكون بإجراء دراسة ميكروبيولوجية على نطاق أكبر

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بريد الكتروني: rabyalahmer@yahoo.co.uk

الكلمات الدالة

التلوث، الجودة الميكروبيولوجية، التغليف، اللحم، الفساد .

Introduction

Meat spoilage is mainly caused by biological deterioration of a product, which is potentially hazardous to health (Anon, 2012; Haque *et al.*, 2008) and considered unacceptable by the consumer due to defects such as off-flavours, off-odour, sour taste, discoloration and slime formation (Nychas *et al.*, 2008; Maltin *et al.*, 2003; Ouattara *et al.*, 2000). Poor operational techniques during the slaughter of animals and the subsequent stages of processing and storage of the meat may lead to elevated microbial counts and hence reduce shelf life and quality (Dave and Ghaly, 2011; FAO, 2007). Packaging is important in maintaining the quality and safety of meat and the type of packaging can influence the microbial flora of meat (Olaoye and Ntuen, 2011). It can also affect the relative humidity of the meat environment, with lower humidity associated with lower microbial counts. Central to the above factors is the control of temperature, with meat needing to be stored at refrigeration temperatures (typically 1-4°C) to restrict microbial growth. Packaging that can maintain such temperatures during transportation aids in the delay of growth of spoilage micro-organisms (Renerre and Labadie, 1993; Dillon and Board, 1991). Wool is often used as an insulator in the construction industry due to its complex physical and chemical composition, which helps control humidity and reduce condensation (Woolcool.com, 2012). Wool based packaging, consisting of 100% pure sheep's wool, hygienically sealed in recyclable food-grade wrap, may therefore have potential as a packaging liner for the transport of meat.

This study was conducted to investigate whether raw meat stored in boxes with lined or unlined wool, is of different microbiological quality to meat transported in conventional expanded polystyrene (EPS) boxes.

Materials and methods

1. Sample collection

Three cardboard boxes were prepared: one containing lined Wool (WC), one unlined Wool (WCUN) and one EPS. A 10 kg variety of fresh meat (Lamb joints) were packed into each box

(Figure 1), a variety of meat was stored at room temperature for 72 h. The boxes were then opened, and swabs taken from the top, middle and bottom surface of each box and from the condensed liquid found on the surface of meat packs. Samples were also taken from the lamb shoulder joint from each box. They were then analyzed for microbiological contamination as described below.

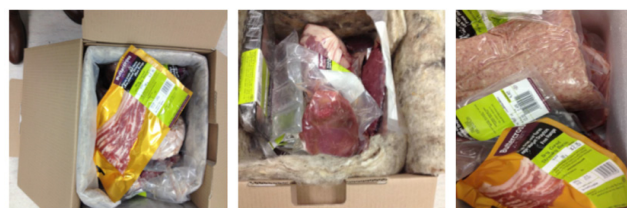


Figure 1. Sample boxes with meat (left-right: Wool lined, Wool unlined, expanded polystyrene boxes).

2. Microbiological characterization

The following media were used to assay bacteria counts on meat and box surfaces: Plate Count Agar (Oxoid, product no CM0463) for total viable counts (TVC), Malt Extract Agar (Oxoid, product no LP0039) for fungi and Brilliance *E. coli*/coliform agar (Oxoid, product no CM0956) for *E. coli* and coliforms; as described in Lahmer *et al.* (2012). The swabs were inoculated into 10 ml of 1/4-strength Ringer solution (Oxoid, product no. BR002), which was then subject to a ten-fold serial dilution series. A 25 g sub-sample was aseptically removed from the lamb shoulder joint, and mixed with 225 ml of Ringer solutions in a Seward 400 stomacher machine (Seward Ltd., Worthing, UK) at 230 rev min⁻¹ for 30 s (Malpass *et al.*, 2010). One ml of the homogenate was then plated following the serial dilution described previously. Plates were incubated for 48 h at 37°C for TVC, 18-24 h at 37°C for *E. coli* and for 3-4 days at 25°C for fungi. Colonies were counted manually.

3. Sensory qualities

After 72 hours of storage in EPS or Wool packed boxes, the sensory quality of each lamb shoulder joint was compared qualitatively (subjectively), using sensory attributes such as colour and flavor.

4. Data analysis

Data was analyzed through IBM SPSS Statistics

version 16.0 for Windows (SPSS Inc, Chicago, Illinois, USA). All plate count, coliform, yeast and mold were $\log_{10}(y + 1)$ transformed prior to analyses to meet the assumptions of ANOVA. Post-hoc analyses were run using Tukey HSD statistic, unless homogeneity of variance could not be assumed, in which case Games–Howell was used.

Results

1. Microbiological characterization

The results of the microbiological analysis based on the measures of TVC, *E. coli*, other coliforms and fungi are presented in Table 1 and Figure 2. Swab samples taken from the middle and top were negative for the microbes tested in all box types (data not shown). For TVC, post-hoc analyses (Games-Howell) found significant differences between EPS and WCUN ($p < .001$), between EPS and WC ($p = .006$) and between WC and WCUN ($p = .014$). For *E. coli* (Tukey HSD), (bottom, condensate and meat sample) there was a significant difference between EPS and WC ($p = .003$), between EPS and WCUN ($p < .001$) and between WC and WCUN ($p = .001$). For coliforms, (bottom, condensate and meat sample) post-hoc analyses (Tukey HSD) found a significant

difference between EPS and WCUN ($p < .001$) and between WC and WCUN ($p < .001$), but no significant difference between EPS and WC ($p = .069$). For fungi (bottom, condensate and meat sample) (Games-Howell) the EPS and WCUN comparison was significant ($p = .009$), as was EPS and WC, $p = .001$ but there was no significant difference between WC and WCUN, $p = .259$. For all microbial measurements, EPS revealed the highest count, with this being significantly higher than WC and WCUN in many cases (with the exception of coliform). In general, WCUN revealed significantly lower counts than WC (except for measurements of fungi).

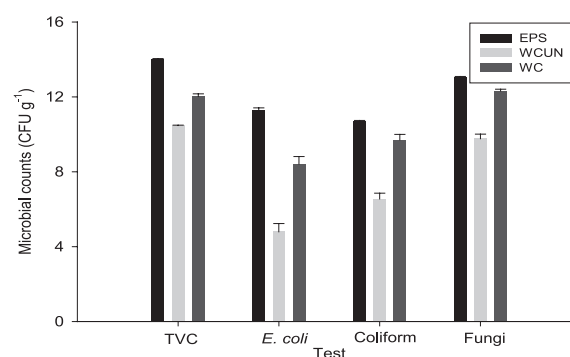


Figure 2. Microbial load analysis in a lamb shoulder joint (log CFUg⁻¹).

Table 1. Microbial counts of swabs taken from EPS boxes containing meat and Woolcool®-lined unlined boxes (WCUN, WC) containing meat. Samples were taken from the top (T), middle (M) and bottom (B) surfaces of boxes; from condensation (C) on meat products; and from a lamb shoulder joint within each box. ‘n.d’ refers to ‘none detected’.

Test	EPS-packed + fresh meat products (CFU ml ⁻¹)					WCUN-packed + fresh meat products (CFU ml ⁻¹)					WC-packed + fresh meat products (CFU ml ⁻¹)				
	T	M	B	C	Meat*	T	M	B	C	Meat*	T	M	B	C	Meat*
Total viable counts	n.d	n.d	0.77	2.26	7.00	n.d	n.d	2.55	1.43	5.23	n.d	n.d	1.69	0.97	6.00
<i>E. coli</i>	n.d	n.d	n.d	n.d	5.64	n.d	n.d	1.33	n.d	2.39	n.d	n.d	n.d	n.d	4.20
Coliform	n.d	n.d	n.d	n.d	5.34	n.d	n.d	n.d	n.d	3.27	n.d	n.d	n.d	n.d	4.85
Fungi	n.d	n.d	n.d	n.d	6.53	n.d	n.d	n.d	n.d	4.88	n.d	n.d	1.67	n.d	5.16

* Lamb shoulder joint

2. Sensory qualities

No difference was detected between meat kept in the two wool packaged boxes (lined and unlined), but meat in the EPS boxes showed some signs of the early stages of spoilage, presumably due to the breakdown of fat, protein and carbohydrates caused by microorganisms (Dave and Ghaly; 2011).

Discussion and Conclusions

In the present study, a variety of meat was stored at room temperature for 72 h in either conventional EPS boxes or cardboard boxes with lined or unlined wool packaging, before being assessed for microbiological quality. For all microbial measurements, EPS revealed the highest count, with this being significantly higher than WC and WCUN in many cases (with the exception of coliform). In general, WCUN revealed significantly lower counts than WC (except for measurements of fungi).

Although based on a limited sample set, these results suggest that wool packaging may be superior to EPS in maintaining the microbiological quality of the meat. The work suggests that the product may have potential market value as packaging liners for transporting meat, and possibly other food products. It should be noted that the study was carried out under small-scale laboratory conditions.

Although the best scientific methodology was practiced throughout, the study has several limitations. Firstly, the number of replicates was low, with each box type tested only once. Secondly, localized bacterial contamination of meat may result in considerable variation of bacteria count between samples. Therefore, directly comparing samples should be done with caution, although the meat types contained within all boxes were the same and the methods used were consistent throughout.

Whilst this paper shows that the wool packaging reduces the presences of microbes in the packaged food further research is needed to allow better characterization in real-world conditions, and understanding of how these packaging liners could maintain food quality on a larger scale. The work should be developed to assess the potential of

contamination points throughout the supply chain and the efficacy of the wool based packaging liners in the preventing of food spoiling due to these points.

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