# Evolution of Intestinal Viscosity in Broilers According to NSP Type and Levels in the Wheat-Based Forage Mixture

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**Abstract**

The objective of this experiment was to assess the effect exerted by different levels and categories of non-starch polysaccharides (NSP) from wheat grains on viscosity in broilers. Wheat's percentage of participation in the forage mixture was between 0 and 40 %. The experiment was performed during 6 weeks, on 120 broilers distributed in four experimental variants (CG, EG1, EG2, and EG3). Between eclosion and 3-week old, the content in soluble non-starch polysaccharides (NSPs) increases directly proportional with the wheat proportion in the structure of the forage mixture, becoming 0.718 percentage points bigger in EG3 than in the EG1. During the second period of growth, respectively from 3 to 6 weeks, the NSPs content has the same evolution, with 0.7 percentage points in EG3. At the age of 3 weeks, viscosity increases with the increase of wheat percentage in the structure of the combined forage, being 53.07 % bigger in the group that was fed on the 40%-wheat forage. At 6 weeks, at duodenum level in EG2, viscosity had values of 2.53cP, 49.04% bigger compared with EG1. At jejuna level, viscosity increases like in duodenum, being also 33.15% bigger in the group fed on combined forage including 40 % wheat, too (EG2 – 3.13cP), compared with the group fed on combined forage without wheat (2.1cP).

**Keywords**: broilers, intestinal viscosity, non-starch polysaccharides, wheat

## 1. Introduction

Wheat has long been considered a superior poultry feed ingredient, but its feeding value can be highly variable and depends to a large extent on its content of high molecular weight, water soluble non-starch polysaccharides (NSP) [l-3]. The performance of broilers fed wheat- and rye-based diets has been shown to be linearly related to the logarithm of intestinal viscosity [4], emphasizing the relevance of this measurement. Enzymes capable of degrading these polymers have been consistently beneficial in rye- and barley-based diets [5]. Literature data suggest that the success of xylanase supplementation is not so dramatic in wheat-based diets as in rye-based diets, and in some cases there is no measurable benefit at all. Poor experimental design, particularly with respect to replication, can explain some of the inconsistencies observed, but inconsistencies may also be attributable to variation in the chemical composition of batches of wheat. The level of pentosans, which are the principal viscous NSPs in wheat, varies considerably [6, 7, 8, 9] from sample to sample, a factor that may partially explain the variability in reported results. Variety and environment appear to play a role in determining pentosan content.

## 2. Materials and methods

The experiment was carried out during a 6-week period, on 120 broilers distributed in four experimental variants (CG, EG1, EG2 and EG3). The hybrid used was Ross 308. The broilers in the four experimental groups were fed as follows: in the first growth period, from eclosion to 3 weeks, the combined forage supplied 3117-3175 kcal EM and a crude protein content of 22.26-22.69%. In

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the second growth period, respectively from 3 to 6 weeks, the forage mixture supplied 3161-3212 kcal EM and 19.99-20.16% CP. The NSP content of the forage mixtures was established in concordance with the tabular values [10]. The difference between groups was given by the percentage of wheat incorporation in the mixture's structure, namely between 0 and 40%, during the entire growth period, respectively from eclosion to 6 weeks. The experimental organization scheme is presented in table 1. The intestinal content sampled from duodenum and jejunum level was submitted to centrifugation at 10,000 rotations/minute, for 10 minutes. The achieved extract was introduced in a container in order to determine viscosity. Viscosity was determined with the Brookfield viscometer. To determine the nutritional value of the forage mixture and also the content in non starch polysaccharides, included in broiler feeding, we applied the methods standardized in concordance with the WEENDE scheme; the analyses were carried out in laboratory, at the Department of Animal Nutrition and Alimentation, Faculty of Animal Sciences and Biotechnologies Timişoara and also at University College Dublin. The testing of the difference significance between groups, regarding the production indices, was performed with the help of the Mann-Whitney-Wilcoxon test.

## 3. Results and discussion

According to tabular data, we obtained the content in soluble, insoluble and total NSP of thecombined forage; these values are presented in table 2. Regarding NSPs content **from eclosion to 3 weeks**, it increases proportionally with the increase of wheat content in forage structure: in EG1, the content is bigger with 0.358 percentage points, in EG2, with 0.538 percentage points and in EG3, with 0.718 percentage points. Regarding the NSPi content, we may observe that it increases, too, but in a smaller measure: it is 0.09 percentage points bigger in EG3, fed 40%-wheat-based combined forage. By totalizing the NSPs and NSPi contents, we obtain NSPt. In table, we may also notice that these values increase linearly with the increase of wheat proportion in the combined forage structure, so that in EG2 the NSPt gets to be 0.81 percentage points bigger than in CG (control group). In the second period of growth, from **3 to 6 weeks**, we may observe the same NSPs evolution: EG1 presents a content that is 0.345 percentage points bigger than CG, EG2 with 0.52 percentage points and EG3 with 0.7 percentage points.

**Table 1** Organization scheme of the experiment

| Period 0-6 weeks | | | |
|---|---|---|---|
| CL | EG1 | EG2 | EG3 |
| Combined forage | Combined forage | Combined forage | Combined forage |
| 0-3 weeks | 0-3 weeks | 0-3 weeks | 0-3 weeks |
| 3-6 weeks | 3-6 weeks | 3-6 weeks | 3-6 weeks |
| 0 % wheat | 20 % wheat | 30 % wheat | 40 % wheat |

**Table 2** The content of combined forages in non-starch polysaccharides (NSP) (%)

| Age | Specification | NSPs[1] (%) | Percentage p % | NSPi[2] (%) | Percentage p% | NSPt[3] (%) | Percentage p% |
|---|---|---|---|---|---|---|---|
| 0-3 weeks | CF with 0% wheat | 0.722 | - | 7.9 | - | 8.62 | - |
| | CF with 20% wheat | 1.08 | 0.36 | 7.93 | 0.03 | 8.959 | 0.34 |
| | CF with 30% wheat | 1.26 | 0.54 | 7.96 | 0.06 | 9.22 | 0.60 |
| | CF with 40% wheat | 1.44 | 0.72 | 7.99 | 0.09 | 9.43 | 0.81 |
| 3-6 weeks | CF with 0% wheat | 0.66 | - | 7.56 | | 8.63 | - |
| | CF with 20% wheat | 1.005 | 0.34 | 7.95 | 0.39 | 9.01 | 0.38 |
| | CF with 30% wheat | 1.18 | 0.52 | 7.97 | 0.41 | 9.22 | 0.59 |
| | CF with 40% wheat | 1.36 | 0.70 | 7.97 | 0.41 | 9.42 | 0.79 |

CF = Combined forage
[1] soluble non-starch polysaccharides
[2] insoluble non-starch polysaccharides
[3] total non-starch polysaccharides

**Table 3** The evolution of intestinal viscosity at duodenum level in broiler chickens at 3 weeks

| Experimental variants | Participation proportion of wheat (%) | Viscosity cP Duodenum | Percentage evolution |
|---|---|---|---|
| CL | 0 | 1.95 | 100 |
| EG1 | 20 | 2.515 | 128.71 |
| EG2 | 30 | 2.82 | 144.61 |
| EG3 | 40 | 2.985 | 153.07 |

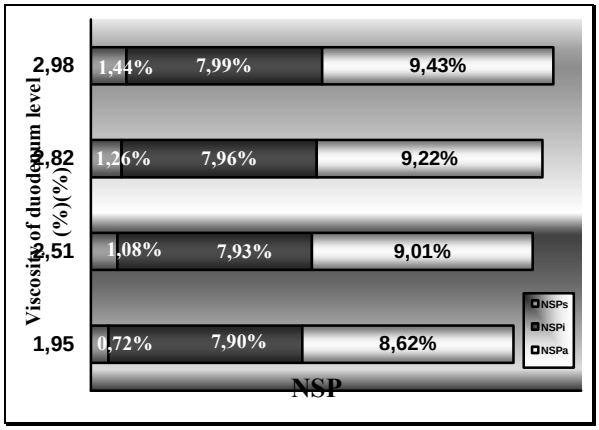
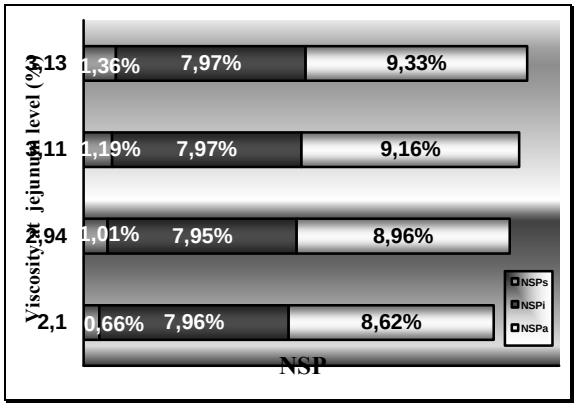



**Figure 1**: Viscosity at duodenum level in chickens at 3 weeks

**Table 4** The evolution of intestinal viscosity at duodenum and jejunum level in broiler chickens at 6 weeks

| Experimental variant | Participation percentage of wheat | Viscosity cP | Percentage evolution |
|---|---|---|---|
| | | Duodenum | |
| | | Mean | |
| CG | 0 | 1.90 | 100 |
| EG1 | 20 | 2.10 | 140 |
| EG2 | 30 | 2.14 | 148.09 |
| EG3 | 40 | 2.53 | 149.04 |
| | | Jejunum | |
| CG | 0 | 2.10 | 100 |
| EG1 | 20 | 2.94 | 110.52 |
| EG2 | 30 | 3.11 | 112.63 |
| EG3 | 40 | 3.13 | 133.15 |



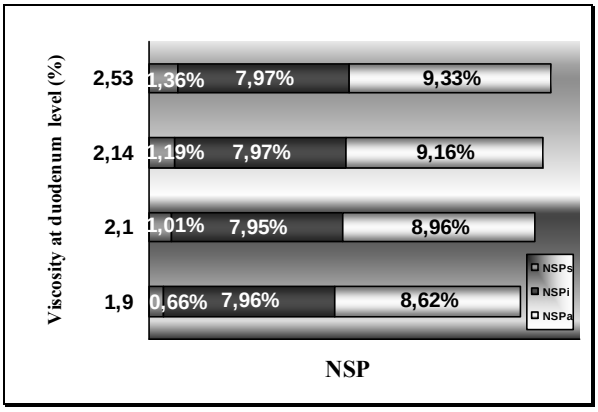




**Figure 2**: Viscosity at duodenum and jejunum level in chickens at 6 weeks

The NSPi increase as well, but in a smaller measure: in EG3, the combined forage NSPi content gets to be 0.42 percentage points bigger than in CG. At the same time, the NSPt increase, too, so that the combined forage used in EG1 presents a NSPt content that is 0.735 percentage points bigger than in CG, in EG2 0.93 percentage points bigger and in EG3, 1.11 percentage points bigger then in CG.

In order to determine forage NSPs effect on the digestive viscosity, we killed chickens at 3-weeks old to establish viscosity at duodenum level; these values are presented in table 3 and figure 1. According to the data presented in this table, we may observe that viscosity increases with the increase of wheat percentage in the combined forage structure, being 28.71 % bigger in the group fed 20%-wheat forage and 53.07 % bigger in the group fed 40%-wheat forage. Successive to broiler killing at 6 weeks, we established intestinal digestion viscosity at duodenum and jejunum level; these values are presented in table 4 and figure 2. In the table mentioned above, we may notice that at duodenum level, in the chickens from EG1, viscosity was of 2.1cP, being 40 % bigger than in CG (1.9Cp), in EG2, it was of 2.14cP, 48.09% bigger, and in EG3 (2.53cP) 49.04% bigger than in CG. At jejunum level, viscosity increases like in duodenum, being also up to 33.15% bigger in the group fed 40%-wheat combined forage (EG3 – 3.13cP) compared with the group fed combined forage without wheat (2.1cP). On the whole, the soluble wheat arabinoxylan is supposed to be responsible for the antinutritional NSP activity, in broiler breeding, because of its capacity of increasing the intestinal viscosity and of modifying the intestinal microflora [3,11]. The increased viscosity of the intestinal content reduces the diffusing rate of digestive enzymes and substances and impedes their effective interaction, causing significant changes in the structure and function of digestive organs [12,13]. To adapt to such changes, the activity performed by the intestinal releasing mechanism may be changed, possibly causing organ hypertrophy. This enlargement of the digestive organs may be a response adapted to the enhanced enzyme requirement [13,14].

## 4. Conclusions

Wheat incorporation, in rising amounts, in the combined forage structure determines the increase of the NSPs and NSPi contents; at 3 weeks old, viscosity in the group fed 40% wheat, in terms of intestinal digestion, increases with 53.07%, and at 6 weeks old, with 49.04% at duodenum level and with 33.15% at jejunum level. The general conclusion that may be drawn from this experiment is that wheat incorporation in forage structure changes the main digestive indices in broilers, especially until 3 weeks old. This requires the control on the antinutritional effect, by using the specific enzymes.

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