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# Effectiveness of a wool based packaging system on the abundance of surface spoilage microorganisms on fresh meat

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## Abstract

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. Swabs were taken from a number of areas within the boxes, including the surface of the boxes (at the top, middle and bottom), within the Woolcool® felt fibres, and from condensed liquid found on the surface of meat packs. A lamb breast joint from each box was sampled directly. Plate Count Agar, violet red bile agar, malt extra agar and brilliance *E. coli*/coliform agar were used to assay bacteria numbers found on the different surfaces. 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 characterisation 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

## 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,

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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 (Renerre and Labadie, 1993, Dillon and Board, 1991).

The ability of wool to act as an insulator is accepted and it is often used for such purposes in the construction industry. Due to its complex physical and chemical composition, wool can also help control humidity and reduce condensation (Woolcool® packaging company, 2012). Given these properties, the potential of wool to be used as packaging liners for the transport of meat is of interest. Woolcool® is a eco–friendly type of packaging, made of 100% pure sheep's wool, hygienically sealed in recyclable food–grade wrap[1] (Figure 1).

This study was conducted to determine whether meat stored in boxes lined with Woolcool® is of different microbiological quality to meat transported in conventional expanded polystyrene (EPS).

**Figure 1.** boxes lined with Woolcool®

## Materials and methods

### 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 analysed for microbiological contamination as described below.

**Figure 2**. Sample boxes with meat (left-right: Wool lined, Wool unlined, expanded p olystyrene).

### 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 ¼-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.

### Data analysis

Data was analyzed through IBM SPSS Statistics version 16.0 for Windows. All plate count, coliform, yeast and mold were log10 (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

### 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 (3). 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, $p = 0.259$ (Figure 3).

In the present study, a variety of meat was stored at room temperature for 72 h in either conventional EPS boxes or cardboard boxes lined or unlined with Woolcool®, 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 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, localised 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.

Although based on a limited sample set, these results suggest that Woolcool® may be superior to EPS in maintaining the microbiological quality of the meat. The findings support those of Lamher *et al*. (2012).

**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 |
| *E. coli* | n.d | n.d | n.d | n.d | 5.64 | n.d | n.d | n.d | 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 | 1.27 | 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 | n.d | n.d | 5.16 |

* Lamb shoulder joint

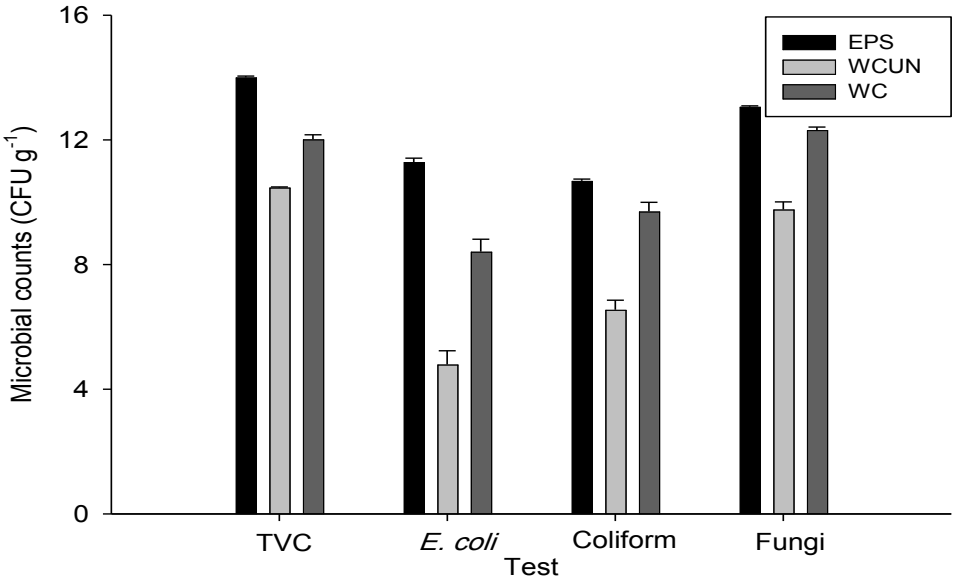


**Figure 3**. Microbial load analysis in a lamb shoulder joint (log $CFUg^{-1}$).

## Conclusions

To conclude, the study revealed 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. Further research is needed to allow better generalisation to real–world conditions, and understanding of how these packaging liners could maintain food quality on a larger scale.

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

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### الملخص

قيمت هذه الدراسة الدراسة الجودة الميكروبيولوجية للحوم المغلفة والمخزنه عند درجة حرارة الغرفة لمدة 40 ساعة في صناديق ال EPS التقليدية وصناديق الورق المقوى المبطن مع ®Woolcool باستخدام تقنيات الزرع القياسية المعتمدة. كما وتمت دراسة نماذج فارغة ايضاً من هذه الصناديق معرضة لنفس ظروف الخزن. لجميع التحليل الميكروبية، وجد ان EPS كان أعلى في العد الميكروبي مقارنه ب wc و wcun باستثناء بكتيريا القولون. بشكل عام، كشفت WCUN أعدادا أقل بكثير من wc 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 اخذاً بعين الاعتبار عوامل اخرى مثل التكاليف، و نتائج مقاييس الحرارة، والامثل يكون بإجراء دراسة ميكروبيولوجية على نطاق أكبر.

مفتاح الكلمات: التلوث، الجودة الميكروبيولوجية، التغليف، اللحم، الفساد