

**EFFECTS OF DIETARY SUCROSE THERMAL OLIGOSACCHARIDE CARAMEL ON
HEMATOLOGICAL PARAMETERS, FIBRONECTIN, SELECTED SERUM BIOCHEMICAL
CONSTITUENTS AND HORMONES, AND CECAL BACTERIAL COUNTS OF WHITE PEKIN
DUCKS**

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Ninety-six, 2-wk-old white Pekin ducks were fed a novel sugar, sucrose thermal oligosaccharide caramel (STOC) to determine its effect on hematological parameters, fibronectin, selected serum biochemical constituents and hormones, as well as cecal total gram-negative bacterial counts in ducks. Red blood cell characteristics were not influenced by the diet. Feeding STOC resulted in more ($P<0.05$) heterophils, a decreased number of lymphocytes, a significant ($P<0.001$) increase in heterophil / lymphocyte ratio and a decrease in basophil counts ($P<0.05$) compared with ducks fed the control diet. The inclusion of STOC in the diet led to a significant increase in serum total protein ($P<0.01$), albumin ($P<0.001$) and globulin ($P<0.05$). Serum from STOC-fed ducks had significantly more Ca ($P<0.05$), more P ($P<0.01$) and increased Anion Gap ($P<0.01$). Serum triglycerides and cholesterol levels were not affected by dietary treatment. The concentration of fibronectin which is associated with cell adhesion, homeostasis and augmenting the function of the mononuclear phagocytic system, was significantly higher ($P<0.01$) in both serum and plasma from ducks fed the STOC diet when compared with those fed the control diet. Levels of triiodothyroxine (T_3), thyroxine (T_4) and corticosterone in the blood were not affected by inclusion of STOC in the diet. The diet did not influence cecal gram-negative bacterial counts (\log_{10}). No salmonella were detected in the ceca of ducks fed STOC or in the ceca of ducks fed the control diet. Feeding STOC to growing ducks seemed to enhance favorable changes in several normal physiological parameters

Key words: Sucrose thermal oligosaccharide caramel, ducks, blood parameters, hormones, cecal gram-negative bacterial counts.

INTRODUCTION

The use of fructo-oligosaccharides (FOS) in poultry diets has resulted in improvements in weight gain, feed efficiency, mortality rate and *Salmonella* colonization (Bailey, et al., 1991; Waldroup et al., 1993; Patterson et al., 1997; Orban et al., 1997). The FOS are selectively utilized by intestinal bacteria resulting in a remarkable increase in beneficial bifidobacteria and a subsequent inhibition of pathogenic bacteria such as *Salmonella enteritidis* (Hidaka et al., 1986). Fukata et al (1999) founded that, feeding fructo-oligosaccharides reduced susceptibility to *Salmonella* colonization whereas Bailey et al (1991) concluded that *Salmonella* did not grow when fructo-oligosaccharide was the sole carbon and energy source. Dietary FOS has been shown to decrease serum triglycerides and cholesterol levels in rats (Tokunga et al., 1986). Our studies in broilers (Orban et al., 1997 and Patterson et al., 1997) have shown that feeding a novel Sucrose Thermal Oligosaccharide Caramel (STOC) resulted in improvement in growth performance of poultry and fostered the growth of beneficial cecal bifidobacteria. The physiological mechanism by which growth enhancement occurs remains to be elucidated.

Depending on the severity of the stress, Maxwell et al. (1992) concluded that some poultry may respond, by producing heterophilia or basophilia. Although they do not correlate well, Gross and Siegel (1983) indicated heterophil: lymphocytes ratio (H/L) and plasma corticosterone (CS) as measures of stress in poultry. Thus H/L measures physiological changes (long-term response), while plasma CS measures short-term changes (Gross and Siegel, 1983). Trout et al (1988) postulated that an increase in CS level followed by a decrease in circulating lymphocytes and monocytes is an early step in the initiation of humoral immunity. There was a positive correlation between H/L ratio and the amount of CS in the feed (Gross, 1992). Corticosterone and H/L ratio tend to increase after feed restriction (Beuving et al., 1989).

Jain (1993) stated that the effect of corticosteroids on leukograms is typically manifested as leukocytosis, neutrophilia, lymphopenia, and eosinopenia. Corticosteroid production causes redistribution of lymphocytes from the circulation to secondary lymphoid organs, such as the spleen, for antigen processing and eventual production of antibodies against invading antigens (Mashaly et al., 1998). On the other hand the quantities of plasma or serum constituents in the blood may be affected by feed restriction and nutritional manipulation.

Fibronectin, a high molecular weight glycoprotein present in plasma and other extracellular fluids, plays an important role in hemostasis, wound healing, and in augmenting the function of the mononuclear phagocytic system (MPS) during tissue injury (Mosesson and Amrani, 1980; Amrani et al., 1986; McKeown-Longo, 1987, and Saba and Jaffe, 1980). Preparations of human plasma fibronectin have been under assessment for clinical use in the treatment of trauma, cancer and infectious diseases, the promotion of wound healing, besides a consideration of its role in thrombosis, hemostasis, fibrosis, cell adhesion, and embryonic cell migration (Horowitz and Chag, 1989; Hynes, 1990; Hay, 1991). Once the range of normal values is known, abnormal values of plasma fibronectin may be of diagnostic and prognostic value (Feldman et al., 1988). Sandstedt et al. (1984) stated that plasma fibronectin, which is important for immunodefense, has been reported to decrease after starvation. On the other

hand, plasma fibronectin concentration tends to decrease in severely sick people (Mosher and Williams, 1978) and in ill dogs (Feldman and Thomson, 1983). This decrease may be due to either increased utilization or decreased synthesis of fibronectin (Feldman *et al.*, 1988). Fibronectin in humans has been used as an indicator of nutritional status (Kirby *et al.*, 1985). Nevertheless, despite its biological significance, plasma fibronectin has not been extensively studied in livestock (Gentry *et al.*, 1992) and in poultry including ducks.

Corticosterone, which has a multiple direct effect on the body immune processes (Parillo and Fauci, 1979), has been found to be a useful physiological indicator of stress in ducks (Harvey *et al.*, 1980). Therefore, it may be expected that in response to physiological stress, fibronectin and plasma CS should increase. Sojka *et al.* (1993) indicated that triiodothyronine (T₃) and thyroxine (T₄) concentration in the blood may be altered by changes in circulating blood proteins or circadian rhythm. The concentration of T₃ and T₄ decreased significantly in deep litter birds during summer compared to winter (Ghodasara *et al.*, 1990). Serum T₃ is the principal metabolically active thyroid hormone and is more strongly correlated with reduction in feed intake in chickens (Williamson *et al.*, 1985; Sechman *et al.*, 1989). During feed restriction plasma concentration of T₃ decreased and T₄ increased in broiler chickens (Gonzales *et al.*, 1998). Yahav and Plavnik (1999) found that plasma T₃ concentration was greatly depressed during thermal challenges. However, May *et al.* (1986) reported that neither T₃ nor T₄ is consistently affected by severe heat exposure (at 41°C for 4 to 6 h.). It is not known whether exclusion of antibiotics from poultry diets or the inclusion of STOC that promotes proliferation of beneficial gut bacteria would influence the blood concentrations of fibronectin, CS, T₃, T₄ and serum biochemical constituents.

The objective of this study was to examine the effect of STOC on hematological values, serum biochemical constituents, blood profiles of CS, T₃, T₄, and fibronectin, together with cecal total gram-negative bacterial counts in white Pekin ducks.

MATERIALS AND METHODS

Ninety-six, 2-wk-old white Pekin ducks were assigned at random to one of sixteen wire pens over a waste pit. The six ducks in each pen were fed one of two diets for 3 wk: a duck starter diet or a starter diet containing 3.5% STOC. Diets were formulated to contain 22% crude protein and a minimum of 2,900 Kcal/kg of ME as well as recommended levels of minerals and vitamins which met or exceeded the NRC recommendations (NCR, 1994). Neither diet contained antibiotics. Each diet was fed to eight replicate pens of ducks, all in one room. Group body weight and feed intake were obtained weekly for each pen.

Sampling Procedures:

At the end of the feeding period, eight ducks from each treatment group were randomly selected for hematological and microbiological studies. Ducks were individually weighed and blood samples were collected from each bird early in the morning via cardiac puncture into two collecting tubes, one containing ethylene diamine tetra - acetic acid (EDTA) as anticoagulant and the other a vacutainer tube for serum separation. Care was taken to avoid subjecting the birds to unnecessary stress. The birds were then euthanized by cervical dislocation.

Ceca were aseptically removed and stored on ice for determination of gram-negative bacteria and enumeration of salmonellae.

Hematological Examinations:

The hematological values obtained from the EDTA blood sample included: packed cell volume (hematocrit, % PCV), hemoglobin (Hb), red blood cells (RBC), white blood cells (WBC), and differential leukocyte count. Heterophil to lymphocyte (H/L) ratio, mean corpuscular volume (MCV), and mean corpuscular hemoglobin concentration (MCHC) were then calculated. The microhematocrit method (Harrison and Harrison, 1986) was used for determining the hematocrit. Red blood cells were counted with a Model ZBI Coulter Counter and Hb was read on a Coulter Hemoglobinometer². Following red blood cell lysis and prior to measuring Hb, samples were centrifuged for 10 min. (x1000 rpm) to remove nuclear material and cytoplasmic debris. Total WBCs were counted using the Eosinophil Unopette Test B-D No. 5877³. The total heterophils and eosinophils counted by the Unopette technique were used to calculate the total number of WBCs from the percentage of heterophils and eosinophils determined by differential leukocyte count. Differential leukocyte counts were determined on blood smears stained with Wright-Giemsa.

Serum Biochemical Constituents:

Serum was harvested from the blood samples after centrifugation within 6 h of collection and stored frozen at -80°C until analyzed for calcium (Ca), inorganic phosphate (P), sodium (Na), potassium (K), chloride (Cl), total CO₂, anion gap (AG), total bilirubin, unconjugated bilirubin, delta bilirubin, aspartate aminotransferase (AST), alkaline phosphatase (ALP), glucose, total protein, albumin, uric acid, creatinine, cholesterol, and triglycerides. The assays were performed on a Kodak Ektachem 700 Dry Chemistry Analyzer⁴.

Plates were read using Bio-Rad Microplate Reader⁵.

Plasma and Serum Fibronectin:

Fibronectin in plasma and serum samples obtained from the control and STOC-fed ducks was determined in duplicate using competitive ELISA as described by Carrengie (1990) and outlined by Novero and Asem (1993). Briefly, frozen plasma and serum samples were thawed overnight at 4°C. Samples were diluted 1:4000 with PBS buffer (pH 7.4) containing 0.85% NaCl. The concentration of plasma and serum fibronectin was determined after log-logit transformation of the standard curve using a Bio-Rad microplate manager (Novero and Asem, 1993).

CS, T₄, and T₃ Radioimmunoassay (RIA):

Blood plasma from each of eight ducks in the control and STOC groups were assayed for CS as described by Pierson *et al.* (1981), with the exception that extraction efficiencies were done for individual samples rather than a plasma pool. Serum concentrations of T₄ and T₃ were measured as described by Sojka *et al.* (1993) using RIA kits⁶. Frozen samples were thawed in a refrigerator before being assayed. The assay was validated for precision, accuracy, and sensitivity (Sojka *et al.* 1993).

²Coulter Electronics, Inc., Hialeah, FL 33116-9015

³Becton-Dickson, Rutherford, NJ 07417

⁴Clinical Products Division, Eastman Kodak Co., Rochester, NY 14650 (wt/vol) and 10 mM NaH₂PO₄.

⁵Bio-Rad Laboratories, Richmond, CA 94808

⁶Diagnostic Products Corp., Los Angeles, CA 90045.

Bacteriological Culture of Ducks Ceca:

The pair of ceca from each duck, aseptically removed, was placed in a sterile stomacher bag with 10 ml sterile saline. The bag was blended for 60 sec using a Stomacher Lab-Blender⁷ to produce a homogeneous suspension. One ml of the suspension was removed, serially diluted

In sterile saline up to 10-8 dilution in sterile test tubes. One-tenth ml from each dilution was spread-plated on McConkey plates in duplicate. The plates were incubated for 24 h at 37 °C and the number of gram-negative bacterial colonies (lactose fermenters as well as lactose nonfermenters) were counted. Mean colony plate counts were transformed to logarithmic values and expressed as log 10 gram negative bacteria per bird cecal content. To detect Salmonella, 100 ml of freshly prepared tetrathionate broth was added to the cecal suspension in the stomacher bag. The bags were incubated at 41 °C for 24 h. Contents were then plated on LXT4 plates and incubated for 48 h at 37 °C. The plates were examined for salmonella suspect colonies. Salmonella suspect colonies were confirmed using recommended biochemical and serological procedures (Edward and Ewing, 1986). When Salmonella organisms were detected their count in a cecal pair was determined from a 1 ml cecal suspension sample removed from the stomacher bag kept at 4°C.

Statistical Analyses:

Statistical analyses were performed using the GLM procedures of SAS (1985) for analysis of variance. Separation of means was done using the Student-Newman-Keuls test (SAS, 1985). Pooled standard errors of the mean (SEM) were calculated and reported with least square means and probability values. Statistical significance of observed effects was defined at 5% probability.

RESULTS

Hematological values:

The mean PCV, Hb, MCV and MCHC did not differ ($P > 0.05$) in ducks fed the STOC diet when compared with ducks fed the control diet (Table 1). No significant differences were found in total WBCs, monocyte or eosinophil counts between ducks fed the two diets. The results showed a significantly higher ($P < 0.01$) H/L ratio in the blood from ducks fed the STOC diet. Ducks fed the STOC diet had more heterophils but fewer basophils ($P < 0.05$) compared with those fed the control diet (Table 1).

Biochemical Constituents:

Serum from STOC-fed ducks had significantly higher Ca ($P < 0.05$), P ($P < 0.01$) and AG ($P < 0.01$) than control ducks. Mean values for total proteins and albumin were higher ($P < 0.01$) in serum from STOC-fed ducks than in serum from the control group. STOC feeding resulted in greater serum globulin concentrations ($P < 0.05$) (Table 3). Fibronectin was higher ($P < 0.01$) in plasma and serum of STOC-fed ducks than in plasma and serum obtained from ducks fed the control

⁷Tekmar Co., Cincinnati, OH 45242-9576.

Table 1. Least-squares means (\pm SEM) of the hematological profile in growing Pekin ducks fed diets with or without sucrose thermal oligosaccharide caramel (STOC)

Item	Diet		SEM	Significance of effects ¹
	Control	STOC		
Hematocrit, %	34.5	31.7	2.3	NS
Hemoglobin, g/dL	10.0	9.4	0.8	NS
RBC, $10^6/\mu\text{l}^{-1}$	2.8	3.3	0.4	NS
MCV, fl	123.5	101.3	20.9	NS
MCHC, g/dL	29.0	30.7	4.3	NS
WBC, $10^3/\mu\text{l}^{-1}$	10.3	18.9	4.1	NS
Heterophils, $10^3/\mu\text{l}^{-1}$	5.9	16.2	3.8	*
Lymphocytes, $10^3/\mu\text{l}^{-1}$	3.5	2.0	0.5	NS
Heterophils:lymphocytes	1.7	8.2	0.8	**
Monocytes, $10^3/\mu\text{l}^{-1}$	0.2	0.5	0.1	NS
Eosinophils, $10^3/\mu\text{l}^{-1}$	0.1	0.3	0.01	NS
Basophils, $10^3/\mu\text{l}^{-1}$	0.6	0.3	0.05	*

** $P < 0.01$. * $P < 0.05$.

RBC, WBC = red and white blood cells, respectively.

MCV = mean cell volume.

MCHC = mean cell hemoglobin concentration

Table 2. Least-squares means (\pm SEM) for blood electrolytes, minerals, bilirubin and enzymes in growing Pekin ducks.

Item	Diet		SEM	Significance of effects
	Control	STOC		
Number of observations	8	8		
Ca, mg/dL	10.44	10.77	0.10	*
P, mg/dL	7.11	8.07	0.25	**
Na, mmol/L	139.28	140.00	0.67	NS
K, mmol/L	2.43	2.76	0.17	NS
Cl, mmol/L	105.28	103.12	0.91	NS
Total CO ₂ , mmol/L	25.57	25.75	0.65	NS
Anion gap, mmol/L	11.28	13.37	0.51	**
Total bilirubin, mg/dL	0.31	0.36	0.12	NS
Unconj. bilirubin, mg/dL	0.10	0.11	0.01	NS
Delta bilirubin, mg/dL	0.28	0.37	0.14	NS
AST, IU/L	72.43	102.25	33.52	NS
ALP, IU/L	271.28	302.12	16.35	NS

** $P < 0.01$. * $P < 0.05$. STOC = sucrose thermal oligosaccharide caramel.

AST = aspartate aminotransferase.

ALP = alkaline phosphatase

diet (Table 3). Although not significant ($P > 0.05$), STOC feeding resulted in a decrease in serum triglycerides.

Table 3. Least-squares means (\pm SEM) for body weight, serum glucose, proteins, and lipids in growing Pekin ducks

Item	Diet		SEM	Significance of effects
	Control	STOC		
Number of observations	8	8		
Body weight, g	1277.30	1376.57	24.52	**
Glucose, mg/dL	187.86	184.62	5.87	NS
Total protein, g/dL	2.71	3.01	0.07	**
Albumin, g/dL	1.27	1.40	0.03	***
Globulin, g/dL	1.44	1.61	0.06	*
A/G	0.88	0.86	0.03	NS
Fibronectin (plasma) ng/ μ L	255.04	326.07	13.04	**
Fibronectin (serum) ng/ μ L	144.30	288.00	21.27	**
Uric acid, mg/dL	4.31	4.71	0.41	NS
Creatinine, mg/dL	0.16	0.19	0.02	NS
Cholesterol, mg/dL	117.00	126.87	7.00	NS
Triglycerides, mg/dL	81.57	66.12	6.14	NS

*** $P < 0.001$. ** $P < 0.01$. * $P < 0.05$

A/G = albumin:globulin ratio.

Hormonal profiles and bacterial counts:

Levels of plasma CS and serum T_3 and T_4 in ducks fed the examined diets are presented in Table 4. No diet related differences were detected. Total

Table 4. Least-squares means (\pm SEM) for some hormones and \log_{10} gram-negative bacteria/cecal pair in growing Pekin ducks

Item	Diet		SEM	Significance of effects
	Control	STOC		
Corticosterone (ng/mL)	16.89	20.15	2.86	NS
Triiodothyronine (T_3) ng/mL	1.49	1.39	0.10	NS
Thyroxine (T_4) ng/mL	14.36	12.45	1.14	NS
Gram-negative bacteria (\log_{10})	5.8	4.3	1.0	NS

NS = Not significant, $P > 0.05$

gram-negative bacteria count in the ceca of ducks fed STOC were not significantly (mean \log_{10} count = 4.3) different from those fed the control diet (mean \log_{10} count = 5.8) (Table 4). No *Salmonella* colonies were detected in ceca from any of the ducks.

DISCUSSION

The use of sugars and complex carbohydrates in poultry diets was initiated early in this century (Barnes *et al.*, 1979; Beach, 1925; Beach and Davis, 1925; and Beach and Card, 1925). Recently, oligosaccharides were found to have beneficial effects for improving health in humans as well as enhancing growth and production in animals (Hidaka *et al.*, 1986). STOC has been tested in a number of studies at Purdue University (Orban *et al.*, 1997; Patterson *et al.*, 1997) to determine its effects on growth performance and intestinal microflora in broiler chickens, ducks, and swine. The use of STOC in broiler and duck diets resulted in improved growth and increased numbers of beneficial bifidobacteria in the feces (Orban *et al.*, 1997). Additional studies showed that broilers fed diets containing STOC at 3.5% of the diet performed better (weight gain and feed intake) under heat stress and low vitamin-mineral fortification than broilers that were not fed STOC diets (Orban *et al.*, 1997). A similar effect was observed in the present study where the STOC-fed ducks had an 8 % greater weight gain than ducks fed the control diet. Similar improvements in weight gain and feed efficiency were reported by Ammerman *et al.* (1988) and Sims *et al.* (1998) in broiler chickens fed oligosaccharides.

There were significantly higher levels of total protein, albumin, and globulin as well as minerals (Ca and P) in serum from ducks fed the STOC-diet when compared with the controls. Total serum protein or serum albumin may be an indicator of protein reserves in an animal, and perhaps a reflection of greater protein intake (Allison, 1955). Leveille and Sauberlich (1961) stated that the increase in serum albumin, and therefore total serum protein, when the dietary protein level was increased beyond the requirement for growth, reflected the ability of the chick to store unreserved protein even after the maximum capacity for depositing tissue or less labile protein has been reached. Moreover, increased protein intake in poultry may enhance resistance to infection (Seeler and Ott, 1945). The results of this study are in agreement with the observations of Leveille *et al.* (1960) who showed that dietary protein level markedly affected the level of total serum protein and albumin.

Feeding oligosaccharides has been shown to increase mineral absorption and there is also an inverse relationship between mineral absorption and pH (Demigne *et al.*, 1980, 1989; Remesy *et al.*, 1989; Levrat *et al.*, 1991; Ohta *et al.*, 1993; Schultz *et al.*, 1993; Delzenne, *et al.*, 1995). Short chain fatty acids and decreasing pH have also been shown to increase mineral absorption (Trinidad, *et al.*, 1997). The increased serum levels of minerals in the present study confirm these findings. However, changes in pH and VFA concentrations are not consistently observed when oligosaccharides are fed, so the mechanism for increased mineral absorption is not clear. Similar results were reported in the rat (Ohta *et al.*, 1998; Morohashi *et al.*, 1998) and in humans (van den Heuvel *et al.*, 1999) where feeding fructooligosaccharide increased Ca absorption. Dietary calcium had no significant influence on the body levels of calcium and phosphorus in turkeys (Kohne and Jones, 1975). In laying hens, dietary calcium levels of 1.8%, 2.8%, 3.8%, and 4.8 % did not significantly affect serum calcium levels (Sullivan and Gehle, 1962). The inclusion of STOC in the diet did not decrease serum cholesterol levels in ducks. However, the findings of this study regarding triglycerides were similar to those of Tokunga *et al.* (1986) and Williams (1999) in that FOS feeding tended to decrease serum triglycerides and cholesterol levels

in rats. Similarly a lipid lowering effect by oligosaccharides was reported by Delzenne and Kok (1999) in rats that could be a beneficial property. They attributed the antilipogenic effect of oligosaccharides to decreased serum insulin and glucose.

Wide variations in serum uric acid, AST and bilirubin were observed. The values reported in the present study were similar to those for ducks of Webb *et al.* (1991), but higher than the values given by Spano *et al.* (1987). The serum P level is in agreement with that reported by Webb *et al.* (1991), but higher than the values of Spano *et al.* (1987). Although our results for TG are not in agreement with those reported by Spano *et al.* (1987), our observations for cholesterol confirm the findings of Hamza *et al.* (1974). Differences for some of the serum constituents observed in the literature and in this investigation may be partly due to the biochemical methods used to perform the analysis, as suggested by Spano *et al.* (1987). In addition, breed; age of the bird and management may influence some of the biochemical constituents in duck serum.

Inclusion of STOC in the diet did not affect either T₄ or T₃, which may suggest that the STOC contribution to short-term alleviation of stress does not work through these hormones. Similarly Ghodasara *et al.* (1990) concluded that the mechanism of short-term acclimation involves physiological responses other than changes in the level of circulating thyroid hormones.

Although normal fibronectin concentrations in plasma and serum from ducks are not available to allow for direct comparisons, the results are within the range published for other species. Fibronectin concentrations in the plasma and serum from the control group were 255.0 ng/ μ l and 144.30 ng/ μ l and in the plasma and serum in the STOC-fed group were 326.07 ng/ μ l and 288.0 ng/ μ l, respectively. O'Neil *et al.* (1986) reported a mean normal fibronectin concentration for dogs of 320 μ g/mL of plasma. In mares, Feldman *et al.* (1990) reported a level of 38 μ g/ml of plasma. The lower serum fibronectin levels observed in this study may be explained by the fact that fibronectin binds to fibrin in the clot and becomes crosslinked to it in a calcium-dependent reaction (Mosher 1975, 1976; Matsuda *et al.*, 1978). A number of hypotheses have been suggested regarding the cause of plasma fibronectin change. A decrease in fibronectin concentration may be attributed to the use of this protein by the mononuclear phagocyte system for a plasma clearance function, consumption by incorporation into intravascular thrombin and fibrin matrices, proteolytic destruction by granulocytic or tissue proteases, binding to areas of tissue damage and denatured collagen, or decreased synthesis (Mosher, 1980). Increases in fibronectin concentration have been observed in rats with sepsis (Grossman *et al.*, 1983) and in humans with metastatic mammary neoplasia (Choate and Mosher, 1983). Whether fibronectin concentration is increased because of a certain protein synthetic stimulus in the liver has not been determined (Feldman *et al.*, 1988). Nutrition was found to be another factor influencing fibronectin concentrations (Scott *et al.*, 1982; Dillon *et al.*, 1982). Kono *et al.* (1988) reported that plasma fibronectin concentrations decreased after energy restriction.

Linden *et al.* (1986) found a decrease in plasma fibronectin concentration in persons on a low-energy diet, and total parenteral nutrition improved fibronectin synthesis in stressed and septic patients. Also, Kirby *et al.* (1985) found that plasma fibronectin concentrations showed a significant increase in all patients after 1 wk of nutritional treatment. Sandstedt *et al.* (1984) stated that plasma fibronectin, an alpha-2-glycoprotein of importance for immunodefense, has been

reported to decrease after starvation and in severely ill patients with cancer. In a preliminary study, administration of the synthetic glucocorticoid, dexamethasone, to rabbits was found to induce parallel increases in circulating fibrinogen and fibronectin (Lichen, 1988). In this study, STOC feeding resulted in an increase in plasma and serum fibronectin. This effect may be due to increased intake of feed that concomitantly increased total protein consumption, or through enhancing liver synthesis of fibronectin. The liver was found to be the principal site for synthesis of plasma fibronectin (Amrani *et al.*, 1985).

The higher plasma and serum fibronectin, blood H/L ratio and serum globulin in STOC-fed ducks may also be explained by the fact that STOC feeding can induce physiological changes, perhaps through endotoxins released from the rapidly proliferating bifidobacteria or through another mechanism. These effects of STOC may be beneficial for the immune response since both fibronectin and leukocytes are engaged in phagocytic functions. Also, a high plasma level of fibronectin is beneficial to health in malnourished humans (Sanberg, 1990). The increase in fibronectin observed in this study is in agreement with the observations of Lichen (1988).

Dietary sugars, such as lactose, were reported to increase the acidity of the cecal contents and helped in controlling salmonella infections (Barnes *et al.*, 1979; Freter, 1974, and Oyofe *et al.*, 1989). This effect has been attributed to the influence of these carbohydrates on the growth, character, and fermentation of normal flora (Rettger, 1915; Rantala and Nurmi, 1973, and Meynell, 1963). The mechanism by which normal flora decreases intestinal colonization by enteropathogens such as *Salmonella* is not well known. Production of bacteriostatic short chain volatile fatty acids, particularly acetic, butyric and propionic acids by normal anaerobic flora present in the cecum and colon is one suggested mechanism (Barnes *et al.*, 1979; Bohnhoff *et al.*, 1964; Rantala and Nurmi, 1973 and Meynell, 1963). Similar findings were reported by Fukata *et al.* (1999), who stated that fructooligosaccharides reduce salmonella colonization, and Bailey *et al.* (1991) who concluded that *Salmonella* did not grow when fructooligosaccharide was the sole carbon and energy source. Although fructooligosaccharide reduces cecal pH in chickens (Chambers, 1997) and enhances the concentration of lactic acid producing bacteria (Le Blay, 1999) no consistent effect on the organisms was established. This study showed a high anion gap, which is indicative of the presence of slight acidosis that might have an effect on the organisms.

In summary, feeding STOC to growing ducks seems to enhance favorable changes in several normal physiological parameters.

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**EFEKTI SAHAROZNOG TERMALNOG OLIGOSAHARIDNOG KAMELA NA HEMATOLOŠKE
PARAMETRE, FIBRONEKTIN, BIOHEMIJSKE SASTOJKE SERUMA, HORMONE I BROJ
BAKTERIJA U CEKUMU BELE PEKINSKE PATKE**

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SADRŽAJ

U obroke 96 belih pekinških pataka starih dve nedelje dodavan je novi saharozni termalni oligosaharidni karamel (STOC) kako bi se ispitaio njegov uticaj na hematološke parametre, koncentraciju fibronektina, određene biohemijske parametre, neke hormone i ukupan broj Gram - negativnih bakterija u cekumu. Ishrana STOC-om je rezultirala povećanjem broja heterofila ($P < 0.05$), smanjenjem broja limfocita, značajnim povećanjem heterofilno-limfocitnog indeksa ($P < 0.001$) i smanjenjem broja bazofilnih granulocita ($P < 0.05$). Osim toga, dodatak STOC-a u obroke, doveo je do značajnog povećanja koncentracije ukupnih serumskih proteina ($P < 0.01$), albumina ($P < 0.001$) i globulina ($P < 0.05$). U serumu pataka hranjenih STOC-om bilo je značajno više kalcijuma ($P < 0.05$), fosfora ($P < 0.01$) a anjonska razlika je bila povećana. Nivo triglicerida i holesterola u serumu nije bio izmenjen. Koncentracija fibronektina koji se dovodi u vezu sa adhezijom ćelija, homeostazom i stimulacijom funkcija mononuklearnog fagocitnog sistema bila je značajno veća ($P < 0.01$) i u serumu i u plazmi pataka hranjenih STOC-om. Koncentracija hormona T₃, T₄ i kortikosterona u krvi nije bila promenjena kao ni broj Gram negativnih bakterija u cekumu. Prema tome, ishrana pataka uz dodatak STOC-a dovodi do pozitivnih promena nekoliko fizioloških parametara.