608 The impact of pectin types on the rheological and physical properties of yogurt. S. S. Mohamed*[1,2] and J. A. Lucey[1], [1]*University of Wisconsin, Madison,* [2]*University of Kafrelsheikh, Egypt.*

Pectin is commonly used as a gelling agent in the manufacture of yogurt. The objective of our study was to evaluate the impact of 4 different types of pectin that had different degrees of esterification (DE) and amidation (DA), on the physical properties of set type yogurt. The pectin samples included 2 types of low methoxyl (LM) pectin with 38% and 45% DE, one type of low methoxyl amidate (LMA) with 39% DE and 14% DA, and one of high methoxyl (HM) with 72% DE. Other pectin types resulted in phase separation in milk. Pectins were added to heated reconstituted skim milk at various concentrations (0.005, 0.05, 0.1 and 0.2%). Gelation properties were monitored using dynamic low amplitude oscillatory rheology and infrared light backscatter. Microstructure was studied using fluorescence microscopy. Wheying off and permeability (porosity) were analyzed at pH 4.6. At pectin concentration of 0.005% no significant differences were observed in yogurts. Yogurt made with 0.05 or 0.1% LMA, LM with 38% DE, and LM with 45% DE, had significantly lower storage modulus (G'), light back scatter ratio at pH 4.6 (RpH4.6), wheying off and permeability compared with control yogurt (no pectin). Permeability and wheying off increased with increasing LMA concentration from 0.1 to 0.2%, while the G' and RpH4.6 values were reduced. Complete inhibition of wheying off was observed when 0.2% LM (38% DE) pectin was used in yogurt and this sample also had the lowest permeability. In yogurt made with 0.2% of HM pectin, the R value gradually decreased after gelation pH until pH 4.6. Wheying off and permeability increased with an increase in the concentration of HM (from 0.005 to 0.2%). HM pectin produced yogurt with the lowest G' and RpH4.6 values compared with other treatments. The microstructure results indicated that yogurt made with HM pectin had an open network, especially at 0.2% pectin, while yogurt made with LM (38% DE) had higher degree of interconnectivity of strands. In conclusion, pectin types greatly impact gelation behavior and yogurt texture. LM pectin with low DE value and without amidation gives the best gelation properties.

Key words: yogurt, pectin, rheology

609 Engineering yogurt texture: Interactions between texturing lactic acid bacteria and processing conditions in low fat stirred yogurt. K. B. Qvist*, C. Gilleladen, J. Trihaas, and C. Svane, *Chr. Hansen, Hoersholm, Denmark.*

Recent years has seen increasing use of highly texturizing cultures in yogurt manufacture, and also a rapid diversification regarding protein ingredients used. This caused us to question whether the current understanding of yogurt technology is adequate, given that most of it was derived before widespread use of new protein ingredients and highly texturizing cultures. To study effects and interactions of the following factors we executed a so-called D-optimal design experiment with 168 yogurts samples (representing 1134 samples of a full factorial): protein type used for fortification (skimmilk (SKM), or PM500G (fortified in whey protein compared to SKM, from IDI); protein addition level (0.7, 1.05, 1.4%); fat content (0.5, 1.0, 1.5%); back pressure during cooling in plate heat exchanger (0, 0.1, 0.2 MPa); filling temperature (12, 18.5, 24°C); and 7 commonly used yogurt cultures differing in EPS production and other properties. Shear stress assessed at a shear rate of 300 s^{-1}, and complex modulus at 1 Hz (StressTech rheometer), were used to represent mouth thickness and gel stiffness, respectively. Major variables determining shear stress and complex modulus were culture used, protein addition level and type, and back pressure. Shear stress and modulus increased substantially when raising protein addition from 0.7 to 1.4%, but decreased when back pressure was increased from 0 to 0.2 MPa. The most important new insight was that interactions between culture, protein type, and amount of protein added can be complex. For instance, the effect of amount of protein added on shear stress can depend strongly on which culture is used. Also, with some cultures, PM500G increased shear stress much more efficiently than SKM. Regarding the modulus, with a highly texturizing culture, adding SKM did little to increase the modulus, while addition of PM500G was highly effective. In conclusion, a much higher level of process optimization can be achieved by exploiting interactions between cultures, ingredients and technology, than by thinking of these factors independently of each other.

Key words: yogurt texture, cultures, interactions

610 Yogurts made from milk where heating was performed at different pH values. T. Ozcan[1,2] and J. Lucey*[1], [1]*University of Wisconsin-Madison, Madison,* [2]*Uludag University, Bursa, Turkey.*

It is well known that the pH of milk during heat treatment has significant effect on level/type of whey protein interaction with casein micelles. As the pH of heating decreases there is an increase in the proportion of denatured whey protein associated with casein micelles (bound aggregates) and less soluble denatured whey proteins. The objective of this research was to investigate the effects of heating milk at different pH values, with or without readjustment to pH 6.7 after heating, on the properties of yogurt gels. Reconstituted skim milk was adjusted to pH values 6.2, 6.7 or 7.2 and heated at 85°C for 30 min. Another set of milks were heated as above but readjusted to pH 6.7 after heating. Milks were inoculated with 3% yogurt culture and incubated at 40°C until pH 4.6. Gel formation was monitored using dynamic oscillatory rheology and light backscattering. Fluorescence microscopy was used to observe gel microstructure. The G′ values at pH 4.6 were highest in gels made from milk heated at pH 6.7 and lowest in milk heated at pH 6.2, with or without pH adjustment after heating. The G′ values at pH 4.6 were lower in samples adjusted to pH 6.7 after heating. No maximum in the loss tangent parameter was observed during gelation for yogurts heated at pH 6.2 but a maximum was observed at pH~4.8 for milks heated at pH 6.7 or 7.2, with or without pH adjustment after heating. Profiles for the light backscatter ratio (R) during gelation indicated that higher R values were observed in samples heated at higher pH values, with or without pH adjustment after heating. The first derivative of light backscatter ratio (R') also revealed differences between samples. The R' profiles for samples heated at pH 6.7 and 7.2 had 2 peaks during gelation but the pH 6.2 sample had only one. Higher peak values in the R' profiles were observed with an increase in the pH of heating. No clear differences were observed in the microstructures of gels between treatments. Heating milk at pH 6.7 created an optimum balance of bound and soluble denatured whey proteins, which resulted in yogurt with the highest gel stiffness.

Key words: yogurt, rheology, gelation

611 Dextran addition to model acid gels to explore the mechanism by which EPS influence yogurt texture. U. Pachekrepapol* and J. A. Lucey, *University of Wisconsin - Madison, Madison.*

Exopolysaccharides (EPS) are biopolymers produced by lactic acid bacteria and EPS production can impact the rheological properties of yogurt. It is not clear when EPS is produced during the yogurt fermentation process. We believe that the point in the fermentation process when EPS are produced could greatly impact gelation and rheological properties of yogurt. Our objective was to use a model acid gel system to explore the impact of biopolymer addition at various pH values. High molecular weight dextran (2×10^6 Da) was used as a simple model biopolymer instead of bacterial EPS. Reconstituted skim milk was acidified to pH 4.4, 4.6, 4.8 and 4.9 at ~0°C by addition of 3N HCl. Dextran solution was then added into cold acidified milk to give a dextran concentration of 0.5% (w/w). Milk was then warmed up in a rheometer at a rate of 0.5°C/min until the temperature reached 30°C and it was held for 17 h at 30°C. The cold acidified milks gelled as they were warmed to 30°C. The rheological and microstructural properties of these gels were determined by small amplitude oscillation rheology and confocal scanning laser microscopy (with image analysis), respectively. No significant difference in the gelation time or storage modulus (G′) was observed in gels with or without dextran addition for gels made at the same pH value. Image analysis was used to determine the percentage of area of the protein aggregates in gels. Image analysis indicated that there was no significant difference in protein aggregate area in gels made at the same pH with or without dextran. However, gels made at different pH levels had different area of protein aggregates. At pH 4.4 and 4.6, the areas of protein aggregates were similar and higher than those of gels made at pH 4.8 and 4.9. In conclusion, we did not find that the addition of dextran had any significant impact on gel properties. Although, we added a high concentration (0.5%) of a high molecular weight dextran, possibly other physical characteristics of EPS (e.g., branching or charge) could be important in the ability of EPS to impact yogurt texture.

Key words: EPS, yogurt, Dextran

612 Effect of the addition of glucose/glucose oxidase and packagings with different permeability oxygen rates on some characteristics of probiotic yogurts. A. Cruz[1], J. Assis*[1], D. Granato[2], S. Bogusz Junior[1], and H. Godoy[1], *[1]University of Campinas (UNICAMP), [2]University of São Paulo (USP).*

The use of the enzymatic complex glucose/glucose oxidase has been presented as a potential option for removal of the dissolved oxygen in stirred probiotic yogurt. In this research, the stability of probiotic yogurt packaged in plastic material with different values of oxygen permeability was investigated during 28 d. Probiotic yogurts supplemented with *Lactobacillus acidophilus* La14, *Bifidobacteria longum* BL05, 62.32 ppm of glucose oxidase and 4.35 ppm glucose were manufactured and packaged in conventional polypropylene cups (PP) or PP coextrused with different levels of vinyl ethylene alcohol (VEOH), presenting the following permeability oxygen rates (TPO2): 0.09 (P1), 0.20 (P2), 0.39 (P3) and 0.75 (P4) ml O2/cup*day. Postacidification, dissolved oxygen, proteolysis, viable count of yogurt and probiotic bacteria, carbohydrate consumption (glucose and lactose), organic acid production (acetic and lactic acid) and aroma compounds (diacetyl and acetaldehyde) were monitored weekly (1, 7, 14, 21, and 28 d). A significant ($P < 0.05$) effect of the packaging system was observed for all analyzed parameters. P1 and P2 presented the lowest values of dissolved oxygen, reflecting in an increased metabolism of probiotic cultures. These samples also presented a greater postacidification, proteolysis, carbohydrate consumption, organic acid levels and aroma compounds, suggesting a continuous performance of the enzymatic system. P3 and P4 had the opposite trend, maybe due to the difficulty of the enzymatic complex in removing the oxygen in the product. As a conclusion, if plastic materials with a low barrier to oxygen are used a higher concentration of glucose should be added into the yogurt to guarantee the best enzymatic efficiency and, hence, the functionality of the stirred probiotic yogurt during the shelf life.

Key words: probiotic yogurt, glucose oxidase, stability

613 Effect of increased concentration of glucose oxidase in probiotic stirred yogurt on functionality, proteolytic pattern, and metabolic products. A. Cruz, W. Castro, and J. Assis*, *University of Campinas (UNICAMP).*

The addition of increased concentrations of glucose oxidase, a potential oxygen remover, in probiotic stirred yogurt was evaluated. Probiotic yogurts supplemented with *Lactobacillus acidophilus* La-14 and *Bifidobacteria longum* BL 05, added with 0, 200, 400, 600, 800 and 1000 ppm glucose oxidase were manufactured and packaged in 200 mL polypropylene cups. Post acidification, dissolved oxygen, proteolysis, viable count of yogurt and probiotic bacteria, carbohydrate consumption (glucose and lactose) and organic acid production (acetic and lactic acid) were monitored weekly during 1, 7, 14, 21, and 28 d refrigerated storage. Independent of the amount of added enzyme, a rapid consumption of the substrate (glucose) was observed and also an increase of dissolved oxygen during the storage time, probably because of the high oxygen permeability of the package. Consequently, the count of viable probiotic microorganisms (mainly *B. longum*) decreased as function of storage time as well as lower carbohydrate consumption, lower proteolysis and lower ph values ($P < 0.05$). No effect was observed in the lactic acid production ($P > 0.05$). However, at the of shelf life the counts of *Lactobacillus acidophilus* and *Bifidobacteria longum* were still 7 and 6 log cfu/g, respectively. Based on such results it was concluded that it is necessary to improve the oxygen barrier of the package to benefit from the use of glucose oxidase and prolonging the shelf life of probiotic stirred yogurt.

Key words: probiotic yogurt, glucose oxidase, stability

614 Impact of adding galactooligosaccharides on the physical and optical characteristics and sensory acceptance of vanilla ice cream. A. Cruz, J. Faria*, W. Castro, R. Cadena, and H. Bolini, *University of Campinas (UNICAMP).*

Prebiotic and conventional dairy foods should present similar technology and sensory performance. The research aimed to evaluate the effect of adding galactooligosaccharide (GOS) on the physico-chemical and optical characteristics and sensory acceptance of ice cream. Vanilla ice creams supplemented with 0, 1.5% and 3.0% w/w (0G, 1.5G, 3G) galactooligosaccharides (GOS) were subjected to physico-chemical analysis (pH, firmness, melting rate, and overrun) and optical analysis (instrumental color). Simultaneously, vanilla ice creams supplemented with 1.5% or 3% w/w (1.5F, 3F) fructooligosaccharides (FOS) were also produced and submitted to the same analyses. In addition, a consumer test (30 consumers, triangular test) was performed. The 3G ice creams were characterized as firmer and with lower melting rates as compared with the others samples ($P < 0.05$) while absence of effect was observed in the pH and instrumental color values. The results from the consumer test indicated that the 3G ice creams were perceived as different from the 0G ice creams ($P < 0.05$), whereas the 1.5G, 1.5F, and 3F ice creams were perceived as similar ($P > 0.05$) to the control sample. The findings suggest it is possible to manufacture ice creams

supplemented with 1.5% GOS, which presented more stable and with a sensory perception similar to the conventional ice creams.

Key words: ice cream, galactooligosaccharides, stability

615 Physical properties and functionality of probiotic vanilla ice creams manufactured with different overruns levels. A. Cruz, J. Faria*, W. Castro, R. Cadena, and H. Bolini, *University of Campinas (UNICAMP)*.

The effect of different overrun levels on the physical properties and functionality of probiotic ice creams was investigated. Vanilla ice creams supplemented with *Lactobacillus acidophilus* were manufactured with 45, 60 and 90% (O45, O60, O90) overruns levels. Physical analysis (pH, viscosity, melting rate) were performed. In addition, *L. acidophilus* counts were performed during 60 d of frozen storage at −20°C. Probiotic ice creams manufactured with higher overrun levels showed better stability ($P < 0.05$), presenting lower melting rate and improved viscosity, while no effects on pH were observed. Overrun levels also influenced the survival of *L. acidophilus* ($P < 0.05$). O60 presented viable probiotic counts ranging from 8.10 and 8.02 log cfu/g while for O90 this parameter ranged from 7.00 to 6.06, respectively. However, O45 presented viable probiotic counts ranging from 8.06 to 8.04 log cfu/g ($P > 0.05$), during storage. These findings suggest it is important to optimize the overrun levels during the probiotic ice cream processing to keep its functionality, without negative impact on its intrinsic parameters of quality.

Key words: probiotic ice cream, overrun, functionality

616 Withdrawn