

1 Abstract

2 Providing the neonatal calf with a sufficient quantity and quality of colostrum may optimise future
3 health, performance and reduce the risk of morbidity. A 6-month double blind trial with 80 prepartum
4 dairy cows was conducted to determine if supplementation with mannan oligosaccharide (MOS)
5 influences colostrum quality, quantity and subsequent calf performance. The Holstein cross Friesian
6 80 cows (no heifers) were allocated into a control and treatment group at the point of drying off by
7 previous lactation number and yield. The control and treatment group were fed the same commercial
8 standard dry cow diet throughout the trial supplemented with a mineral concentrate without or with
9 1.33% MOS, respectively. Cows were milked out of colostrum within 40 min of calving prior to calf
10 suckling, weight was recorded. Mannan oligosaccharide fed cows produced significantly more
11 colostrum on first milking (7.5 kg, SEM±0.69) compared with cows fed without MOS (5.6 kg,
12 SEM±0.43). The immunoglobulin G (IgG) concentrations (control 53.7 IgG g/l, SEM±5.8 and MOS
13 of 42.7 IgG g/l, SEM±4.9) and total mass of IgG did not differ between treatments. No significant
14 observable MOS-derived effect on calf health or weight gain occurred during the study.

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16 Implications

17 Mannan oligosaccharides (MOS) are a yeast-based by-product which may enhance gastrointestinal
18 conditions and overall animal health, resulting in improved animal performance. In dairy cows, MOS
19 prepartum supplementation increases colostrum quantity which could improve future calf
20 performance.

21

22 Introduction

23 Colostrum is the primary source of immunoglobulins and nutrients essential for neonatal calf survival
24 as the bovine placenta inhibits the transfer of immunoglobulins and essential vitamins (Quigley and
25 Drewry, 1998). Immunoglobulins G (IgG) account for up to 85% of the immune proteins and is the
26 most predominant immunoglobulin found in the intestine of the calf (Butler, 1983). Colostral IgG
27 concentration and yield can vary greatly between individual cows and is influenced by a number of
28 factors including parity number, time interval from calving to first milking and colostral weight
29 (Conneely et al., 2013). In a study of 704 Irish dairy cows, colostral IgG concentrations ranged from
30 13 up to 256 g/l, with increasing colostral weight having a negative effect on IgG concentrations
31 (Conneely et al., 2013).

32

33 The European Union ban on antibiotics as growth promoters in animal feed supplements in 2006 and
34 in calf milk replacers in 2013 has intensified the need to improve the quality and quantity of
35 colostrum produced to promote calf performance (Conneely et al., 2014). Alternatives such as
36 probiotics are being examined to determine their suitability to inhibit the activity of pathogens,
37 stimulate the immune system, enhance digestion, increase yield and quality of animal proteins
38 (Vohara et al., 2016).

39

40 A key probiotic group are yeasts such as *Saccharomyces cerevisiae* which is approved for human use
41 by The European Food Safety Authority (Vohara et al., 2016). Mannan oligosaccharide is derived
42 from the cell wall of *S. cerevisiae* yeast which contains both mannan proteins and complex
43 carbohydrates including β -glucans. It has been termed a nutrice, meaning it has no direct nutritive
44 value but maintains intestinal digestive and absorptive functions, thus improving the health and
45 performance of farmed animals (Halas and Nochta, 2012). The objective of this study is to evaluate if
46 supplementing MOS to housed dairy cows prepartum affects colostrum IgG concentration, quantity
47 and subsequent calf performance.

48

49 Material and methods

50 Experimental design

51 In total, 80 Holstein cross Friesian cows (no heifers) were randomly assigned at point of drying off,
52 over a 6-month period, by previous lactation number and yield into a treatment (MOS) and control (C)
53 group in a double blind feeding trial. Cows were housed throughout the trial period in the same
54 building split into two sections.

55

56 A standard dry cow total mixed ration (Table 1) was fed ad libitum from drying off until point of
57 calving. The control group received a standard commercial dry cow supplement (www.Scotmin.com)
58 without MOS and the treatment group received the same supplement with MOS (Table 2). The
59 mineral supplements were top-dressed at a rate of 150 g/head daily as fresh feed was delivered. The
60 treatment provided 2 g/cow per day of MOS for a minimum of 4 weeks pre-calving as recommended
61 by the manufacturer. Cows were moved from the cubicles to ensure they consumed mineral
62 supplement at the same time every day.

63

64 Table 1 Calculated composition of prepartum TMR diet

65

66

Animal details ¹	Weight (Kg)	690
	Fat mobilisation change (kg/day)	0.50
Feeding plan ² (kg)		
	Molasses	1.60
	Megastart Pre Calver Mineral	0.20
	Straw -Wheat	5.00
	Second cut silage	18.00
	Calcined Magnesite	0.08
	Hipro soya Meal	0.75
	Myerscough blend	1.50
Nutrients ³		
	DM intake (kg/d)	12.4
	Forage DM (kg/d)	9.0
	ME (M/D)	9.7
	Protein (%DM)	13.4
	MP -N (g/d)	1157
	MP -E (g/d)	1017
	MP (limiting) (% req)	152
	Microbial CP (% N/E)	125
	Starch (%DM)	2.9
	Sugar (%DM)	10.5
	Starch plus Sugar (%DM)	13.4
	NDF (%DM)	49.1

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82 1 TMR formulation on per cow basis then multiplied up by number of cows and fed ad libitum to all
83 cows on trial.

84 2 Calculated values.

85

86 Table 2 Specification of dry cow mineral ^{1,2,3} (as received)

 Chemical composition ² (%)

Calcium	1.30
Phosphorus	4.00
Magnesium	20.00
Sodium	12.30
Chlorine	19.00
Potassium	0.08
Sulphur	0.08
Yeast cell wall material (MOS)	1.33

93 MOS=mannan oligosaccharide.

94 1 MOS added at 1.33% in the above to the treatment group.

95 2 Additional trace minerals included; cobalt, copper, iodine, manganese, selenium, zinc and vitamins
96 A, D3, E and B12.

97 3 Chemical composition as legally declared and supplied by Scotmin Nutrition (www.Scotmin.com).

98

99 Sample collection

100 Colostrum samples were obtained from 59 of the 80 Holstein-Friesian dairy cows, as any cows that
101 calved unattended or where the calf was known to have suckled, were not sampled. Cows were
102 milked out of colostrum using a Fullwood® (Fullwood Ltd, Ellesmere, Shropshire, UK) mobile
103 milking machine and calibrated milking vessel in a crush close to calving pen within 40 min of
104 calving. This allowed time for milk let-down to be stimulated and cow to calf bonding to occur but
105 colostrum removal took place prior to calf suckling.

106

107 Total colostrum weight was measured, six samples (30 ml) were taken and once temperature of the
108 colostrum reached 22°C the density was measured using a Volac® (Volac International Ltd Royston,
109 Hertfordshire, UK) colostrometer. Samples were frozen (-20°C) following cooling and stored for IgG
110 concentration. The remaining colostrum was bottled and immediately fed to the corresponding calf.

111

112 At birth, the sex of each calf and weight were recorded. Calves were weighed in a Ritchie® (Ritchie
113 Agriculture, Forfar, Angus, UK) mobile weigh crate. The weight of calves was taken on transfer to an
114 individual pen and fortnightly until 2 weeks post weaning.

115

116 Laboratory analysis

117 Whole colostrum was analysed for IgG by single radial immunodiffusion (SRID) using BOV
118 IgGIDRing® Test kit (IDBiotech; ImmunoDiffusion Biotechnologies, Issoire, France). Total mass of
119 immunoglobulin produced was calculated by multiplying IgG concentration (g/l) by milk volume (l)
120 (Osaka et al. 2014).

121

122 Statistical analysis

123 Data analysis was carried out using Minitab® 17 statistical software package (www.minitab.com,
124 2012). Residual values were checked for normality. Parametric data were examined using ANOVA
125 tests; whereas non-parametric data were examined using Kruskal–Wallis tests.

126

127 Results

128 Colostrum immunoglobulin G and quantity

129 There was a wide variation in colostrum IgG concentration in both trial groups ranging from 19.5 to
130 85.1 g/l with an overall average of 47.8 g/l (SEM±3.8). Treatment did not affect colostrum IgG
131 concentration (P=0.08) with mean IgG of 42.7 g/l (SEM±4.9) for MOS and control IgG 53.7 g/l
132 (SEM±5.8).

133

134 Mean colostrum produced immediately post-calving in the MOS group was 7.5 kg (SEM±0.69) v.
135 control 5.6 kg (SEM±0.43). Mannan oligosaccharide significantly increased the weight of colostrum
136 produced by an average of 1.96 kg per cow (P=0.02).

137

138 Despite increased volume of colostrum produced by MOS fed cows, there was no effect (P=0.76) on
139 the total mass of immunoglobulin produced when compared with control cows (MOS 288 total IgG,
140 SEM±53.4 v. 276 total IgG, SEM±55.3).

141

142 Calf performance

143 There were 16 male and 13 female calves in MOS group and 10 males and 9 female calves in control
144 group. Average birth weight of MOS fed calves was 44.9 kg (SEM±1.1) v. control 43.5 kg

145 (SEM±1.0). Birth weights (P=0.43), 8 week weaning weights (P=0.42) and gain from birth to
146 weaning (P=0.75) did not differ between treatments.

147

148 Discussion

149 The current study found that supplementation prepartum of MOS derived from *S. cerevisiae*, had no
150 effect on colostrum IgG concentration. This work supports the findings of Franklin et al. (2005) who
151 reported similar concentrations and levels of variation in colostral IgG but no difference in cows fed
152 MOS (35.5 to 52.2 g/l, SEM±7.1 to 10.8) and control diet (33.8 to 60.6 g/l, SEM±6.6 to 13.8). The
153 wide variation found in IgG concentration may explain the absence of treatment effect in both these
154 studies.

155

156 Lactation number has been identified as a potential source of variation particularly in cows entering
157 third lactation and above (Conneely et al., 2013). This was confirmed by Franklin et al. (2005)
158 reporting significantly higher colostral IgG concentration, regardless of treatment, for cows in third
159 lactation or greater compared with second lactation. History of previous mammary quarter diseases
160 may be a key influencing factor in IgG concentrations. Baumrucker et al. (2014) identified that any
161 quarter within the udder can produce different concentrations and mass of IgG in first-milked
162 colostrum. Cows in third lactation or above may exhibit larger fluctuations in IgG due to previous
163 mammary infections damaging the mammary epithelium (Baumrucker et al., 2014). In this study
164 more than two-third of cows sampled were in their third lactation or above for both MOS and control
165 groups and likely to be responsible for the high level of variation in colostral IgG concentration.

166

167 Time interval from calving to first milking of colostrum is another source of variation in IgG
168 concentrations. Conneely et al. (2013) found significantly lower IgG in cows milked post 9 h from
169 calving. All results in this present study were from cows milked within first hour after calving
170 therefore the variation found is unlikely to be due to time interval from calving to first milking.

171

172 In this study feeding MOS prepartum increased the quantity of colostrum produced. Franklin et al.
173 (2005) conversely found no significant change in the quantity of colostrum due to treatment (MOS
174 6.5±1.6 to 7.1±1.1 kg v. control 6.4±1.2 to 8.1±1.3 kg). The potential mode of action may involve the
175 stimulating effect of MOS on the innate immune system, increasing the production of mannose-
176 binding proteins which enhances phagocytosis (Franklin et al., 2005). During the vulnerable last 4
177 weeks prepartum Franklin et al. (2005) found that feeding MOS influenced the immune system of the

178 cow as demonstrated by increased rotavirus titres in serum and colostrum in previously unvaccinated
179 cows. It could be hypothesised that this enhancement of the immune system, both specific and innate,
180 may lead to enhanced colostrum production levels due to more efficient metabolism.

181

182 Several studies have emphasised that it is not just the quality or quantity of colostrum consumed that
183 is essential but the mass of immunoglobulin intake that is important. Osaka et al. (2014) found that the
184 total mass of IgG consumed affected the serum level of IgG in calves. The total mass of
185 immunoglobulin produced in the present experiment was not significantly different between MOS and
186 control, indicating that mass immunoglobulin intake would be similar for both groups of calves when
187 left on their dams for first 24 h and therefore unlikely to affect future calf health and performance.
188 Previous studies have examined the effect on calf performance of including MOS in milk replacers. In
189 this trial no differences in calf performance were found in MOS fed calves. Similarly, Terre' et al.
190 (2007) found no difference in overall average daily gain or weaning weight of calves fed MOS via the
191 milk replacer but did see an initial effect on starter feed intake. Feed intake was not recorded in this
192 trial and calves had access to the same feeds and forages.

193

194 Conclusions

195 Mannan oligosaccharide derived from *S. cerevisiae* does not affect IgG concentration or the total IgG
196 mass but does increase the weight of colostrum produced. Further studies on the effect of MOS on
197 prepartum cow health particularly metabolic and immune status and eliminating or reducing the
198 influence of variables such as previous lactation number and history of mammary disease are
199 warranted.

200

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208 References

209 Baumrucker, CR, Stark, A, Wellnitz, O, Dechow, C and Bruckmaier, RM 2014. Short
210 communication: immunoglobulin variation in quarter-milked colostrum. *Journal of Dairy Science* 97,
211 3700–3706.

212 Butler, JE 1983. Bovine immunoglobulins: an augmented review. *Veterinary Immunology and*
213 *Immunopathology* 4, 43–152.

214 Conneely, M, Berry, DP, Murphy, JP, Lorenz, I, Doherty, ML and Kennedy, E 2014. Effect of
215 feeding colostrum at different volumes and subsequent number of transition milk feds on the serum
216 immunoglobulin G concentration and health status of dairy calves. *Journal of Dairy Science* 97,
217 6991–7000.

218 Conneely, M, Berry, DP, Sayers, R, Murphy, JP, Lorenz, I, Doherty, ML and Kennedy, E 2013.
219 Factors associated with the concentration of immunoglobulin G in the colostrum of dairy cows.
220 *Animal* 7, 1824–1832.

221 Franklin, ST, Newman, MC, Newman, KE and Meek, KI 2005. Immune parameters of dry cows fed
222 mannan oligosaccharide and subsequent transfer of immunity to calves. *Journal of Dairy Science* 88,
223 766–775.

224 Halas, V and Nochta, I 2012. Mannan oligosaccharides in nursery pig nutrition and their potential
225 mode of action. *Animal* 2, 261–274.

226 Osaka, I, Matsui, Y and Terada, F 2014. Effect of the mass of immunoglobulin (Ig) G intake and age
227 at first colostrum feeding on serum IgG concentration in Holstein calves. *Journal of Dairy Science* 97,
228 6608–6612.

229 Quigley, JD III and Drewry, JJ 1998. Symposium: practical considerations of transition cow and calf
230 management. *Journal of Dairy Science* 81, 2779–2790.

231 Terre, M, Calvo, MA, Adelantado, C, Kocher, A and Bach, A 2007. Effects of mannan
232 oligosaccharides on performance and microorganism fecal counts of calves following an enhanced
233 growth feeding program. *Animal Feed Science and Technology* 137, 115–125.

234 Vohara, A, Poonam, S and Anshu, M 2016. Probiotic yeasts in livestock sector. *Animal Feed Science*
235 *and Technology* 219, 31–47.