EFFECTS OF MILK PROTEIN INGREDIENTS ON PHYSICO-CHEMICAL PROPERTIES OF RICE STARCH

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ABSTRACT

The overall aim of this thesis is to determine if the interactions between normal and waxy rice starch and milk proteins from four milk protein ingredients, namely skim milk powder (SMP), milk protein concentrate (MPC), sodium caseinate (NaCAS) and whey protein isolate (WPI) do occur, and to identify the mechanisms underlying these interactions.

Different milk protein ingredients at various concentrations (0 to 10%, w/w) affected markedly and differently the pasting behaviour of 10% (w/w) rice starches. SMP delayed the pasting of both rice starches by increasing the onset temperature (T_{onset}) and the peak viscosity temperature (T_{peak}) of pasting. This was mainly due to the presence of lactose and ions, which was further supported by the investigation of the effects of UFSMP (a solution of salts and lactose present in SMP at their proper concentration) and lactose. The addition of NaCAS also delayed the pasting of rice starch; T_{peak} in the case of both starches was increased. For normal rice starch paste, MPC and WPI decreased the T_{peak}. MPC had no affect on T_{peak} of waxy rice starch paste.

The qualitative viscoelastic behaviour of rice starch/milk protein ingredient gels obtained from the above pastes was dominated by the continuous phase made of the starch molecules. There was evidence, as indicated by confocal microscopy, of phase separation between the milk proteins of SMP and MPC and the two starches. The phase separation was not observed in the addition of either NaCAS or WPI.

Studies on the thermal behaviour of rice starch/milk protein ingredient mixtures by differential scanning calorimetry (DSC) showed that SMP, similarly to UFSMP, delayed the gelatinization of both starches. NaCAS also delayed the gelatinisation of both starches but had a greater effect on waxy than normal rice starch. The addition of NaCAS did not affect T_{onset} but increased T_{peak} for normal rice starch, whereas the gelatinisation temperature of waxy rice starch was highly affected by the addition of NaCAS with both T_{onset} and T_{peak} shifted to higher temperatures. MPC had no affect on

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the gelatinization temperature of normal rice starch, whereas the gelatinization temperature of waxy rice starch was increased by the addition of MPC. The addition of WPI to both rice starches showed two thermal transitions. The first of these was due to the gelatinisation of the starches and the second to the denaturation of β-lactoglobulin (β-lg). The addition of WPI to normal rice starch showed that the thermal behaviour of normal starch and protein were independent from each other. In contrast, the thermal behaviour of waxy rice starch was modified by the addition of WPI; both T_{onset} and T_{peak} were increased.

SMP decreased the T_{onset} of swelling, swelling ratio and the amount of starch leaching from both starches. These observed changes were due to the presence of lactose and ions in SMP. NaCAS slightly increased T_{onset} of swelling but the amount of starch leaching was reduced for both rice starches. The rigidity of both starches tended to increase in the presence of NaCAS. MPC and WPI affected the swelling behaviour of normal and waxy rice starch differently. A dramatic increase in the swelling of normal rice starch/MPC or WPI mixtures was observed, whereas this trend was not evident for waxy rice starch/ MPC or WPI mixtures. The difference in the water holding ability and gelatinization peak temperatures of the two starches over the temperature range at which whey proteins denature and form gels are believed to be responsible for the observed differences.

The results from confocal microscopy showed that milk proteins, such as α-casein, β-casein, β-lg and α-lactalbumin (α-la), were adsorbed onto the granule surface of both normal and waxy rice starch. The mechanism for this adsorption is the hydrophilic interactions; hydrogen bonds between hydroxyl group from terminated glucan molecule that protrude around starch granule surface-hydroxyl; amino, or other electron-donation or electron-accepting groups of the added proteins. Using sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) it was found that for SMP and MPC the adsorbed α_s- to β-casein ratio on both starches was similar to the α_s-casein to β-casein ratio in the casein micelle at low SMP and MPC concentrations. But at high concentrations of SMP or MPC, this ratio decreased indicating that more β-casein was adsorbed preferentially to α_s-casein. In the case of NaCAS, α_s-casein was adsorbed

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preferentially to β-casein. Moreover, there was evidence of multilayer adsorption of α_s-casein into the surface of rice starch granules. Compared to the other milk protein ingredients, very small amounts of the β-lg and α-la from WPI were adsorbed onto starch granules. However, the adsorbed amounts of β-lg and α-la from WPI continuously increased with increasing WPI concentration, suggesting that these two proteins, particularly β-lg, adsorbed in multilayers too.

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