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Feasibility of using cold-set binding with SmartShape technology and development of a process

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Abstract

Cold-set binders allow smaller cuts of meat to be combined to reduce wastage and enable more effective portioning of the cut for food service and retail markets. In this project the combination of cold-set binding and Smartshape technology was applied to cuts of meat. The experiments involved two primals (Insides and Tenderloins), two cold-set binders (Pearl E and Activa KS-LS), varying amounts of each binder and the time to apply the Smartshape after binder application (0 to 4 hours). The procedure that was developed consists of sprinkling the cold-set binder onto the surfaces to be joined, placing the two cuts together, wrapping tightly in cling wrap and holding for at least 30 minutes, before processing in the SmartShape machine. This process worked using the consistent and cut surfaces of the Inside for both cold-set binders. This process also worked for binding the uneven surfaces of a Tenderloin using Pearl E. Activa KS-LS was not successful in binding the surfaces of Tenderloins under the conditions studied. The process was developed on half Tenderloins as the compression rubber in the prototype SmartShape is too short to handle full beef Tenderloins. It is recommended that future versions of the machine have a rubber that is at least 750 mm long. The cold-set binding and Smartshape process produced portion-controlled logs of meat suitable for slicing into even portions

Executive summary

The SmartShape technology enables meat primal cuts to be formed into cylindrical logs, which assists portioning of those cuts for food service or retail markets. Primal cuts such as smaller beef Tenderloins are difficult to portion without considerable wastage and two Tenderloins are often bound together 'top-to-tail' using a cold-set binder. The ideal would be to form these into a consistent shape for portioning using the SmartShape machine. Trials were undertaken to develop a process for cold-set binding and shaping beef primal cuts.

Initial trials were undertaken with muscle portions from beef Insides (*M. semimembranosus* and *adductor femoris*) to determine the conditions for application of the commercial binders, Pearl E and Activa KS-LS, prior to processing in the SmartShape machine. The binders were sprinkled evenly onto the contact surfaces of the samples, wrapped in cling film and stored, chilled for periods of 0.5, 1.0, 2.0 and 4.0 hours prior to processing in the SmartShape. Controls were included which had binder applied, but no Smartshaping. The strength of the bond was measured by conducting adhesion tests using a Lloyd LRX tensile testing machine on raw and cooked samples, 18 to 24 hours after application of the binders. Initial trials with Insides showed that Pearl E provided a stronger bond for both the raw and cooked samples with an adhesion strength approximately twice that of Activa KS-LS. Meat pieces bound with Pearl E could be successfully processed in the SmartShape 30 minutes after application of the binder. Extending the time more than 30 minutes did not change the strength of the bind for Pearl E. For the Insides, samples prepared using Activa KS-LS appeared to have a stronger bond when shaping was applied 60 minutes after bind application, compared to 30 minutes.

From the initial trials, it was determined that for Pearl E, Smartshaping could occur 30 minutes after application of the binder. For Activa KS-LS, it was thought that Smartshaping could occur 1 hour after application of the binder. Thus with the Tenderloins, which had a more uneven surface, these selected times of Smartshaping after binding application were tested. Unfortunately, for Active LS-KS, there was no success in getting a bind between the Tenderloin pieces, except for unshaped control samples left for 18-24 hrs. For Pearl E, Smartshaping of the Tenderloins 30 minutes after application of the binder, and holding for 18-24 hours resulted in an acceptable bind, in both the raw and cooked product. Thus a suitable procedure for preparing and shaping primal cuts is:

- Coat both product surfaces to be bonded by evenly sprinkling with Pearl E at about 1 g/100 cm^2 of total join surface area.
- Immediately place both surfaces together and wrap tightly in cling film.
- Hold the product for a minimum of 30 minutes at refrigeration temperatures.
- Process through the SmartShape machine.

If the product is not to be shaped until the following day, Activa KS-LS may also be a suitable binder as the bond is likely to be strong enough after 18 to 24 hours to withstand the forces during shaping.

The prototype machine used has a rubber compression tube that is 600 mm long. The bottom 80 mm or so of the rubber is not usable due to the nature of the compression system. Full beef Tenderloins are 500 mm or more long. Therefore for future machines, a rubber that is at least 750 mm long is recommended.

Contents

1 Background

The SmartShape machine has been developed to form meat cuts into a uniform cylindrical shape which will aid portion control. The machine is able to shape both cold and hot-boned primals to create innovative red meat products that are of consistent shape, which allows more efficient usage of the product. This results in a cut that can be readily sliced and cooked.

Cuts such as the Tenderloin and Oyster blade are of irregular shape resulting in significant value loss through the trimming required for them to be presentable to the consumer. If these cuts are combined and 'shaped', the wastage through trimming to shape, for consistent cooking and portion size would be significantly reduced. The opportunity exists for value adding to these cuts by using SmartShape in conjunction with cold-set binding. This would broaden the potential applications for the SmartShape technology, increasing carcase utilisation and adding value by combining smaller cuts into larger, consistently shaped 'cuts' suitable for food service and retail markets.

Work done to date has been inconclusive regarding the bond strength using binders on cuts processed in the SmartShape machine. Insufficient work has been done to determine the optimum parameters of binder type, concentration and duration to leave before shaping to achieve successful outcomes.

2 Project objectives

The objectives of the project were to:

1. Conduct a trial to determine the effects of using two different types of binders, with cuts of varying tenderness and shape, using different concentrations of binder, hold ('binding') durations, post bind/shaping chilling and freezing performance and cooking performance.
2. Identify most suitable binder against parameters measured via objective trials of bind strength on raw and cooked meat.
3. Make recommendations for incorporation of the combined cold-set bind and SmartShape technology into the existing adoption and commercialisation strategy for SmartShape technology.

3 Methodology

The SmartShape machine shown in Figure 1 was transported to the Coopers Plains site of CSIRO Food and Nutritional Sciences and installed in the processing area. Three CSIRO staff members were instructed in its operation by Johanne Taylor of Industry and Development, NSW.

The strategy for developing a protocol for binding and shaping beef Tenderloins was to carry out experimental trials on a less expensive cut (Inside) then to confirm the results on Tenderloins. Chilled, vacuum packed Inside red meat primal cuts (Handbook of Australian Meat No. 2035) were purchased from an export establishment for all initial trials. Small beef Tenderloins – side strap off (HAM No. 2160) were used to confirm that the procedure

developed was applicable to the Tenderloins. The Inside consists primarily of the *Mm. semimembranosus* (SM) and the *adductor femoris*, while the Tenderloin was predominately the *M. psoas major* (PM).

Figure 1: SmartShape machine

3.1 Cold-set binders

Two samples of cold-set binders were obtained. A 200 g sample of Pearl E was supplied by Earlee Products of Brisbane, Qld and a 1 kg sample of Activa KS-LS, manufactured in France by Ajinomoto, was supplied by the Brisbane office of Kerry Ingredients. Activa KS-LS is a transglutaminase binder whereas Pearl E is a protein active meat binder. Both are supplied in a light-coloured powder form and were applied by sprinkling the powder on the

surfaces of the meat to be joined. The data sheet supplied with Activa KS-LS specified that it should be mixed with water in the ratio of 1:5 before application but it was found to have poor solubility and was ineffective in bonding. Kerry Ingredients confirmed that it was more effective when applied as a dry sprinkle, thus this technique was used.

3.2 Sample preparation

Samples to be bonded and shaped were cut from the Inside by slicing the primal cut in the direction of the meat fibres to a size to suit the medium (82 mm) or small (75 mm) SmartShape packaging size. The meat was weighed and the area of the surfaces to be bonded was measured. Both surfaces to be bonded were sprinkled with a measured amount of the cold-set binder powder and immediately placed together, then wrapped tightly in cling film. The samples were then placed into a chiller operating at 2 - 3°C for periods of: 0.5, 1.0, 2.0 and 4.0 hours prior to processing through the SmartShape machine. For each binder, four replicates were prepared at each time, in addition to four replicates of the control samples. Control samples were prepared by holding bonded samples in the cling wrap only for 18 to 24 hours, at 2 - 3°C, before testing. After packaging in the SmartShape machine, each sample was clip-sealed at both ends and stored at 2 - 3°C for a minimum of 18 hours before being prepared for adhesion testing of raw and cooked samples.

Tenderloin primal cuts were prepared by adhering them 'top to tail'. As whole adhered Tenderloins were too long (around 500 mm) to be processed through the SmartShape, they were halved laterally before treatment. It is estimated that the maximum length of cut that can be processed through this model of the machine is 450 mm. The tenderloin samples were processed in a similar manner to the Inside meat but only at one time point (30 min for Pearl E and 60 min for Activa KS-LS) determined as the optimum time for bind strength to develop from previous trials. Two half-tenderloin samples were prepared for each binder.

Trials were also undertaken to assess the effect of the amount of binder applied to Inside samples on the strength of the bind. Ten samples were prepared and the surfaces to be joined sprinkled with varying amounts of Pearl E (n = 5) and Activa KS-LS (n = 5). The surfaces were pressed together and the samples wrapped tightly in cling wrap and then stored at 2 to 3°C for 24 hours prior to performing adhesions tests on raw samples.

3.3 Adhesion testing

Samples were removed from the chiller and cut in to two. One portion was used to prepare cooked samples while the other was prepared for measurement of adhesion on raw product.

3.3.1 Cooking procedure

Samples to be cooked were sliced into 25 mm-thick steaks which were cooked on a Silex grill to an internal temperature of 70°C (medium to well done). The grill, with the lid set to a gap of 20 to 25 mm was set to 250°C and the temperature allowed to stabilise between samples. Each steak was cooked for 3 minutes with the lid closed, then turned and cooked for a further 3 minutes. After cooking, steaks were blotted dry, placed into individual plastic bags and placed in a refrigerator operating at 4°C to cool prior to testing.

3.3.2 Sample preparation for adhesion tests

Both raw and cooked samples were sliced into 15 mm steaks which were each cut into 6 mm sections to produce individual test samples (n = 10-12). Each sub-section was then

trimmed to approx 20 mm either side of the binder joining seam. Each sub-sample therefore measured approximately 15 mm (wide) x 6 mm (thick) x 40 mm (long) as shown in Figure 2.

Figure 2: Raw and cooked samples prepared for adhesion tests

3.3.3 Adhesion test

The tests were conducted on a Llyod LRX, using pneumatic clamps to grip the samples. The clamps were positioned 20 mm apart, the sample inserted, and then pulled apart at 100 mm/min until a break was detected. The force to separate the sample at the binder join was recorded in Newtons (N). Results for samples that did not break at the seam but between the muscle bundles were discarded.

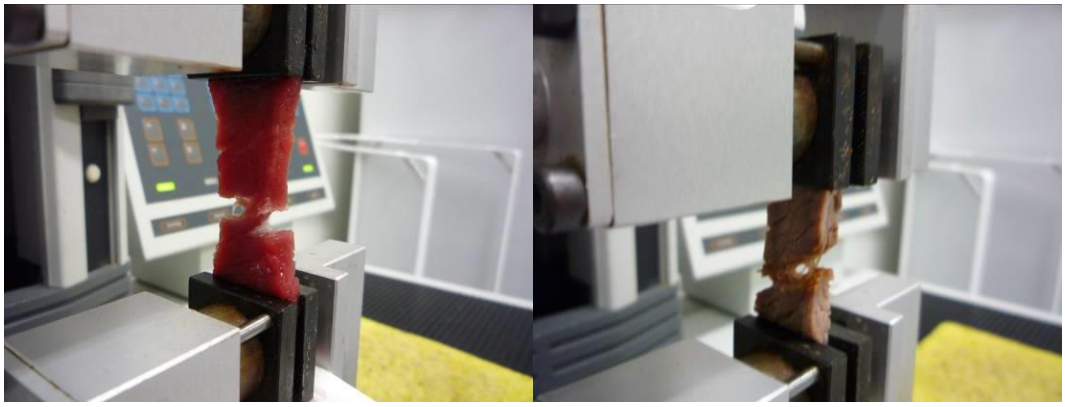

Figure 3: Raw and Cooked samples with a break at the binder seam.

3.3.4 Statistical analysis

Statistical analyses were conducted in the GenStat statistical package (GenStat 2009). Adhesion values were analysed by ANOVA.

4 Results and discussion

In accordance with instructions from the suppliers, both meat surfaces to be joined were sprinkled with binder so the surface was completely and evenly covered by Pearl E or Activa KS-LS powder prior to placing the surfaces together. Figure 4 shows a typical view of the samples after application of the powder.

Figure 4: Typical sample appearance after application of Activa KS-LS (left) and Pearl E (right)

4.1 Performance of binders with beef Insides

Pearl E - A similar visual coverage of binder was attempted for all samples and an average of 1.07 g/100 cm^2 (0.71 to 1.60 g/100 cm^2) of Pearl E was applied. This was equivalent to an average 2.80 g/kg of product. As shown in Figure 5, cooking increased the strength of the bond from 2 – 3 N to 4 – 5 N (P<0.001) but there was little effect of the SmartShape process or the time between application of the powder and shaping on the adhesion value (P>0.05). All samples were processed through the SmartShape machine without major incident, although tube selection was critical. If the sample was slightly too large, there appeared to be negligible compression resulting in difficulty in getting the sample to completely enter the packaging unit. This problem may have been due to the nature of the Inside cut.

Active KS-LS - Activa KS-LS is a coarser powder than the Pearl E and a larger amount was used to obtain a similar appearance of coverage. As a result an average of 2.48 g/100 cm^2 (range 1.49 to 3.50) was applied to the surfaces. This equated to 7.77 g/kg of product. The adhesion values using Activa KS-LS on the Inside samples were lower than for the Pearl E, especially for the raw samples where the bond strength was about 1.0 N (P<0.001). The adhesion values increased to 2.5 to 3.0 N after cooking, relative to the adhesion values for raw samples (P<0.001). As shown in Figure 6, there is little effect of SmartShape or time before shaping on strength of the bond (P>0.05). All Inside samples were processed through the SmartShape machine without any apparent slippage.

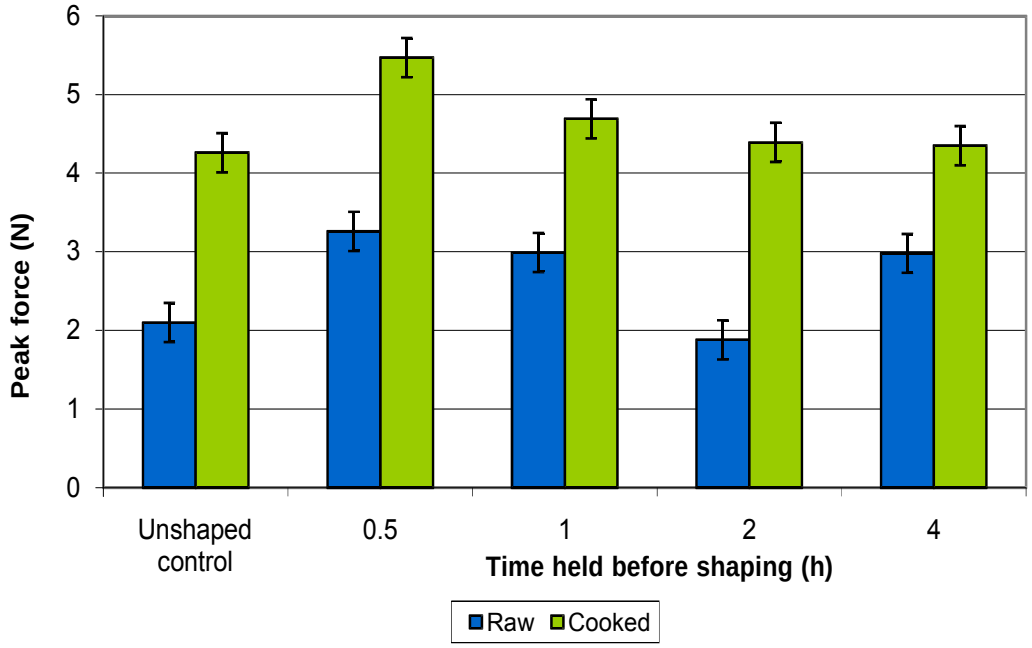

Figure 5: Adhesion values (N) for beef Inside samples treated with Pearl E at times of 0.5, 1.0, 2.0 and 4.0 h prior to processing through the SmartShape machine. Each mean is a least squares mean and error bars show the standard error of the difference.

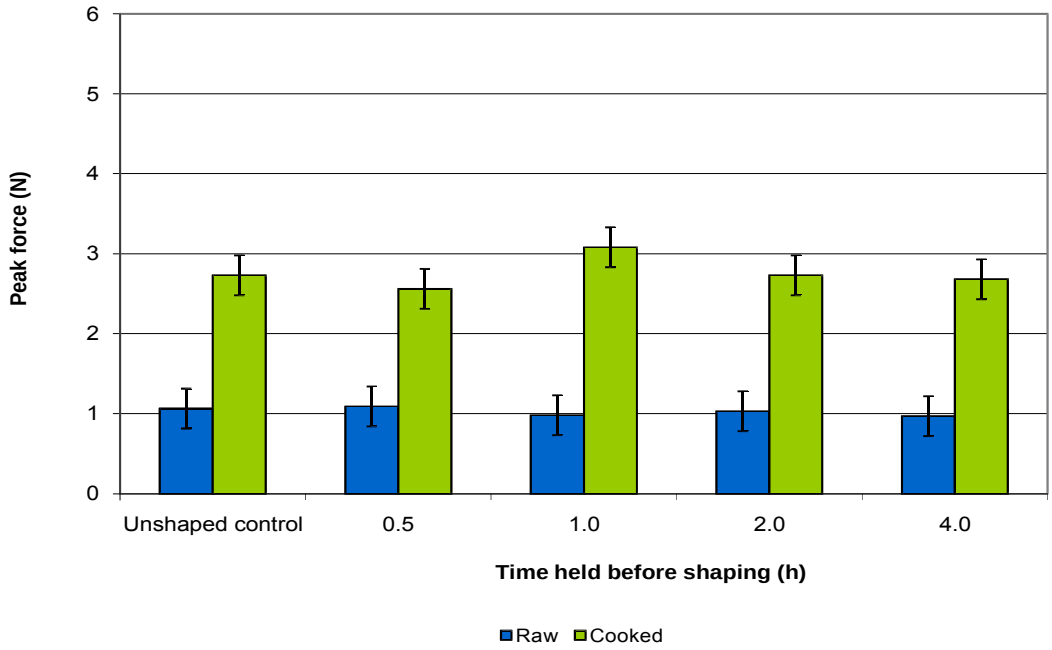

Figure 6: Adhesion values (N) for beef Inside samples treated with Activa KS-LS at times of 0.5, 1.0, 2.0 and 4.0 h prior to processing through the SmartShape machine. Each mean is a least squares mean and error bars show the standard error of the difference.

The adhesion values for both Pearl E and Activa KS-LS using samples of beef Insides are summarised in Table 1.

Table 1: Adhesion values (N) for beef Inside samples with Pearl E and Activa KS-LS applied at times of 0.5, 1.0, 2.0 and 4.0 hours prior to processing in SmartShape machine

		Unshaped control	Time held before shaping (h)				
			0.5	1.0	2.0	4.0	SED
Pearl E	**Raw**	2.11	3.26	2.99	1.88	2.98	0.352
	Cooked	4.26	5.47	4.69	4.39	4.36	0.352
Active KS-LS	**Raw**	1.06	1.09	0.98	1.03	1.02	0.352
	Cooked	2.73	2.56	3.08	2.73	2.67	0.352

4.2 Performance of binders with Tenderloins

Pearl E - Pearl E appeared to provide adequate adhesion with samples that were shaped 30 minutes after application of the powder, so this interval was selected for use with the half tenderloins. An average of 0.92 g/100 cm^2 of Pearl E was applied to the surfaces of the tenderloins which equated to 1.58 g/kg of meat. The results of adhesion values for the shaped tenderloin and the unshaped control samples which were wrapped in cling film are presented in Figure 7. This indicates that the shaped cut had lower adhesion values than the control however it was difficult to obtain a result for many of the samples as the muscle fibres tended to part before the join gave way.

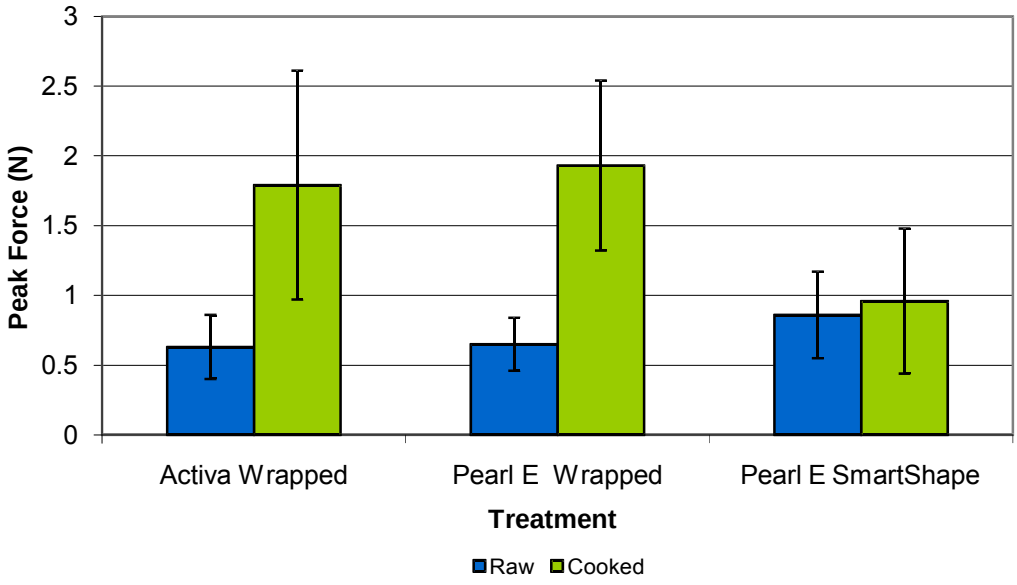

Figure 7: Adhesion values (N) for tenderloin samples treated with Pearl E 0.5 h prior to processing through the SmartShape machine. Error bars show standard deviations.

The half tenderloins were packaged using the medium (82 mm) tube but one sample became jammed in the tube entry and a portion of the muscle had to be manually trimmed with a knife to allow it to fit. This may have been because the small tenderloins requested could not be supplied and the cuts were slightly too large. It did demonstrate though, that even when a great deal of pressure was put on the samples, they did not slip at the join.

Activa KS-LS - Tenderloin samples treated with Activa KS-LS were held for 60 minutes after coating before attempting to shape them. However each time, both tenderloin samples slipped at the join and only one portion was able to be pushed into the tube. It was clear from the earlier results with the Insides that Pearl E produced a stronger bond with raw samples than Activa KS-LS. The Tenderloin sample treated with Activa KS-LS and wrapped in cling film overnight, with no shaping, had an adequate cooked adhesion value of 1.8 N and a raw measurement of 0.6 N (Figure 7).

4.3 Effect of quantity of binder

Increasing the amount of binder sprinkled on the surfaces increased the strength of the join for the raw samples for Pearl E but had no effect when Activa KS-LS was used. For the high concentration of about 1.5 g/100 cm^2 of pearl E, the muscle fibres parted before the join but that amount of binder resulted in a distinct light-coloured band being visible across the sample. Figure 8 shows the relationship between bind strength in raw samples and the amount of Pearl E binder used.

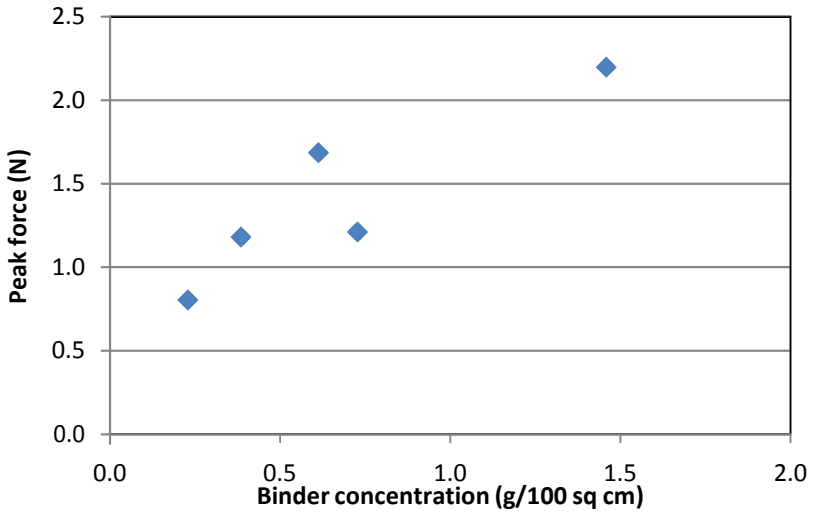

Figure 8: Relationship between raw sample bind strength and Pearl E concentration

4.4 Operation of SmartShape machine

The SmartShape machine operated well throughout the trials in processing over 40 samples. The Insides samples were mostly of even initial shape and did not generally present much of a challenge. However selection of the correct tube size was critical as the samples could only be compressed to a small extent. The Tenderloin samples were of less regular shape but as shown in Figure 8 could be converted to a shape suitable for portioning.

Figure 8: Portion of a tenderloin before and after shaping

A procedure for binding and shaping meat products that was found to provide sound results is described below:

- Coat both product surfaces to be bonded by evenly sprinkling with Pearl E at about 1 g/100 cm^2 of total join surface area.
- Immediately place both surfaces together and wrap tightly in cling film.
- Hold the product for a minimum of 30 minutes at refrigeration temperatures.
- Process through the SmartShape machine.

Activa KS-LS was suitable for product where the join is even and parallel to the outer surface but the raw adhesion strength was not adequate for an irregularly shaped product such as Tenderloins. It may be possible that Tenderloins could be shaped if held overnight, prior to shaping, but this was not tested with Activa.

The prototype SmartShape machine used in these trials has a 600 mm-long compression rubber but full beef Tenderloins are usually at least 500 mm in length. The bottom 80 mm of the tube is not usable due to the nature of the compression system. Therefore it is recommended that future versions of the machine have a rubber that is at least 750 mm long to allow full beef tenderloins to be processed.

5 Conclusions and recommendations

Cold-set binders are useful for adhering smaller pieces of meat together into a form that is suitable for portioning for food service or retail purposes. The SmartShape technology provides a potential advantage in being able to form meat into a uniform log for easier portioning.

The results of this work demonstrate that the two processes can be combined and a suitable procedure has been developed to prepare cold-set bound logs of uniform shape. When meat products such as beef tenderloins are to be bound and shaped on the same day, Pearl E can be applied to the contact surfaces and the product wrapped and held for a minimum of 30 minutes prior to processing in the SmartShape machine. If the product is not to be shaped until the following day, Activa KS-LS may also be a suitable binder as the bond is likely to be strong enough after 18 to 24 hours to withstand the forces during shaping. The time required after application for the full bond strength to develop with raw product was not tested as part of this project but could be a subject of further investigation.

The recommended procedure for binding and shaping product is:

- Coat both product surfaces to be bonded by evenly sprinkling with Pearl E at about 1 g/100 cm^2 of total join surface area.
- Immediately place both surfaces together and wrap tightly in cling film.
- Hold the product for a minimum of 30 minutes at refrigeration temperatures.
- Process through the SmartShape machine.

6 References

GenStat (2009) Release 12.1, Copyright 2009, VSN International Ltd.

Appendix A: Photographs:

Figure A1: Wrapped Inside pieces

Figure A3: Tenderloin sample before application of binder

Figure A4: Tenderloin sample wrapped

Figure A5: Tenderloin sample after SmartShaping

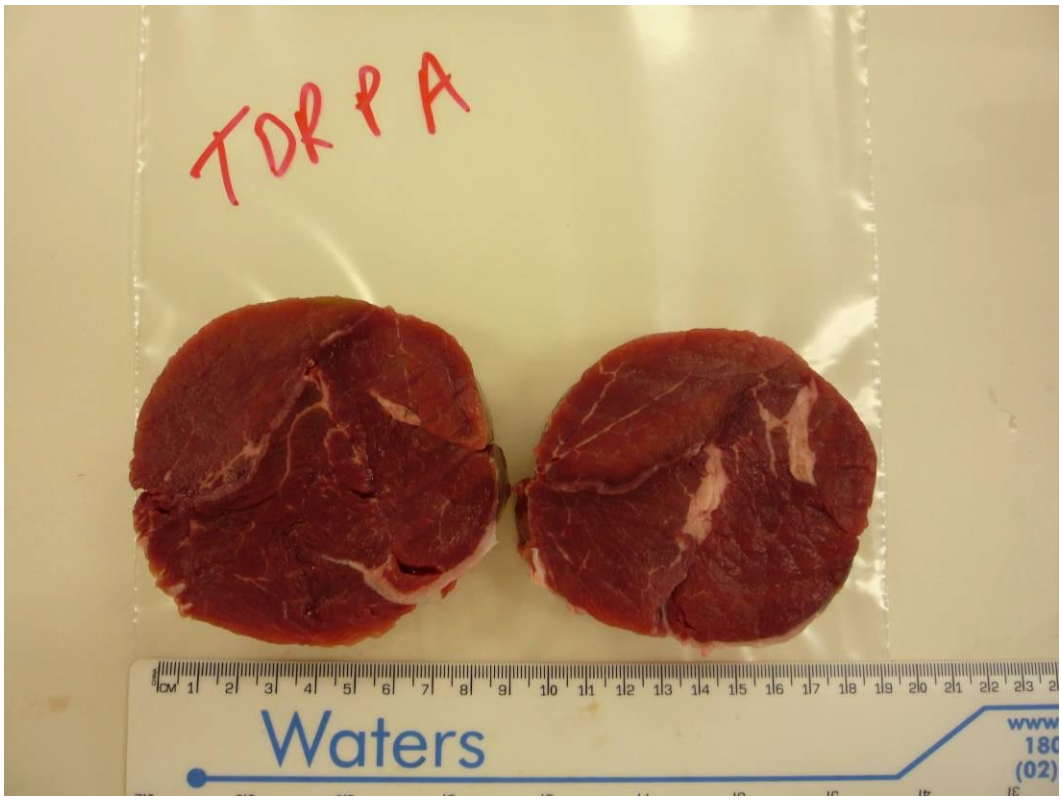

Figure A6: Shaped Tenderloin steaks