Effects of Fructooligosaccharides and Other Saccharides on Ca, Mg and P Absorption in Rats

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The effects of administration of lactose (Lac), fructooligosaccharides (FO) and other oligosaccharides (galactooligosaccharides: GO; isomaltooligosaccharides: IM, raffinose: RF) in the diet on absorption of calcium (Ca), magnesium (Mg) and phosphorus (P) in weaning male rats were examined by *in vivo* studies. In rats fed the FO diet, Ca, Mg and P absorption was significantly higher than in rats fed the LA diet. FO had a dose-dependent effect on mineral absorption (Exp. 1). The enhancement of Ca, Mg and P absorption by FO persisted for as long as one month. A significant increase in the ash and mineral contents of the femur was observed in rats fed the FO diet, as compared with controls (Exp. 2). FO had a positive effect on mineral absorption, and GO and RF had similar but somewhat variable effects. However, IM had no effect (Exp. 3). There was a significantly positive correlation between mineral absorption and L-lactate concentration in the cecum. It was suggested that L-lactate concentration in the cecum had a direct effect on mineral absorption (Exp. 3).

Key Words fructooligosaccharides, oligosaccharides, absorption, calcium, magnesium.

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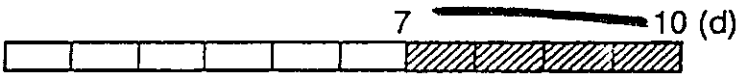
Experiments

1) Animal ; ~~Sprague-Dawley rats~~ (♂, b.w.100～110g)

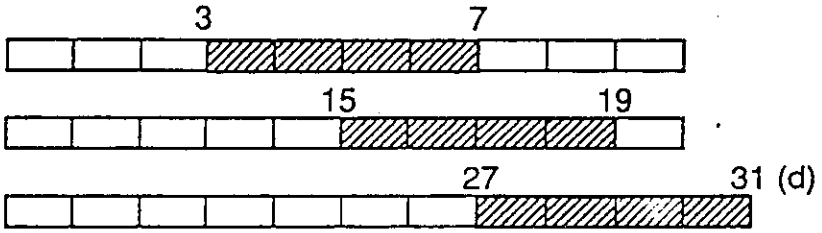
2) Schedule and measurements

Exp.1



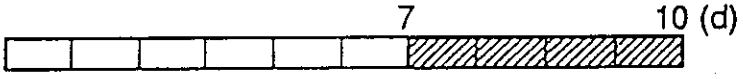
balance study of Ca, Mg and P absorption for 4 days

Exp.2



① balance study of Ca, Mg and P absorption for 3 periods (4 days each)
② weight and mineral (Ca, Mg, P) contens of femur

Exp.3



① balance study of Ca, Mg and P absorption for 4 days
② measurement of VFA and lactic acid concentration in cecum

Table 1 Composition of experimental diet (%)

	Exp. I							Exp. II		Exp. III				
	Cont.	LA		FO				Cont.	FO	Cont.	IM	GO	RF	FO
		5%	15%	1%	3%	5%	15%		5%		5%	5%	5%	5%
Cascin	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Corn starch	44.5	44.5	44.5	44.5	44.5	44.5	44.5	49.5	49.5	49.5	49.5	49.5	49.5	49.5
Corn oil	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vitamin mix. [a]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Salt mix. [a]	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Cellulose	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Sucrose	15.0	10.0	—	14.0	12.0	10.0	—	10.0	5.0	10.0	5.0	5.0	5.0	5.0
Lactose	—	5.0	15.0	—	—	—	—	—	—	—	—	—	—	—
Isomalutose [b]	—	—	—	—	—	—	—	—	—	—	5.0	—	—	—
Raffinose	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Galactooligo[c]	—	—	—	—	—	—	—	—	—	—	—	—	5.0	—
Frucutooligo[d]	—	—	—	1.0	3.0	5.0	15.0	—	5.0	—	—	—	—	5.0

[a] Prepared according to AIN-76 prescription (Ca 0.52%, Mg 0.05%, P 0.40%).
[b] Isomaluto900-P[㈜] [c] Cuppoligo-P [㈜] [d] Meioligo-P[㈜]
LA, lactose diet; FO, fructooligosaccharide diet; IM, isomaltooligosaccharide diet
GO, galactooligosaccharide diet; RF, raffinose diet

Table 2 Effects of lactose and fructooligosaccharides on the absorption of calcium, magnesium and phosphrus in rats.

	Ca absorption (%)	Mg absorption (%)	P absorption (%)
Cont.	56.5 ± 3.0 ^{a}	69.2 ± 1.7 ^{a}	77.2 ± 1.8 ^{a}
LA 5%	60.4 ± 3.7 ^{ab}	71.3 ± 2.3 ^{a}	77.5 ± 2.2 ^{a}
LA 15%	64.2 ± 3.4 ^{bc}	80.8 ± 3.6 ^{c}	79.7 ± 3.0 ^{a}
FO 1%	61.0 ± 5.4 ^{abc}	65.9 ± 1.2 ^{a}	78.5 ± 2.3 ^{a}
FO 3%	61.1 ± 2.8 ^{b}	75.2 ± 3.2 ^{b}	77.7 ± 1.4 ^{a}
FO 5%	65.2 ± 3.4 ^{c}	83.4 ± 4.0 ^{c}	78.3 ± 1.1 ^{a}
FO 15%	82.0 ± 3.4 ^{d}	88.8 ± 2.0 ^{d}	87.6 ± 2.7 ^{b}

Values are mean±SD (n=7).

Mean not sharing a common superscript letter are significantly different ($p<0.05$).

Absorption={(Intake-Fecal output)/Intake}×100 (for each rat).

Exp 1.

Table 3 Effects of fructooligosaccharides on the balance of calcium, magnesium and phosphrus in rats.

			3~7 days	14~18 days	27~31 days
Ca	Cont.	absorption (%)	58.6±3.9	55.3±3.0	38.3±3.2
		retention (%)	58.2±3.8	54.9±3.0	37.7±3.0
	FO 5%	absorption (%)	75.0±4.8 ***	64.0±4.0 ***	51.4±3.0 ***
		retention (%)	73.9±4.9 ***	62.9±3.9 ***	50.2±3.2 ***
Mg	Cont.	absorption (%)	61.0±3.2	55.3±3.7	49.8±5.3
		retention (%)	44.8±9.0	35.9±8.8	25.3±4.7
	FO 5%	absorption (%)	83.1±3.0 ***	78.3±5.2 ***	73.3±4.9 ***
		retention (%)	51.7±14.7	37.3±6.5	26.6±5.2
P	Cont.	absorption (%)	71.1±3.5	68.3±1.9	60.6±2.7
		retention (%)	46.3±5.5	41.4±9.3	29.5±4.1
	FO 5%	absorption (%)	80.7±3.4 ***	72.5±3.1 **	63.7±1.3*
		retention (%)	57.8±3.8 ***	44.6±4.8	26.2±2.5

Values are mean±SD (n=7).

*, **, *** Significantly different from Cont. group (* $p<0.05$, ** $p<0.01$, *** $p<0.001$)

Absorption=[(Intake-Fecal output)/Intake]×100

Retention=[(Intake-Fecal output-Urinaly output)/Intake]×100

Table 4 Effects of fructooligosaccharides on weight and mineral contents of femur

	dry weight (mg)	Ash (%)	Ca (%)	Mg (%)	P (%)
Cont.	551±27	60.4±0.53	23.2±0.76	0.462±0.022	8.52±0.168
FO 5%	570±16	62.1±0.70***	25.0±0.66***	0.487±0.018*	10.1±0.168***

Values are mean±SD (n=7).

*, *** Significantly different from Cont. group (* $p<0.05$, *** $p<0.001$).

Contents(%)=(Mineral amount/Dryweight)×100.

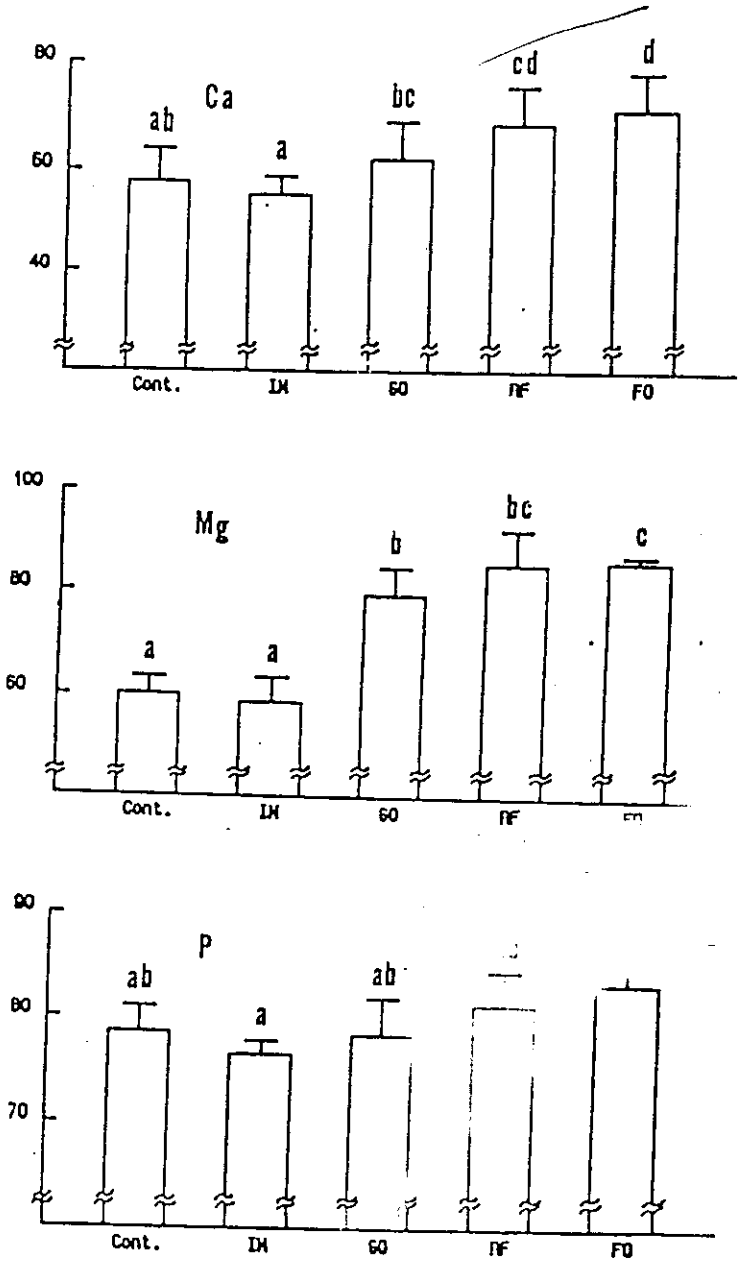
Table 5 Effects of oligosaccharides on the pH and organic acids concentration in the cecum contents of rats.

	pH	Acid concentration (mM)				
		Acetate	Propionate	Butyrate	d-Lactate	l-Lactate
Cont.	6.88±0.14 [a]	50.7±8.3 [a]	10.5±3.4 [bc]	8.5±3.7 [ab]	28.7±7.7 [a]	29.0±4.9 [a]
IM	7.06±0.18 [a]	52.4±6.8 [a]	15.2±2.9 [c]	7.4±2.8 [a]	32.6±11.8 [a]	34.0±5.1 [ab]
GO	5.62±0.31 [b]	62.9±17.7 [a]	6.3±2.1 [a]	17.0±3.5 [c]	41.4±13.6 [ab]	42.8±12.4 [bc]
RF	5.54±0.33 [b]	65.9±37.0 [ab]	7.8±5.0 [ab]	10.7±8.5 [ac]	50.4±14.6 [b]	50.1±13.8 [c]
FO	5.24±0.16 [b]	35.0±10.3 [b]	6.8±3.0 [a]	14.8±6.8 [bc]	87.1±12.6 [c]	68.8±5.7 [d]

Values are mean±SD (Cont.:n=6, IM, GO, RF, FO:n=7)

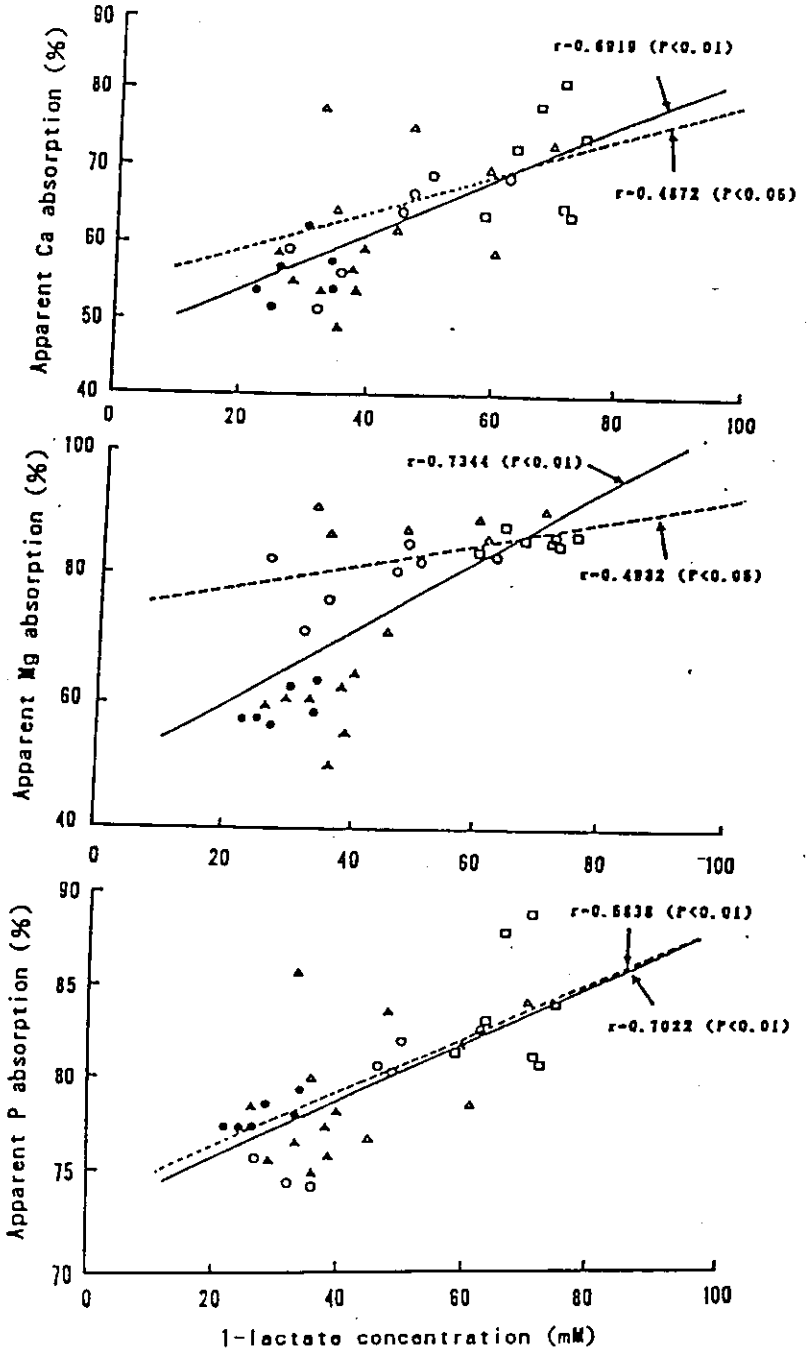
Exp 3.

Fig. 1 Effects of oligosaccharides on apparent absorption of calcium, magnesium and phosphorus in rats



Values are mean±SD (n=7).
Mean not sharing a common superscript letter are significantly different ($p<0.05$).
Absorption= {(Intake-Fecal output)/Intake} ×100
IM, GO, RF, FO are same abriviatants in the Table 1.

Fig. 2 Correlation between apparent mineral absorption ratio of rats fed oligosaccharides and l-lactate concentration



● : Cont. , ▲ : IM, ○ : GO, △ : RF, □ : FO
----- Correlation in three groups (GO, RF, FO : n=21)
—— Correlation in all groups (n=34)