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Influence of Soybean and Corn Gluten Proteins as Substitutes for Milk Protein in Milk Replacers on Growth, Liver and Thyroid Functions in Buffalo Calves

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TWENTY buffalo calves (3 weeks old) were allotted to four nutritional groups : Control group, fed 100 skim milk-based replacer (Group A) ; and in the other three groups 50% of milk protein was substituted by American soybean flour (Group B), Egyptian soybean meal (Group C) and corn gluten (Group D). Fat was added to all replacers at the rate of 20% on dry basis. Calf starter and hay were offered **ad libitum** with the liquid diets from the fourth week. Body weight was recorded weekly, Serum proteins, cholesterol, T_4, T_3 and GOT, GPT and alkaline phosphatase activities were determined at 6, 9, and 12 weeks of age.

The use of American soybean and corn gluten proteins resulted, approximately, in the same body weight gain as in the skim milk fed-group, indicating that whole milk can be reserved for human consumption and the calves can be reared on milk replacers containing plant proteins. Substitution of milk protein with soybean and corn gluten protein significantly ($P < 0.01$) increased serum A/G ratio and cholesterol, and significantly ($P < 0.05$) decreased serum total proteins, serum globulins and GPT activity. Growth and thyroid function were not affected by substituting milk protein with soybean and corn gluten proteins.

Key words : Buffalo calves, milk, replacers, plant proteins, performance, liver function, thyroid activety.

The increasing demand for milk in human diets, especially in developing countries, forced milk producers to replace milk protein in diets of calves with other less costly sources, such as plant proteins. There is supporting evidence that 50% substitution of skim milk with plant protein is economic and does not affect the performance of buffalo calves, *e.g.* digestibility, nitrogen balance, feed utilization and daily weight gain (El-Bassiony, 1983). Soybean protein is one of the attractive sources because of its high

nutritive value and availability as a by-product of oil industries (Evans and Bandemer, 1967). The response of young calves to milk replacers containing soybean proteins of different products (protein concentrates or meal) and undergoing different treatments has been reported (Colvin and Ramsey, 1969; Roy and Ternouth, 1972 and Nitsan *et al.*, 1972). The effect of substituting skim milk with rice gluten on body weight gain in buffalo calves was studied (Ragab *et al.*, 1978).

The main objective of the present study was to investigate the effect of substituting skim, milk with soybean and corn gluten on some parameters known to influence general metabolism in buffalo calves. The parameters studied were daily body gain, serum proteins, cholesterol, thyroid hormones (T_3 & T_4), GOT, GPT and alkaline phosphatase.

Material and Methods

Twenty male and female buffalo calves (at the age of three weeks) with body weight ranging between 52 and 64 kg, were randomly assigned to four nutritional groups (A, B, C and D). In group A the calves were fed 100% skim milk-based replacer as the main source of protein. In the other three groups 50% of milk protein was substituted by American soybean flour (group B), Egyptian soybean meal (group C) and corn gluten (group D). Fat, in the form of hydrogenated oil, was added at the rate of 20% on dry matter basis and mixed with the freshly prepared liquid diets. Table (1) shows the chemical composition and the nutritive values of the different milk replacers. The replacers were offered at a rate of 6 lit/calf/day twice at 8.00 a.m. and 3 : 00 p.m. for three weeks. From the fourth week and up to the end of experiment, the amounts of milk replacers was reduced to 4 lit/calf/day, and calf starter (consisting of : 18.5% crude protein, 6.7% crude fiber, 4.9% ether extract, 11.3% ash and 58.5% nitrogen-free extract gross energy 425.9 Kcal/100 gm). Clover hay and fresh tap water were offered to all groups. Body weight was recorded weekly. Blood samples were collected from each calf at the end of the 6th, 9th and 12th week of age. Serum was separated and stored at —20°C till analyzed for total proteins (Armstrong and Carr, 1964), albumin, A (Doumas *et al.*, 1971), cholesterol (Watson, 1960), transaminases (GOT

TABLE 1. The chemical composition and nutritive values of different milk replacers.

Items	100% milk protein (A)	50% milk protein + 50% American soybean flour (B)	50% milk protein + 50% Egyptian soybean meal (C)	50% milk protein + 50% Corn gluten (D)
Dry matter %	92.0	91.8	92.6	92.8
Crude protein % DM	21.7	21.7	21.6	21.6
Ether extract % DM	22.3	22.4	22.5	22.9
Crude fiber % DM	1.3	0.6	1.4	2.2
Total carbohydrates % DM	49.4	49.8	50.0	49.5
Ash, % DM	5.3	5.5	4.5	3.8
Gross energy (K cal/gm DM)	4.905	4.880	4.928	4.960
Mineral mixture (1), % DM	0.5	0.5	0.5	0.5
Vitamin mixture (2), % DM	1.0	1.0	1.0	1.0
Calculated lactose, % DM	35.3	36.2	35.5	33.9
Calculated T.D.N., %	104.5	104.0	104.0	106.0
Calculated D.P., %	19.1	19.0	19.0	19.0

(1) Mineral mixture was composed of the following ingredients : dicalcium phosphate 89%, sodium chloride 6%, magnesium oxide 2% and trace elements (Zn : Mn : Fe : Cu mixed as 2.5 : 1 : 1 : 0.5) 2%.

(2) Vitamin mixture composed of the following vitamins (mg/kg) : vitamin A 400, vitamin E 22, vitamin B-12 200, vitamin D-3 12.5, ascorbic acid 150, chloride coline (5%) 40, riboflavin 8, floic acid 0.2, nicotinic acid 30 and Ca-plantothenate (80%) 20.

and GPT) activity (Teitman and Frankel, 1957), alkaline phosphatase (Bessey, 1946), triiodothyronine, T_3 (Larsen, 1972), and total thyroxine, T_4 (Chopra, 1972). Serum globulin, (G), A/G ratio and T_3/T_4 ratio were calculated. The data were statistically examined according to Snedecor and Cochran (1982).

Results and Discussion

Substituting 50% of milk protein by plant proteins did not affect the daily body weight gain (Fig. 1). The use of American

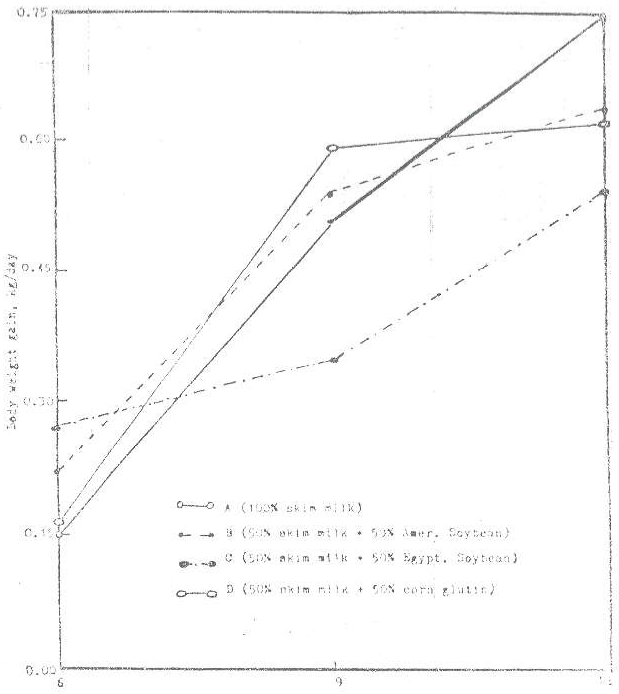

Fig. 1. Effect of substituting 50% of milk protein by soybean and corn gluten proteins on body weight gain (kg/day) in buffalo calves.

soybean and corn gluten proteins resulted, approximately, in the same body weight gain as the skim milk-fed group. However, the Egyptian soybean protein caused an insignificant decrease in body weight gain. This finding offers a new dimension in buffalos calf nutrition, whole milk can be reserved for human consumption since calves can be reared on milk replacers containing plant proteins without any significant decrease in body gain. However, diarrhea was frequently noted in the calves fed milk replacers containing plant proteins (group B, C and D) as compared with those fed skim milk (group A). It has been reported that inclusion of soybean protein in milk replacers resulted in reduced performance, and lower digestibility and absorption of nutrients, especially during the first 3 weeks of lite (Nitsan *et al.*, 1972 and Roy and Ternouth, 1972). Also, Ragab *et al.* (1978) found that the daily body gain decreased as the skim milk decreased and rice gluten increased. On the other hand, Wittenberg and Ingalls (1979) showed that growth rates of Holstein calves were similar when 0, 25, 50 and 80% of total protein in milk replacers was supplied by faba bean protein concentrate.

Table 2 shows that the substitution of milk protein with corn gluten protein resulted in a significant ($P < 0.05$) decrease in serum total proteins which was mainly due to a highly significant ($P < 0.01$) decrease in serum globulins. Also, corn gluten-fed group had significant ($P < 0.01$) increase in serum A/G ratio and cholesterol. However, substituting 50% of milk protein with soybean protein (either American soybean flour or Egyptian soybean meal) did not have any significant effect on blood constituent mean values as compared with skim milk. In non-suckling ruminants, Boling *et al.* (1970) did not observe any significant difference in plasma total proteins of steers fed soybean meal, when compared with the controls. Although O'Kelly (1973) reported that the plane of nutrition had no significant influence on plasma cholesterol in cattle, Amer and El-Sebai (1977) found that total serum cholesterol in rams was decreased with increasing the level of crude protein in rations. However, the mean values of serum total proteins obtained in the present study are within the range of normal values of buffalo calves reported by Foad *et al.* (1975), indicating that the substitution of milk protein by plant proteins is safe and does not have serious effect on the performance of calves.

TABLE 2. Effect of substituting 50% of milk protein by soybean and gluten on blood constituents buffalo calves gluten on blood constituents buffalo calves (mean ± S.E.).

Items	Age (weeks)	100% milk protein (A)	50% Milk protein		
			+ 50% American soybean flour (B)	+ 50% Egyptian soybean meal (C)	+ 50% Corn gluten (D)
Serum total proteins, gm/dl*	6	6.3 ± 0.15a	6.3 ± 0.16b	6.3± 0.17c	5.9 ± 0.17abcd
	9	6.3 ± 0.20a	6.2 ± 0.20b	6.3 ± 0.16c	5.8 ± 0.18abcd
	12	6.1 ± 0.16b	6.3 ± 0.05a	6.1 ± 0.14c	5.9 ± 0.10ad
Serum albumin, gm/dl	6	2.9 ± 0.04	2.8 ± 0.03	2.9 ± 0.06	2.8 ± 0.04
	9	3.0 ± 0.05	2.8 ± 0.02	3.0 ± 0.04	3.0 ± 0.09
	12	3.0 ± 0.07	2.9 ± 0.06	3.0 ± 0.04	3.1 ± 0.10
Serum globulins, gm/dl**	6	3.4 ± 0.17	3.5 ± 0.16	3.4 ± 0.21	3.2 ± 0.15
	9	3.2 ± 0.21C	3.4 ± 0.21A	3.3 ± 0.16B	2.8 ± 0.15ABD
	12	3.2 ± 0.10B	3.4 ± 0.02A	3.2 ± 0.15C	2.9 ± 0.04AD
A/G ratio**	6	0.86 ± 0.05	0.82± 0.04	0.87± 0.07	0.90± 0.04
	9	0.95± 0.07B	0.81± 0.06AD	0.90± 0.05AC	1.90+ 0.07A
	12	0.95± 0.02C	0.87± 0.02AD	0.96± 0.05B	1.11± 0.06A
Serum cholesterol, gm/dl**	6	55.6 ± 0.50AD	61.0 ± 4.59B	70.7 ± 3.70A	59.9 ± 5.60AC
	9	53.9 ± 1.89ABD	65.8 ± 5.94A	57.8 ± 1.77C	65.7 ± 5.42B
	12	53.4 ± 0.54ABD	64.2 ± 2.47B	56.4 ± 1.07AC	70.7 ± 0.67A

* $P < 0.05$.

** $P < 0.01$.

Within rows, means with the same superscripts are significantly different.

TABLE 3. Effect of substituting 50% of milk protein by soybean and corn gluten on enzymatic activity in buffalo calves (mean ± S.E.).

Items	Age (weeks)	100 % milk protein (A)	50% Milk protein + 50% American soybean flour (B)	+ 50% Egyptian soybean meal (C)	+ 50% Corn gluten (D)
Serum GOT, U/dl	6	62.1 ± 2.79	59.2 ± 4.24	62.5 ± 1.70	71.6 ± 1.44
	9	66.1 ± 1.41	67.1 ± 2.67	69.5 ± 1.06	68.2 ± 2.33
	12	67.2 ± 2.82	70.3 ± 4.51	72.3 ± 2.69	70.5 ± 3.10
Serum GPT, U/dl*	6	25.5 ± 1.01	21.1 ± 0.48	20.9 ± 0.59	22.4 ± 1.99
	9	25.5 ± 2.59a	21.9 ± 0.22ac	22.1 ± 0.74ab	21.6 ± 1.32ad
	12	26.4 ± 2.50a	21.8 ± 1.45ac	22.7 ± 0.62ab	21.2 ± 0.83ad
Serum alkaline phosphatase, U/l	6	46.4 ± 6.80	39.2 ± 4.81	51.5 ± 8.80	48.5 ± 5.93
	9	53.1 ± 5.47	48.0 ± 3.06	50.7 ± 6.50	47.7 ± 4.95
	12	58.1 ± 5.21	51.3 ± 11.72	47.4 ± 4.48	53.7 ±13.02

* $P < 0.05$.

Within rows, means with the same superscripts are significantly different.

TABLE 4. Effect of substituting 50% of milk protein by soybean and corn gluten on serum triiodothyronine (T_3), thyroxine (T_4) and T_4/T_3 ratio in buffalo calves (mean ± S.E.).

Items	Age (weeks)	100 % milk protein (A)	50% Milk protein + 50% American soybean flour (B)	+ 50% Egyptian soybean meal (C)	+ 50% Corn gluten (D)
Serum triiodothyronine, ng/dl	6	47.8 ± 9.36	63.1 ±13.41	58.0 ± 3.93	59.8 ± 9.01
	9	70.0 ± 5.80	66.3 ± 9.02	75.3 ± 6.08	55.0 ± 8.50
	12	73.1 ± 5.75	82.9 ±18.77	79.5 ± 3.80	59.0 ± 9.50
Serum total thyroxine, ug/dl	6	3.1 ± 0.49	2.4 ± 0.55	3.1 ± 0.21	3.4 ± 0.78
	9	3.7 ± 0.45	2.5 ± 0.13	3.6 ± 0.23	3.9 ± 0.77
	12	3.4 ± 0.50	3.1 ± 0.43	4.0 ± 0.48	3.9 ± 0.65
T_4/T_3 ratio**	6	71.0 ±12.36A	40.5 ±10.56ABD	54.3 ± 3.59C	65.3 ± 8.37B
	9	54.9 ± 9.85B	29.0 ± 3.42AD	49.1 ± 3.62AC	70.3 ± 4.39A
	12	47.2 ± 8.07AC	33.9 ± 6.79AD	50.3 ± 6.14Ab	68.4 ± 8.89A

** $P < 0.01$.

Within rows, means with the same superscripts are significantly different.

The milk protein-fed group (A) had significantly ($P < 0.05$) higher mean values of serum GPT activity (Table 3) than the plant protein-fed groups (B, C and D). This result suggests that the metabolism is higher in group A than in the groups B, C and D, and perhaps explain the higher body weight gain in group A than those of groups B, C and D. Linear relationship between body weight and serum GPT activity was observed by Boots *et al.* (1969) who demonstrated that any factor which affects metabolism will affect GPT activity.

Table (4) shows that the substitution of milk protein with American soybean protein decreased significantly ($P < 0.01$) the T_4/T_3 ratio, This result may be due to an increase in the perpheral conversion of T_4 to T_3, since the T_4 mean values were decreased and those of T_3 were increased but insignificantly, as compared with T_4 and T_3 of other groups. Hart *et al.* (1981) found an insignificant decrease in the levels of T_3 in female cattle calves fed a milk substitute (0-4 weeks of age) followed by a gradually decreasing ratio or milk substitute : hay and concentrates (4-12 weeks of age) and finally hay and concentrates alone (12-16 weeks of age). However, Trenkle (1978 reported that variations in the concentration of thyroid hormones in plasma of ruminants are related to circadian rhythm, environmental factors in addition to nutrition.

References

Amer, A.A. and El-Sebai, A. (1977) Effect of three levels of crude protein in ration of rams upon their haemogram and total serum cholesterol. Agric. Res. Rev. 159.

Armstrong, W.D. and Carr, C.W. (1964) "Physiological Chemistry". Laboratory Directions. 3rd Ed., Burges Publ. Co. Minneopolis, Minnesota, USA, p. 75.

Bessey, O.A. (1946) Estimation of alkaline phosphatase. J. Biolog. Chem. 164 : 321.

Boling, J.A., Bradley, N.W. and Tucker, H.E. (1970) Plasma nitrogen components and performance of steers fed corn silage supplemented with soybean meal and urea. J. Anim. Sci. 31 : 236. (Abstr.).

Boots, I.R., Crist, W.L., Davis, D.R., Brum, E.M. and Ludwick, T.M. (1969) Effects of age, body weight, stage of gestation and sex on plasma glutamic oxaloacetic and glutamic pyruvic transaminase activities in immature Holstein cattle. J. Dairy Sci. 52 : 211.

Chopra, I.J. (1972) A radioimmunoassay for measurement of thyroxine in unextracted serum. J. Clin. Endocrin. & Metab. 34 : 938.

Colvin, B.M. and Ramsey, H.A. (1969) Growth of young calves and rates fed soy flour treated with acid or alkali. **J. Dairy Sci. 52 : 270.**

Doumas, B., Watson, W. and Biggs, H. (1971) Albumin standards and measurement of serum with bromocresol green. **Clin. Chem. Acta. 31 :** 86.

El-Bassiony, A.A. (1983) Productive performance of artificially reared calves. **Ph. D. Thesis, Ain Shams Univ., Cairo, Egypt.**

Evans, R.J. and Bandemer, S.L. (1967) Nutritive values of some oil seed proteins. **Cereal Chem. 44 : 417.**

Foad, M.T., Awad, Y.L., Elde, M.S. and Fahmy, F. (1975) Certain biochemical abnormalities associating alopecia in buffalo calves. **Egypt. J. vet. Sci. 12 : 23.**

Hart, I.C., Morant, S.V. and Roy, J.H.B. (1981) A note on the variability of hormone concentrations in twice-weekly blood samples taken from heifers calves during the first 110 days of life. **Anim. Prod. 32 : 215.**

Larsen, P.R. (1972) Direct immunoassay of triiodothyronine in human serum. **J. Clin. Invest. 51 : 1939.**

Nitsan, Z., Volcani, R., Hasdia, A. and Gordin, S. (1972) Soybean protein substitute for milk protein in milk replacers for suckling calves. **J. Dairy Sci. 55 : 811.**

O'Kelly, J.C. (1973) Seasonal variations in the plasma lipids of genetically different types of cattle steers on different diets. **Comp. Biochem. Physiol. 44 : 303.**

Ragab, M.T., Helali, E., Farrag, F. and Lashin, M. (1978) Raising newly born buffalo calves on milk replacers. **J. Agric., Mansoura Univ. 3 : 205.**

Reitman, S. and Frankel, S. (1957) A colorimetric method for thedetermination glutamic-oxaloacetic and glutamic pyruvate transaminase. **Amer. J. Clin. Path. 28 : 56.**

Roy, J.H.B. and Ternouth, J.H. (1972) Nutrition and enteric diseases in calves. **Proc. Nutr. Soc. 31 : 53.**

Snedecor, G.W. and Cochran, W.G. (1982) "Statistical Methods". 7th Ed., The Iowa State Univ. Press, Ames, Iowa, USA.

Trenkle, A. (1978) Relation of hormonal variations to nutritional status and metabolism or ruminants. **J. Dairy Sci. 61 : 281.**

Watson, D. (1960) A simple method for the determination of serum cholesterol. **Clin. Chem. Acta. 5 : 637.**

Wittenberg, K.M. and Ingalls, J.R. (1979) Utilization of faba bean protein concentrate milk substitute diets by preruminant calves. **J. Dairy Sci. 62 : 1626.**

تأثير استخدام بروتينات كسب الصـــويا وجلوتين الاذرة كبديل لبروتينات اللبن فى بدائل الالبان على النمو ووظائف الكبد والغدة الدرقية فى العجول الجاموسى

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قسمت عشرون عجل جاموسى عمر ثلاثة اسابيع الى اربعة مجمـــوعات – الاولى غذيت ببديل لبن مصدر البروتين فيه لبن فرز (مقارنا) والمجاميع الثلاث الباقية تم استبدال ٥٠ ٪ من بروتين اللبن الفرز ببروتينـــات دقيق صويا امريكى فى المجموعة الثانية ، كسب صـــــويا مصرى فى المجموعة الثالثة وجلوتين اذرة فى المجموعة الرابعة . وقـد أضـــيف الدهن الى تركيبات كل البدائل بنســـبة ٢٠ ٪ من المادة الجـــافة .

وقـــد قـــدم بـــادىء ودريس برســـــيم الى العجـــــول بصورة حرة بجانب التغذية السائلة ابتداء من الاسبوع الرابع . سجل التغير فى اوزان الحيوانات اسبوعيا كما درست بروتينـــات الســـيرم والكولسترول و T_4, T_3 وانزيمات الترانس أمينيز والاكالين فوسفاتيز عند ٦ ، ٩ ، ١٢ اسبوع من العمر .

وتشير النتائج ان الزيادة فى الوزن فى مجموعة دقيق الصويا الامريكى كان مشابها لمجموعة اللبن الفرز مما يشير الى امكانية توفيراللبن الكامل للاستهلاك الادمى وتنشئة العجول على بدائل البان تحتوى على بروتينات نباتية . اوضحت النتائج ان الاستبدال الجزئى لبروتين اللبن ببروتينات الصويا او جلوتين الاذرة صحبه زيادة معنوية فى نسبة الالبيومين الى الجلوبيولين وكذلك تركيز الكولسترول – فى حين كان هناك انخفاض معنوى فى تركيز البروتينـــات الكلية فى مصل الدم وأيضـــا تركيز الجلوبيولين رانزيم جلوتاميك بيروفيك ترانس امينيـــز . ولم يتـأثر بالمعاملة كل من النمو ونشاط الغدة الدرقية .