ISSN- O: 2458 - 868X, ISSN –P: 2458 - 8687

*International Journal of Medical Science and Innovative Research (IJMSIR)*

*IJMSIR : A Medical Publication Hub*

*Available Online at: www.ijmsir.com*

*Volume – 2, Issue –5, September- October - 2017, Page No. : 384 - 390*

# Measurements of the Acid Binding Capacity and Buffering Capacity of Ingredients Used in Poultry Feeds

Mehdi Dadgar

**Correspondence Author: Mehdi Dadgar,** Department of Animal Science, Faculty of Agriculture, University of Ankara, Ankara Turkey.

**Conflicts of Interest:** Nil.

**Acknowledgements:** On this occasion, I would like to thank Prof. Dr. Ibrahim Ciftci for helping me with his information and suggestions during my research.

## Abstract

The objective of this study was to measure the acid-binding capacity (ABC) and buffering capacity (BUF) of feed ingredients and feed additives commonly used in poultry rations. Ingredients were categorised as cereals, vegetable proteins, amino acids and minerals. ABC was calculated as the amount of acid or base milli equivalents (meq) required to reach the pH of 1kg feed to (a) pH 4.0 (ABC-4) and (b) pH 3.0 (ABC-3).

Categories of feed ingredients had significantly different ($P<0.001$) for ABC and BUF values. Within feed category, ABC-3 and ABC- 4 values were highly correlated. It was concluded that poultry diets in different pH, ABC and BUF values may be formulated through careful selection of feed ingredients.

**Keywords:** poultry, feed, ingredients, Acid-Binding Capacity,

## Introduction

One of the important factors in the digestive system of animals in terms of digestibility and availability of nutrients is the pH of the feed and digestive system. One of the important features of feeds is its buffer capacity (BUF). It; an ingestion is defined as the amount of acid or base used to create a unit change at a pH of 1 kg. BUF value of an oath is important because it affects the digestibility of the feed and has important roles in ensuring proper conditions in the digestive tract. As the amount of HCl acid in the hatching is small in the chicks after the incubation period as in the case of the baby pigs, giving the foods with high BUF value can affect the health conditions of the chicks negatively (Levic et al. 2005; Peader et al.2005).

The main problem that arises from the high FBF swallowing in the wings is that the harmful bacteria (pathogens) can multiply easily in the digestive tract. Different nutrients in the structure of feeds lead to an increase in the buffering capacity of that feed. Feeds with high buffering capacity are reported to cause more mortality in pigs and wings than in feeds with low buffering capacity (Levic et al., 2005). The acid binding capacity (ABC) in terms of wings is the ability to absorb the H + (HCL) ions at the edge by the feed substances.

BUF and ABC values of feed, raw materials and feed additives are not generally taken into consideration in feed producing factories. However, these values are of great importance, especially in chicks and young animals. For this reason, it is important to estimate the value of BUF and ABC for that feed using the BUF and ABC values of the feed raw materials during the mixed feed preparation stages. The low pH of the digestive tract is important for a number of reasons: passage of the pepsin enzyme from the mideed inactive (pepsinogen) to the active (pepsin) occurs only in low pH environments. For this reason, in case of high stomach pH, mideed protein digestion is affected negatively. The undigested protein reaches the advanced parts of the digestive tract, forming toxic biogenic amines that result in excess protein fermentation in the jejunum and colon sections (Making, 2001), resulting in diarrhea in animals.

In addition, it may be possible to formulate a mixed feed formulation with desired properties using the BUF or ABC values of feed raw materials. On the other hand, feeds prepared by considering such criteria can also be used for protection strategy against E. coli and Salmonella in adult wing. The prohibition of the use of antibiotics in feeds, particularly in the European Union, in 2006 suggesting resistance in pathogens is of great importance for the development of such feed formulation strategies. The biggest problem in forming such feeds is the lack of information on the BUF and ABC values of forage materials used in formulating feeds. In this study, it was aimed to determine the BUF and ABC values of commonly used feed raw materials and feed additives in poultry mixed feeds,

**Materials and Methods**

**Materiel**

**Feed material**

Fodder feeds (grain, vegetable and animal protein sources and fats) and feed additives generally used in poultry feeds have been obtained from different regions of the anatomical region and feed factories as 4 replicates. These samples were stored in glass jars and under appropriate conditions until the time of analysis.

Table 1. Feed ingredients used in the trial.

| | |
|---|---|
| Barley | Chicken flour |
| Wheat | Whole-fat soybean |
| Maize | DCP |
| Soybean meal | Soybean oil |
| Sunflower seed meal | |
| DL-Methionine | |
| L-Lysine HCL | |
| L-Threonine | |
| Mineral premix | |
| Vitamin premix | |
| Salt | |
| limestone | |
| Sodium bicarbonate | |

**Chemical analyzes**

All feed ingredients, except for feed additives, were milled through a 1 mm sieve in a laboratory hammer mill before analysis.

PH, buffering capacity (BUF-4 and BUF-3) and acid binding capacity pH: 3 (ABC-3) and pH: 4 (ABC-4) in raw materials and feed additives is determined according to (Lawlor *et al.*, 2005a) and (Jasaitis *et al.*, 1987).

Samples from each feed were continuously mixed in 100-fold (0.75 g: 75 ml) de-ionized distilled water in a magnetic stirrer. The pH of the liquid was then titrated steadily with 0.1N HCl or 0.1N NaOH depending on the initial pH until 4 or 3 min.

To determine ABC-4 and ABC-3 values in all assays above the initial pH of 4 in the assay, all titrations were performed with HCl acid (0.1 NHCL) and with ABC-3 and ABC-4 to 0.1 N NaOH was used.

**Calculation of acid binding capacity (ABC)**

The acid binding capacity (ABC) was calculated as the amount of milli-equivalent (meq) acid required to lower the pH of a 1 kg sample to (a) pH 4.0 (ABC-4) and (b) pH 3.0 (ABC-3).

**Calculation of Buffer Capacity (BUF)**

Buffering capacity (BUF) is expressed as the amount of acid required to produce a unit change over the pH of a feed / feed sample, and the buffering capacity (BUF) is calculated by dividing the ABC value by the total change in pH units [from initial pH to final pH a) 4.0 (BUF-4) and (b) 3.0 (BUF-3).

BUF value = all change in ABC / pH unit (from initial pH to final pH)

**Statistical analyzes**

The mean and standard deviation values for each raw material pH, ABC-4, ABC-3, BUF-4 and BUF-3 were calculated. Findings obtained from raw materials and mixes; variance analysis was applied and the correlations between the predicted and the results found in the analyzes were calculated. The values of the parameters obtained as a result of the research were evaluated by using Minitab 13.0 package program in variance analysis (Düzgüneş et al., 1983). Differences between groups were determined using the Duncan test (Duncan, 1955) in the Mstat-C program.

## RESULTS

**pH of the raw materials, ABC-4, ABC-3, BUF-4, and BUF-3 values**

All the raw materials in the experiment were analyzed in 4 replicates and the values of pH, ABC-4, ABC-3, BUF-4 and BUF-3 were given in Table 2. Statistically significant differences were found between the mean values of pH, ABC-4, ABC-3, BUF-4 and BUF-3 of all raw materials in the trial (P <0.001).

Table 2. pH values of raw materials (Mean, SEM value, relative standard deviation (RSD), Minimum, Maximum)

| | | pH | | | | |
|---|---|---|---|---|---|---|
| *Rraw Materials* | N | Mean | SEM | RSD % | Min | Max |
| Maize | 4 | 5.58 f | 0.039 | 2.63 | 5.32 | 5.79 |
| Wheat | 4 | 5.89 de | 0.041 | 2.80 | 5.66 | 6.15 |
| Barley | 4 | 5.14 g | 0.034 | 2.63 | 4.93 | 5.37 |
| Soybean Meal | 4 | 6.42 c | 0.016 | 0.97 | 6.36 | 6.52 |
| Whole Fat Soybean | 4 | 6.52 c | 0.040 | 2.44 | 6.25 | 6.76 |
| Sunflower Seed Meal | 4 | 5.88 de | 0.074 | 5.07 | 5.43 | 6.25 |
| Chicken flour | 4 | 5.70 ef | 0.165 | 7.08 | 5.18 | 6.04 |
| Soybean Oil | 3 | 4.02 j | 0.027 | 1.33 | 3.99 | 4.1 |
| Limestone | 4 | 9.11 a | 0.002 | 0.06 | 9.11 | 9.12 |
| DCP | 4 | 5.92 de | 0.304 | 14.51 | 5.12 | 6.91 |
| Salt | 4 | 5.04 g | 0.073 | 4.11 | 4.74 | 5.25 |
| Sodium bicarbonate | 4 | 8.38 b | 0.028 | 0.95 | 8.24 | 8.45 |
| Vitamin Premix | 4 | 5.97 d | 0.275 | 13.81 | 5.25 | 7.38 |
| Mineral Premix | 4 | 4.77 h | 0.014 | 0.85 | 4.71 | 4.8 |
| L-Lysine HCL | 4 | 4.72 h | 0.082 | 5.47 | 4.34 | 5.01 |
| DL-Methionine | 5 | 4.29 i | 0.083 | 6.72 | 3.85 | 4.58 |
| L-Threonine | 4 | 4.09 ij | 0.085 | 6.21 | 3.82 | 4.64 |
| *P value* | | <0.001 | | | | |

a-1: the differences between the means with different letters in the same column are statistically significant (P <0.05) N: Number of Samples, SEM; standard error of the mean RSD: relative standard deviation

As can be understood from Table 2, the differences between the pH averages of the raw materials were statistically significant (P <0.001). When we look at the chart, sodium bicarbonate and limestone have the highest values and lysine, methionine, mineral premix, soybean oil and threonine have the lowest pH values among the raw materials, while Soybean meal and full fat soybean are the third.

Table 3. Acid binding capacity (ABC-3) values of the raw materials (Mean, SEM value, relative standard deviation (RSD), Minimum, Maximum).

| | | ABC (3) | | | | |
|---|---|---|---|---|---|---|
| *Raw Materials* | N | Mean | SEM | RSD % | Min | Max |
| Maize | 4 | 90.0 g | 3.62 | 15.03 | 73.3 | 106.7 |
| Wheat | 4 | 129.2 g | 6.52 | 20.20 | 106.7 | 186.7 |
| Barley | 4 | 103.8 g | 4.22 | 16.25 | 80 | 133.3 |
| Soybean meal | 4 | 646.7 f | 13.24 | 8.19 | 546.7 | 760 |
| Whole-fat soybean | 4 | 499.2 f | 9.81 | 7.86 | 453.3 | 560 |
| Sunflower seed meal | 4 | 499.2 f | 17.13 | 13.72 | 413.3 | 613.3 |
| Chicken flour | 4 | 723.3 f | 29.85 | 10.11 | 600 | 780 |
| Soybean oil | 3 | 13.3 g | 0.00 | 0.00 | 13.3 | 13.3 |
| Limestone | 4 | 11772.5 b | 16.01 | 0.38 | 11700 | 11800 |
| DCP | 4 | 4865.0 e | 14.02 | 0.81 | 4800 | 4900 |
| Salt | 4 | 5.3 g | 0.00 | 0.00 | 5.3 | 5.3 |
| Sodium bicarbonate | 4 | 12774.7 a | 634.51 | 14.05 | 8555.2 | 14301.6 |
| Vitamin premix | 4 | 8260.6 d | 165.73 | 6.02 | 7636.4 | 8727.3 |
| Mineral premix | 4 | 11165.0 c | 19.18 | 0.49 | 11100 | 11220 |
| L-Lysine HCL | 4 | 50.7 g | 1.78 | 11.09 | 40 | 53.3 |
| DL-Methionine | 5 | 52.2 g | 1.11 | 7.37 | 46.7 | 60 |
| L-Threonine | 4 | 59.3 g | 2.59 | 13.13 | 46.7 | 66.7 |
| *P value* | | <0.001 | | | | |

a-1: the differences between the means with different letters in the same column are statistically significant (P

<0.05) N: Number of Samples, SEM; standard error of the mean RSD: relative standard deviation

As can be understood from Table 3. The differences between the ABC-3 averages of the raw materials were statistically significant (P <0.001). Raw materials with the highest ABC-3 values among raw materials, sodium bicarbonate, DCP, limestone, mineral premix, vitamin premixes and the raw materials with the lowest ABC-3 value are amino acids. There was no difference in terms of ABC-3 value between soybean pulp, whole oil soybean, Sunflower seed meal and chicken flour.

Among the feedstuffs, barley, Sunflower seed meal (SSM), wheat, sodium bicarbonate, lysine, corn, chicken flour and threonine are the raw materials with the highest standard deviation (RSD) in terms of ABC-3.

Table 4. Acid binding capacity (ABC-4) values of the raw materials (Mean, SEM value, relative standard deviation (RSD), Minimum, Maximum).

| | ABC (4) | | | | | |
|---|---|---|---|---|---|---|
| *Raw Materials* | N | Mean | SEM | RSD % | Min | Max |
| Maize | 4 | 40.0 g | 2.88 | 26.95 | 26.67 | 53.3 |
| Wheat | 4 | 55.0 fg | 2.62 | 19.04 | 40 | 80 |
| Barley | 4 | 39.0 fg | 2.53 | 25.96 | 20 | 60 |
| Soybean meal | 4 | 331.7 ef | 6.04 | 7.28 | 280 | 380 |
| Whole-fat soybean | 4 | 279.2 efg | 6.80 | 9.74 | 240 | 320 |
| Sunflower seed meal | 4 | 225.0 efg | 15.86 | 28.20 | 146.67 | 320 |
| Chicken flour | 4 | 360.0 e | 12.65 | 8.61 | 300 | 380 |
| Soybean oil | 3 | 0.0 g | 0.00 | 0 | 0 | 0 |
| Limestone | 4 | 7175.0 b | 16.37 | 0.65 | 7100 | 7200 |
| DCP | 4 | 2385.0 d | 10.52 | 1.25 | 2320 | 2400 |
| Salt | 4 | 2.7 g | 0.00 | 0.00 | 2.67 | 2.7 |
| Sodium bicarbonate | 4 | 12617.2 a | 632.68 | 14.18 | 8395.2 | 14141.6 |
| Vitamin premix | 4 | 2531.3 d | 87.92 | 10.42 | 2181.82 | 2727.3 |
| Mineral premix | 4 | 3062.5 c | 18.30 | 1.69 | 3000 | 3100 |
| L-Lysine HCL | 4 | 6.7 g | 0.00 | 0.00 | 6.67 | 6.7 |
| DL-Methionine | 5 | 5.6 g | 1.38 | 86.10 | 0 | 13.3 |
| L-Threonine | 4 | 3.0 g | 2.51 | 254.41 | -6.67 | 13.3 |
| *P value* | | <0.001 | | | | |

a-1: the differences between the means with different letters in the same column are statistically significant (P <0.05) N: Number of Samples, SEM; standard error of the mean RSD: relative standard deviation

As can be understood from Table 4. Differences between the ABC-4 averages of the raw materials were statistically significant (P <0.001). Raw materials with the highest values of sodium bicarbonate, DCP, limestone, mineral premix and vitamin premix and barley, wheat, lysine, methionine, corn, soybean oil, threonine and salt have the lowest ABC-4 value in terms of ABC-4 among the aw materials. There was no difference between the amino acids in terms of ABC-4 values.

Barley, Sunflower seed meal, wheat, sodium bicarbonate, DL-methionine, maize, L-threonine and vitamin premixes are among the raw materials with the highest relative standard deviation (RSD) in terms of ABC-4.

Table 5. Buffer capacity (BUF-3) values of the raw materials (Mean, SEM value, relative standard deviation (RSD), Minimum, Maximum).

| | BUF (3) | | | | | |
|---|---|---|---|---|---|---|
| *Raw Materials* | N | Mean | SEM | RSD % | Min | Max |
| Maize | 4 | 13.1 h | 0.582 | 16.62 | 10.3 | 16.46 |
| Wheat | 4 | 44.6 fgh | 1.793 | 16.09 | 37.8 | 62.02 |
| Barley | 4 | 48.3 fgh | 1.468 | 12.16 | 37.7 | 56.74 |
| Soybean meal | 4 | 189.0 ef | 3.69 | 7.81 | 161.7 | 224.19 |
| Whole-fat soybean | 4 | 142.1 efgh | 3.021 | 8.50 | 121.5 | 157.75 |
| Sunflower seed meal | 4 | 173.5 efg | 3.6 | 8.30 | 138.7 | 191.07 |
| Chicken flour | 4 | 269.7 e | 8.786 | 7.98 | 250.0 | 309.09 |
| Soybean oil | 3 | 13.1 h | 0.328 | 5.00 | 12.1 | 13.47 |
| Limestone | 4 | 1925.6 d | 2.383 | 0.35 | 1914.9 | 1931.26 |
| DCP | 4 | 1799.9 d | 183.919 | 28.90 | 1237.9 | 2311.32 |
| Salt | 4 | 2.6 h | 0.098 | 10.51 | 2.4 | 3.07 |
| Sodium bicarbonate | 4 | 2373.4 c | 111.307 | 13.26 | 1632.7 | 2628.97 |
| Vitamin premix | 4 | 2931.8 b | 199.766 | 20.44 | 1876.4 | 3393.94 |
| Mineral premix | 4 | 6311.1 a | 56.26 | 2.52 | 6166.7 | 6561.40 |
| L-Lysine HCL | 4 | 29.7 gh | 0.866 | 9.23 | 26.5 | 33.54 |
| DL-Methionine | 5 | 42.3 fgh | 2.902 | 23.76 | 32.9 | 62.75 |
| L-Threonine | 4 | 56.5 fgh | 4.252 | 22.57 | 40.7 | 81.30 |
| *P value* | | <0.001 | | | | |

a-1: the differences between the means with different letters in the same column are statistically significant (P <0.05) N: Number of Samples, SEM; standard error of the mean RSD: relative standard deviation

As can be understood from Table 5. Sodium bicarbonate, DCP, limestone, mineral premix and vitamin premix were the highest and barley, wheat, lysine, methionine, Maize, soybean oil, threonine and salt showed the lowest BUF-3 values. There was no difference between the BUF-3 averages of the amino acids.

Table 6. Buffering capacity (BUF-4) values of the raw materials (Mean, SEM value, relative standard deviation (RSD), Minimum, Maximum)

| | | | | BUF (4) | | |
|---|---|---|---|---|---|---|
| *Raw Materials* | N | Mean | SEM | RSD % | Min | Max |
| Maize | 4 | 25.2 e | 1.46 | 21.677 | 17.78 | 31.5 |
| Wheat | 4 | 29.1 e | 1.04 | 14.317 | 23.33 | 39.8 |
| Barley | 4 | 33.9 e | 1.60 | 18.896 | 21.51 | 44.4 |
| Soybean meal | 4 | 137.0 de | 2.30 | 6.705 | 117.65 | 159.0 |
| Whole-fat soybean | 4 | 111.0 de | 2.50 | 9.016 | 96.62 | 125.5 |
| Sunflower seed meal | 4 | 119.2 de | 5.50 | 18.469 | 74.07 | 144.8 |
| Chicken flour | 4 | 221.1 d | 21.92 | 24.285 | 186.27 | 316.7 |
| Soybean oil | 3 | 0.0 e | 0.00 | 0 | 0 | 0.0 |
| Limestone | 4 | 1403.1 c | 3.01 | 0.607 | 1389.43 | 1409.0 |
| DCP | 4 | 1502.7 c | 235.62 | 44.35 | 811 | 2142.9 |
| Salt | 4 | 2.7 e | 0.20 | 21.398 | 2.13 | 3.6 |
| Sodium bicarbonate | 4 | 2879.1 b | 134.74 | 13.237 | 1980 | 3185.1 |
| Vitamin premix | 4 | 1419.2 c | 118.72 | 25.096 | 798.49 | 1745.5 |
| Mineral premix | 4 | 3988.1 a | 86.34 | 6.123 | 3750 | 4366.2 |
| L-Lysine HCL | 4 | 10.8 e | 1.58 | 46.397 | 6.6 | 19.6 |
| DL-Methionine | 5 | 11.4 e | 2.67 | 81.442 | 0 | 26.1 |
| L-Threonine | 4 | 9.3 e | 11.37 | 367.836 | -39.23 | 58.0 |
| *P value* | | <0.001 | | | | |

a-1: the differences between the means with different letters in the same column are statistically significant (P <0.05) N: Number of Samples, SEM; standard error of the mean RSD: relative standard deviation

As seen in Table 6. barley, wheat, lysine, methionine, maize, threonine and salt had the lowest BUF-4 values while sodium bicarbonate, DCP, limestone, mineral premix and vitamin premix had the highest BUF-4 values. This value is zero in soybean oil. The raw materials with the highest values in terms of BUF-4 values are respectively belong to the mineral premixes, sodium bicarbonate, DCP and limestone and the raw amino acid groups and cereals having the lowest BUF-4 values. There was no difference in the value of BUF-4 between amino acids and cereals.

## Discussion

### Raw Material ABC and BUF Values

Significant statistical differences (P <0.001) between the ABC and BUF averages of the feed raw materials at the trial indicate that the acid binding capacity and buffer capacities of the raw materials are different according to the raw material.

When we look at the values of ABC-3, ABC-4, BUF-3 and BUF4 obtained from the analyzes of raw materials used in the trial, sodium bicarbonate, limestone, mineral premix, vitamin premix and DCP showed the highest ABC-3 values in terms of ABC-3 (lysine, methionine, threonine) in soybean oil, salt and amino acid species (lysine, methionine, threonine) show the lowest ABC-3 values in the second row of soybean oil, whole soybean, sunflower seeds meal and then cereals (maize, wheat and barley).

In terms of ABC-4 values, sodium bicarbonate, limestone, mineral premix, DCP and vitamin premix were the highest ABC-4 values among the experimental groups, while chicken flour, soybean meal, whole oil soybean and sunflower seed meal were the second. The cereals (maize, wheat, barley) were in third place, and the amino acid types showed the lowest values in terms of ABC-4 value and the ABC-4 value of soybean oil was found to be zero.

Mineral premix, vitamin premix, sodium bicarbonate, limestone and DCP showed the highest values for BUF-3 value. Chicken flour, Soybean meal, sunflower seed meals and full-fat soybeans were second-ranked. Amino acid varieties appeared similar to BUF-3 values of wheat and aranian. Maize, salt and soybean oil are the raw materials with the lowest value in terms of BUF-3 value.

Mineral premix, sodium bicarbonate, DCP, vitamin premix and limestone were the highest values in terms of BUF-4 value. Second place was chicken flour, Soybean meal, sunflower seeds meal and whole oil soybean. Grain (maize, wheat, barley) and amino acid varieties (lysine, methionine, threonine) and salt showed the lowest BUF-4 value. The BUF-4 value of soybean oil was found to be zero.

According to the results obtained from the (Lawlor et al., 2005c) studies, a large variation in initial pH, ABC and BUF values was obtained between raw materials and raw materials from different categories (P <0.001). Acid salts and mineral additives have the highest ABC and BUF values. There is a great difference between different mineral types.

Zinc oxide, limestone and sodium bicarbonate have the highest ABC values. Phosphate taken as phosphorus source showed the highest ABC value while DCP showed moderate values. Among the organic substances, meat and fish meal, dairy products, amino acids, roots and some pulps and plant-derived proteins showed the highest ABC and BUF values. Cereals are defined as categories with the lowest values. Among both organic and inorganic raw materials, organic acids have the lowest ABC and BUF values. The researchers found that the ABC values of organic acids were generally negative, as in the results of this study.

According to the results obtained from the (Jasaitis et al., 1987) studies, the mineral admixtures ABC-4 and BUF-4 values were found to be higher than those of organic meddeles. However, According to the (Lawlor et al., 2005c), mineral additives were in second place. The highest ABC and BUF values were attributed to acid salts.

According to the results obtained from the (Jasaitis et al., 1987) and (Lawlor et al., 2005c) studies, limestone and sodium bicarbonate have the highest ABC values, and the floured phosphate has been ranked second in terms of ABC values in the DCP mineral categories. The ABC values of organic substances are related to ash and protein contents of these organs.

According to the (Jasaitis et al.,1987; Bolduan et al., 1988; Bolduan, 1988 ; Prohaszka and Baron ,1980) studies, ABC-3 value of the rations rises with the increase of ration protein content and (Jasaitis et al., 1987) and (Lawlor et al., 2005c) reported that meat and fish flours have the highest ABC and BUF values in organic materials, and that they contain high ore ash and protein.

Among plant-derived proteins, soybean meal and sunflower seeds meal had the highest ABC values. On the other hand, cereals and some roots and pulps were found to have low ABC and BUF values (Lawlor et al., 2005; Jasaitis et al., 1987; Bolduan, 1988; Bolduan et al., 1988; BASF, 1989).

The results obtained from this study are consistent with results of (Lawlor et al., 2005c) and (Jasaitis et al., 1987).

**References**

[1]. Basf 1989. The acid-binding capacity of piglets. Information-Service Animal Nutrition, BASF Aktiengesellschaft, D-6700, Ludwigshafen.

[2]. Bolduan, G. 1988. The regulation of the intestinal flora in piglets and sows - a new feding strategy. Research and Practical Experience, Vol. 23, PP.1-17.

[3]. Bolduan, G., Jung, H., Schnabel, E. and Schneider, R. 1988. Recent advances in the nutrition of weaner pigs. Pig News and Information, Vol. 9, PP. 381-385.

[4]. Duncan, D.B.1955. Multiple rangeon multiple F test. Biometrics, Vol. 11, PP.1-42

[5]. Düzgüneş, O., Kesici, T. ve Gürbüz, F. 1983. İstatistik Metodları- I, Ankara Üniversitesi Ziraat Fakültesi. Yay: 861, Ders Kitabı: 299, 218 s. Ankara Üniversitesi Basımevi. Ankara.

[6]. Jasaitis, D.K., Wohlt, J.E. and Evans, J.L. 1987. Influence of feed ion content on buffering capacity of ruminant feedstuffs in vitro. Journal of Dairy Science, Vol. 70, PP. 1391-1403.

[7]. Lawlor, P.G., Lynch, P.B. and Caffrey, P.J. 2005a. Effect of creep feeding, dietary fumaric acid and level of dairy product in the diet on post-weaning pig performance. Irish Journal of Agricultural and Food Research. Vol. 44. PP. 45-55.

[8]. Lawlor, P.G., Lynel, P.B., Caffery, P.J., O`R-eilly, J.J and O`-Connell, M.K. 2005c. Measurements of the acid binding capacity of ingredients used in pig diets. Irish Veterinary Journal, Vol. 58 (8). PP. 447-452.

[9]. Levic, J., Olivera, P. and Slavica, S. 2005. Understanding the buffering capacity in feedstuffs. Biotechnology in Animal Husbandary, ISSN 1450-91 56.

[10]. Makking, C. 2001. Acid binding capacity in feedstuffs, Feed International, October, PP. 24-27.

[11]. Peadar, G., Lawlor, P., Brendan, L., Patrick, J., Caffrey, James, J., O'-Reilly. and Karen M., O'Connell. 2005. Measurements of the acid-binding capacity of ingredients used in pig diets, Irish Veterinary Journal.

[12]. Prohaszka, L. and Baron, F. 1980. The predisposing role of high dietary protein supplies in enteropathogenic E. coli infections of weaned pigs. Zentralblatt für Veterinärmedicin, Vol. 27, PP. 222-232.

[13]. Ulrich, R. 2006. Informatıon-Service Animal Nutrition 82. BASF, Ludwigshafen, Germany. http://www.animal-nutrition. basf.de/ Accessed June 2008.