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SUMMARY AND CONCLUSIONS

The present study was carried out at Sakha Animal Production Research Station, belonging to the Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, and Animal Production Department, Faculty of Agriculture, Al-Mansourah University during the period from August 2001 to March 2002 for the field study and till May 2003 for the histological examination.

A total of 18 newly born suckling Friesian calves was used in this study having average live body weight of 47.76 kg and one month of age. Animals were divided into three similar groups, six suckling calves in each according to their body weight. Beside berseem hay and milk (during the suckling period), calves in the 1st group were fed on concentrate feed mixture (CFM) and was considered as a control group. Calves were fed on 1% formaldehyde-treated CFM in the 2nd group, and on CFM supplemented with Magnapac (Ca-soap of fatty acids) as a source of protected fat in the 3rd group. The experimental calves were fed according to the recommendation of the **NRC (1984)** allowances.

Throughout the whole experimental period, body wieght and feed intake of calves in all treatment groups were monthly recorded, thereafter average daily gain, feed and protien efficiencies were calculated. Rumen fluid and blood samples were collected to determine some parameters in rumen liquor and blood serum.

At the end of the experimental period, three calves in each group were slaughtered to obtain carcass traits and chemical composition of meat was performed. Each segment of the digestive tract was separated and

anatomical and histological characteristics of each segment were investigated.

The main results of this study could be summarized as follows:

I. Growth performance:

1. At the end of the experiment (8 month of age), LBW of calves fed PP and PF diets represented about 115 and 109% of that in the control calves, respectively. However, LBW of calves fed PP was about 105% of that of calves fed PF.

2. Overall mean of ADG was significantly ($P < 0.05$) higher in calves fed PP and PF diets by about 19.74 and 12.15 %, respectively than in the control calves, however it was insignificantly higher by about 6.8% for the calves fed PP than those fed PF diet.

3. Generally, overall mean of feed efficiency was significantly ($P < 0.05$) better by about 7.24 and 8.14% in calves fed on PP and PF diets, respectively than those fed the control diet.

4. Overall mean of protein efficiency increased by about 19.23 and 8.87% in calves fed PP and PF diets, respectively as compared to those fed the control diet.

II. Rumen parameters:

1. On the basis of overall mean, pH values were significantly ($P < 0.05$) higher in rumen liquor of calves fed PP and PF diets than those fed the control one (6.50 and 6.14 vs. 5.98). However, pH values were significantly ($P < 0.05$) higher in rumen liquor of calves fed PP than PF diets (6.50 vs. 6.14).

2. Overall mean of concentration of VFA's was significantly ($P < 0.05$) higher in calves fed PF and control diets (12.54 and 12.57 m Eq/100 ml,

respectively) than that in calves fed PP diet (10.3 m Eq/100 ml). The differences between calves fed PF and control diets were not significant $P \geq 0.05$.

3. Overall mean of $\text{NH}_3\text{-N}$ concentration was significantly ($P < 0.05$) the highest in calves fed the control diet (21.2 mg/100ml), followed by those fed PF diet (20.2 mg/100ml). Meanwhile, calves fed PP diet showed the lowest values (17.9 mg/100ml).

4. The overall mean of protozoal count was significantly ($P < 0.05$) higher in rumen liquor of calves of the control and PF groups (1.337 and 1.234×10^6), while calves fed PP diet showed significantly ($P < 0.05$) the lowest count of protozoa (1.017×10^6).

5. There was a tendency of higher bacterial count in rumen liquor of the control calves (10.38×10^9) than those fed PF and PP diets, being higher in those fed PF (9.120×10^9) than PP (8.579×10^9) diets.

III. Blood parameters:

1. Haematological parameters:

1. Overall mean of RBCs count in calves fed PP and PF diets was significantly ($P < 0.05$) higher by about 9.9 and 12.4% than those fed the control diet, respectively. However, the differences between both tested groups (PP and PF) were not significant.

2. The overall mean of WBCs count at all ages studied was significantly ($P < 0.05$) higher by about 22.33 and 12% in calves fed PP and PF diets, respectively than in those fed control the diet.

3. Overall mean of lymphocytes distribution was significantly ($P < 0.05$) higher in calves fed PP (70.1%) than PF and the control (65.3 and 64.6%, respectively) diets.

4. Overall mean of monocytes distribution was significantly ($P < 0.05$) higher in calves fed PF and the control (12.6 and 12.9%) diets than those fed the PP (8.7%) diet.

5. Overall mean of granulocytes distribution was higher in calves fed the control and PF diets (22.6 and 22.2%) than those fed PP (20.8%) diet, however, the differences were not significant ($P \geq 0.05$).

6. Also, overall mean of platelets count was the highest in calves fed PP ($621.1/\text{mm}^3$), followed by those fed PF ($597.7/\text{mm}^3$) diet, while, the control calves showed the lowest values ($559.3/\text{mm}^3$). The differences, however, were not significant.

7. Overall mean of PCV% was significantly ($P < 0.05$) the highest in calves fed the PF (46.0%) diet, followed by those fed the PP (44.3%) diet. While the control calves showed the lowest values (41.5%).

8. Overall mean of Hb concentration was significantly ($P < 0.05$) the highest in blood of calves fed PP (10.7 g/100ml), followed by those fed PF (10.06 g/100ml). While, the control calves had the lowest concentration (9.32 g/100ml).

2. Biochemical parameters in blood serum:

1. Overall mean of total protein, albumin and globulin concentrations were significantly ($P < 0.05$) the highest in calves fed PP (7.88, 4.33 and 3.57 g/100ml) diet, followed by those fed PF (7.76, 4.28 and 3.48 g/100ml) diet. Meanwhile, the control calves showed the lowest values (7.39, 4.07 and 3.32 g/100ml). However, AL/GL ratio was not affected significantly ($P > 0.05$) by dietary treatments.

2. Overall mean of total lipids and cholesterol concentrations were significantly ($P < 0.05$) higher in calves fed PF (569.3 and 295.6 mg/100ml)

than those fed the PP (503.5 and 263.6 mg/100ml) and control (495.7 and 251.1 mg/100ml) diets, respectively.

3. Overall mean of glucose concentration was not affected significantly by dietary treatment groups.

4. Overall mean of urea-N concentration was the highest in calves fed PF (31.85 mg/100ml), followed by those fed the control (30.43 mg/100ml) diet. While, calves fed PP diet showed the lowest values (28.07 g/100ml). The differences among dietary treatment groups were significant $P < 0.05$.

5. Also, overall mean of AST and ALT activities did not differ significantly among dietary treatment groups ranging between 36.84 and 37.04 Iu/dl for AST and 16.70 and 16.87 Iu/dl for ALT activities.

IV. Carcass traits:

1. Preslaughter fasting weight and hot carcass weight of calves was significantly ($P < 0.050$) higher in animals slaughtered from PP groups (264.3 and 150.7 kg), followed by those in PF group (251.8 and 140.1 kg), While the control calves showed the lowest preslaughter weight (230.7 and 121.1 kg).

2. Also, dressing percentages on the basis of carcass weight or carcass weights plus weight of edible organs were significantly ($P < 0.05$) higher in calves fed PP (57.0 and 61.1%) and PF diets (55.4 and 58.6%) than those of the control calves (52.5 and 55.7%).

3. Weights of the edible organs, liver, heart, kidney and spleen were almost significantly ($P < 0.05$) higher in calves fed PP diets than in those fed PF and the control diets. However, hepato-somatic and renal-somatic indexes as well as ratios of heart and spleen to carcass weight were similar in calves of all groups.

4. There were insignificant differences in chemical composition of meat among dietary treatment groups.

V. Economic feed efficiency:

Economic feed efficiency in PP group was high (235%) compared to PF and control groups (199 and 198 %).

VI. Anatomical study:**1. Fresh tissue weight of different digestive tract compartments:**

a. The present study indicated that the highest effect of feeding calves on PP and PF diets was on fresh tissue weight of the omasum and the lowest one was on fresh tissue weight of the rumen.

b. Fresh tissue weights of omasum and abomasum as percentages of total fresh tissue weight of the digestive tract constituted significantly ($P < 0.05$) higher percentages in calves fed PP than those fed PF and control diets.

c. Fresh tissue weight of omasum as percentages of LBW or metabolic body weight (MBW) was significantly ($P < 0.05$) higher in calves fed PP than those fed PF and control diets, while percentage of abomasum was significantly ($P < 0.05$) lower in calves fed PF than those fed PP and control diets.

2. Contents weight of different digestive tract compartments:

a. Negative relationship was found between contents weight of abomasum and caecum of calves fed treated diets. Actual contents weight of abomasum was significantly ($P < 0.05$) higher and of caecum was lower in calves fed PP and PF diets than those fed the control diet.

b. As a percentage of total contents weight of the digestive tract weight of contents in abomasum, caecum and colon plus rectum showed significant ($P < 0.05$) differences as affected by dietary treatments.

c. Contents weight of different digestive tract compartments as percentages of LBW, showed significant ($P < 0.05$) differences only in caecum contents weight, being lower in calves fed PP diet than those fed PF and control diets.

3. Physiological volume of different digestive tract compartments:

a. Physiological volume of abomasum was significantly ($P < 0.05$) higher and of caecum was significantly ($P < 0.05$) lower in calves fed PP and PF diets than those fed the control diet. However, physiological volumes of reticulo-rumen, omasum, small intestine and colon plus rectum did not differ significantly among dietary treatment groups. Also, total physiological volume of the digestive tract was not affected significantly by dietary treatments.

b. Relative physiological volume of abomasum was significantly ($P < 0.05$) higher in calves fed PF and PP diets than those fed the control diet (6.0 and 6.3% vs. 3.4%). However, relative physiological volume of the other compartments did not differ significantly among dietary treatment groups. Generally, reticulo-rumen showed the highest physiological volume relative to the total volume of the digestive tract. It represented 63-70% of the total volume of the alimentary tract in all groups.

4. Relative fresh tissue weight of different stomach compartments to their total weight:

Relative fresh tissue weight of omasum significantly ($P < 0.05$) increased and of rumen significantly ($P < 0.05$) decreased in calves fed PP diet as

compared to those fed PF and control diets. However, relative fresh weight of reticulum and abomasum did not differ significantly as affected by dietary treatments. In all treatment groups, rumen showed the highest relative weight (45.5-49.8%), followed by omasum (20-25%) and abomasum (18-20%). While, reticulum showed the lowest weight relative to total weight of stomach compartments (10%).

5. Relative contents weight of different stomach compartments to their total weight:

Only weight of abomasum contents relative to total weight of contents in all stomach compartments was affected significantly ($P < 0.05$) by dietary treatment, being higher in calves fed PF and PP than those fed the control diet. However, relative weight of reticulo-rumen and omasum did not differ significantly among dietary treatment groups.

6. Relative physiological volume of different stomach compartments to their total volume:

Physiological volume of different stomach compartments relative to its total volume showed similar trend to that of relative contents weight.

7. Interior of the rumen:

1. Reticulo-rumen fold:

The length of the reticulo-ruminal fold was affected by dietary treatments, being significantly ($P < 0.05$) longer in calves fed PF (26.0 ± 0.81 cm) and PP (23.7 ± 0.54 cm) than that in the control calves (20.0 ± 1.9 cm). However, nearly similar heights were obtained in calves fed PF (3.8 ± 0.41 cm), PP (3.9 ± 0.25 cm) and control (3.3 ± 0.29 cm) diets.

2. Oesophagae groove:

The length of the oesophageal pillars were significantly ($P < 0.05$) lower in calves fed PF (16.3 ± 0.9 cm) than those fed PP and control diets (19.5 ± 0.4 and 19.3 ± 0.5 cm, respectively).

3. Ruminal pillar system:

a. The dorsal coronary pillar (DCP) showed the lowest surface area in all treatment groups compared with those of the other pillars, but it had almost significantly ($P < 0.05$) the largest surface area in calves fed the PF diet, followed by those fed PP diet. However, the control calves showed the smallest surface area. This reflected in significantly ($P < 0.05$) the lowest surface area of DCP as percentages of total area of all pillars and of total ruminal surface area in all groups. However, the group differences were not significant.

b. The largest surface area of pillars was for ventral coronary pillar (VCP) in the control calves, for cranial pillar (CRP) in calves fed PF and PP diets.

c. Feeding calves on PF diet resulted in significantly ($P < 0.05$) larger surface area of all pillars as compared to those fed PP and control diets. However, feeding PP diet resulted in increasing surface area of DCP only as compared to the control calves.

d. Surface of pillars as percentages of total pillars surface area or total ruminal surface area were almost higher in calves fed PF and PP diets than those of the control calves. However, similar percentages were obtained from calves fed PF and PP diets. Yet, group differences were not significant.

e. Total surface area of pillars, which represented the unapillary surface area of the rumen was significantly ($P < 0.05$) larger in calves fed PF than those fed PP and control diets. However, unapillary surface area proportional to total ruminal surface area was insignificantly higher in calves fed PF and PP diets (about 24%) than the control calves (19.7%).

4. Morphological characteristics of ruminal wall:

a. Unapillary surface area showed significant differences among dietary treatments, being larger in calves fed PF than those fed PP and control diets.

b. Total wet weight showed tendency to be higher in calves fed PF and PP diets as compared to the control calves. However, DM content and, in turn, total dry weight of the ruminal wall tended to be lower in calves fed PP diet and higher in those fed PF diet compared with the control calves.

c. Papillary surface area, total surface area and unapillary surface area proportional to total surface area of the rumen did not differ significantly among dietary treatments. However, unapillary surface area was significantly ($P < 0.05$) higher in calves fed PF diet than those in calves fed PP and control diets.

5. Morphological characteristics of the ruminal mucosa and musculosa:

a. Proportional weight of mucosa to total weight of the ruminal wall and its DM content tended to increase in calves fed PF diet compared with the control calves, but the differences were not significant. However, the proportional weight of the ruminal mucosa in calves fed PP diet was nearly similar to that of the control calves.

b. Feeding calves on PF and PP diets resulted in significantly ($P < 0.05$) higher total wet weight of the ruminal mucosa than the control calves.

However, feeding calves on PP diet resulted in significantly ($P<0.05$) lower total dry weight of the ruminal mucosa than those fed PF and control diets.

c. There was a tendency of higher proportional weight and total wet weight as well as lower DM content and total dry weight of the ruminal musculosa in calves fed PP diet than those fed the control diet.

d. Feeding calves on PF diet resulted in a tendency of lower proportional weight and total weight as well as higher total dry weight of the ruminal musculosa than the control calves. Content of DM in the ruminal musculosa was nearly similar in calves fed PF and control diets.

VII. Histological characteristics of the rumen:

1. Total thickness of tunica mucosa was significantly ($P<0.05$) higher in rumen of calves fed PP diet than that in calves fed PF and control diets.

2. Lamina epithelialis mucosa thickness did not differ significantly in calves fed on PF and PP as compared to the control diet. However, it was significantly ($P<0.05$) higher in calves fed PF than those fed PP diet (0.30 vs. 0.27 mm).

3. Overall mean of st. corneum showed a tendency of thicker type in the control calves (44.3 μm) than in calves fed PF (42.9 μm) and PP (43.2 μm) diets, the differences were not significant.

4. Thickness of lamina propria was significantly ($P<0.05$) higher in rumen of calves fed PP diet than in those fed PF and control diets (1.20 vs. 0.96 and 1.02 mm).

5. Thickness of submucosa was significantly ($P<0.05$) higher in calves fed PF and PP diets than that of the control calves.

6. Thickness of circular muscle layer of tunica musculosa in calves fed PF and PP diets did not differ significantly from that of the control. However, the effect was markedly observed on longitudinal muscle layer and, in turn

on total thickness of tunica muscosa, being significantly ($P < 0.05$) higher in calves fed PF and PP diets than those in the control calves.

Generally, all thicknesses varied significantly between different ruminal sacs as affected significantly ($P < 0.05$) by dietary treatments. Ventral ruminal sac showed significantly ($P < 0.05$) the highest thickness in calves of all groups.

VIII. Ruminal papillae:

1. Papillary length in different ruminal sacs was affected significantly ($P < 0.05$) by dietary treatment, but calves fed PF or PP diets did not differ significantly from that of the control calves. The significant differences in papillary length were found between calves fed PF and PP diets, being significantly shorter in the first than the later.
 2. Papillary width tended to be insignificantly lower in rumen of calves fed PF and PP diets than in the control calves (1.55 and 1.50 vs. 1.72 mm).
 3. Density of papillae in most ruminal sacs was significantly ($P < 0.05$) lower in calves fed PF and PP diets than the controls.
 4. Surface area of each papilla was significantly ($P < 0.001$) lower in calves fed PF diet than those fed PP and control diets, which did not differ significantly.
 5. Papillary surface area per cm^2 was significantly lower in calves fed PF diet, however, PP diet showed insignificantly lower values compared with the control.
 6. Inter-papillary surface area per cm^2 showed negative relationship with papillary density and was significantly affected by dietary treatments, ruminal sac and their interaction.
 7. Total surface area per cm^2 of different ruminal sac mainly affected by surface area of papillae within each cm^2 . So, total surface area/ cm^2 showed
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the same trend of surface area of papillae/cm² as affected by dietary treatment and ruminal sacs.

On the basis of the foregoing results concerning increasing growth performance without any adversely effects on different parameters of the rumen liquor, haematological and biochemical constituents of blood, carcass traits, anatomical characteristics of various compartments of the digestive tract and histogenesis and histometric characteristics of rumen in calves fed PF and PP diets, it could be concluded from the nutritional point of view, that feeding calves on the tested diets resulted in beneficial effects on growth performance of Friesian calves during suckling period and early post-weaning ages. From the economic point of view, feeding calves on PP diets was more efficient than PF and control diets.
