CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

These investigations have given rise to several conclusions;

All of the tofu gels including heat treated (Ht tofu) material, high pressure induced tofu prepared from raw soymilk (HP tofu), and high pressure induced tofu prepared from preheated soymilk (htHP tofu), behaved as weak viscoelastic semi-solid materials (section 3.3.2 and 4.3.2).

In a comparison of the high pressure processed material (with raw soymilk, HP tofu) with the heat induced gels, the HP tofu gels with added GDL and $CaSO_4.2H_2O$ had higher elastic moduli than those of the equivalent Ht tofu gels. The HP tofu gels were observed to have less 'solid like' structures (greater tan δ) than the Ht tofu gels. This was as a result of a more 'liquid' character as evidenced by the increased contribution of the loss moduli (section 3.3.2).

When comparing high pressure treated (with preheated soy milk, htHP tofu) and heat induced gels, it was observed that like HP tofu the htHP tofu gels with added GDL and $CaSO_4.2H_2O$ had higher elastic moduli than those of the equivalent Ht tofu gels (Figures 4.9 and 4.10). Whereas the htHP tofu gels with added 0.14% $CaCl_2.2H_2O$ had lower elastic modulus than those equivalent Ht set gel. However, the loss tangent of both htHP and Ht gels were similar (0.20-0.22) indicating the overall 'solid like' structure of the systems. According to Kohyama *et al*. (1995), the htHP and Ht gels had the same denatured protein (first step), the difference occurred on the second step that the htHP gels formed under the high pressure treatment whereas the Ht gels formed under heat treatment.

CSLM images of the Ht tofu samples (Figures 3.15, 3.16 and 3.17) show homogeneous structures with no evidence of any voids, while the equivalent HP

samples show a more open structure containing a considerable number of voids/spaces that caused the lower water holding capacity of the HP tofus. It has been purposed that this type of structure occurred when the aggregation of coagulum occurs too quickly, compared to the time scale of the denaturation of the protein, a random network that is unable to hold water is formed (Kinsella *et al*., 1994).

The SEM images of the Ht and htHP induced tofu (Figures 4.12, 4.13, and 4.14) appeared to be similar, with uniform microstructures containing small holes/voids. Regarding the functionality of three coagulants used in these studies, $CaCl_2.2H_2O$ seemed to set gels with bigger and course networks with less homogenous structures than those produced using the other two coagulants. The htHP tofu gels with added GDL and $CaSO_4.2H_2O$ showed thicker strand structures and displayed lower water holding than those Ht gels (Figures 4.12 and 4.13).

Comparison of the proteins present as characterised by native PAGE of HP and Ht set gels, showed that heat induced more protein denaturation than that observed for the HP set gels. However htHP set gels showed a similar pattern of protein denaturation as heat set gels. The denaturation of protein in every treatment condition might be due to breaking of hydrophobic interaction as indicated by hydrophobicity studies on the soymilk (Figure 3.4).

The conditions used (preheat 97-100^{o}C for 7 min) had reduced the activity of the trypsin inhibitors present by more than 90% from their original soybean levels. Subsequently samples of preheated soymilk processed either by pressure or heat treatment showed no further significant changes in the activity of the trypsin inhibitors present (Figures 4.2). Thus the tofu products from every treatment condition except those without passing through the preheated process should be safe to consume, as Hackler *et al*. (1965) and Wilson (1989 cited in Liu, 1999) suggested that inactivation of trypsin inhibitors in soymilk to 80-90% is adequate for safety purpose and for maintaining maximum nutritional value.

5.2 Recommendations

5.2.1 The shelf life of tofu products are worth further study. In general the shelf life of filled tofu rather short, a few weeks, and it is of interest to know how pressure can inactivate the microorganism and enable prolong shelf life when compare with heat.

5.2.2 An investigation to compare high pressure and heat set tofu gels by sensory evaluation to determine the organoleptic implications of the differing structure products should be carried out.

5.2.3 Difference types of tofu (such as firm tofu, soft tofu, silken tofu, etc.) or coagulants (e.g. magnesium sulphate, enzyme induced gels, etc.) are also of interest for further study. The present study was limited in filled (packed tofu) and set gels with three types of coagulants. Pressurisation by different gel setting materials may give rise to different novel textural products to gain consumer satisfaction.

5.2.4 The investigation following rate of gel setting of each coagulant should give useful results.