

## NUTRITIONAL VALUE OF THE GRAIN OF KUNITZ-FREE SOYBEAN CULTIVARS

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**Abstract:** Utilization of the raw beans for food and feed is prohibited by the presence of protease inhibitors. Breeding soybean cultivars for reduced amount of anti nutritional factors at Maize Research Institute Zemun Polje resulted in development of two new Kunitz-free cultivars – Lana and Laura. Feeding trials with pigs in different growth stages were conducted to compare the response of growing and finishing pigs to diets containing either raw or extruded standard and KTI-free (Kunitz trypsin inhibitor-free) soybean cultivars. The greatest improvement in growth performance was noted for the group fed extruded KTI-free soybean. This group achieved highest daily weight gain and gain per feed unit. Growth parameters for group of pigs fed raw soybean Kunitz-free cultivar were slightly reduced.

**Key words:** soybean, Kunitz trypsin inhibitor, feeding trials, pigs

### Introduction

The protease inhibitors in soybean, Kunitz trypsin inhibitor (KTI) and the Bowman–Birk inhibitor (BBI) constitute at least 6% of the protein present in soybean seed (*Ryan, 1973*) and with lectin, represent the main anti nutritional factors of soybeans. Approximately, 80% of the trypsin inhibition is caused by KTI (*Brandon, 1993*), which strongly inhibits trypsin, and therefore reduces protein digestibility and food intake. Beside that, KTI is responsible for hypersecretion of pancreatic enzymes, leading to demands of sulphur-containing amino acids and along side previous, resulting in growth depression in non-ruminant animals. Due to this, raw soybean can not be used for animal feeding and needs to be heat-processed to eliminate thermo-labile anti nutritional factors. Heat processing inactivates anti-nutritional factors and modifies the structure of the proteins, making them more available for digestion. Despite the efficiency of thermal treatment to reduce protease inhibitors, residual inhibition (10-20%) is maintained (*Carvalho et al., 1998*). Furthermore, excessive heat treatments (uncontrolled

temperature; long period of time) may decrease protein solubility and lower amino acid availability. Soybean lines with reduced protease inhibitor content could reduce or eliminate the need for expensive heat treatments and lessen the chance of lowering amino acid availability.

A part of the soybean breeding program at the Maize Research Institute »Zemun Polje« is aimed at developing the cultivars with reduced trypsin inhibitors content. As a result, two Kunitz-free (KTI free) varieties Lana and Laura, were released. TI content in new cultivars was about 50% reduced as compared with the conventional cultivars (standard grain type). Numerous studies investigated the effect of soybean variety and processing on growth performance of pigs (*Cook et al., 1988; Palacios et al., 2004*). They demonstrated that the inclusion of raw Kunitz-free soybean in diet was beneficial in terms of better growth performance compared with conventional cultivars, but still inferior to the growth performance obtained by soybean meal, where the KTI and other anti nutritional factors are inactivated by heating. The results obtained by *Tagliapietra et al. (2007)*, suggest that raw soybean can be usefully included in the diets of finishing pigs (80 to 170 kg LW) up to 10% of the complete feed without negative effects on growth performance and health status.

Regarding previous issues, present study was carried out to estimate the nutritional value of new cultivars in feeding trials with pigs and determine whether pigs in different stages of development could be successfully fed raw Kunitz-free soybean cultivars.

## Materials and Methods

During 2008 year, an experiment with pigs was conducted at the „Stari Tamiš“ farm, with two main goals. First, to evaluate the effect of raw soybean on growth performance and health of growing/fattening pigs and second, to determine differences in weight gain of animals fed the mixtures formulated to contain: 20% grits made by extrusion of standard grain quality soybean (Mixture 1), 20% grits of extruded grain of Kunitz-free soybean cultivars (Mixture 2), 20% row Kunitz-free soybean cultivars (Mixture 3).

**Table 1. Number of piglets and initial live weight of the pigs in the experiment**

|                             | Mixture 1<br>(extruded<br>standard cult.) | Mixture 2<br>(extruded KTI-<br>free) | Mixture 3<br>(raw KTI-free) |
|-----------------------------|---|--------------------------------------|-----------------------------|
| Number of animals           | 14  | 14                                   | 14                          |
| Initial weight              | 23.00                                     | 23.20                                | 22.90                       |
| Growing weight (Stage I)    | 56.35                                     | 55.60                                | 52.12                       |
| Finishing weight (Stage II) | 110.35                                    | 116.60                               | 103.73                      |

The sample consisted of 14 animals per each mixture, with initial body weight of 23 kg. Individual daily weight gain (DWG) of pigs was recorded in two stages: Stage 1 (body weight of feeders 56.35 kg, 55.60 kg and 52.12 kg, for the groups fed Mixture 1, Mixture 2 and Mixture 3, respectively) and Stage 2, where the finishing body weight was 110.35 kg, 116.60 kg and 103.73 kg for groups fed Mixture 1, Mixture 2 and Mixture 3, respectively (Table 1). The amount of feed distributed to each group was daily recorded.

## Results and Discussion

The growth performance data from the pig experiment showed that the best average daily weight gain (DWG) of pigs was achieved for the group fed mixture with extruded KTI-free soybean cultivar (Mixture 2) in Stage 2 (Table 2). This group performed the best overall growth rates (Index=106.87%). Feeding raw KTI-free soybean (Mixture 3) to pigs depressed daily weight gain by 14.29% as compared with the average DWG achieved by pigs fed extruded KTI-free cultivar (Mixture 2). The growth depression could be explained by other heat-labile anti-nutritional factors present in raw soybeans – Bowman-Birk trypsin inhibitor and lectin. Previous results suggest that simple removal of Kunitz inhibitor without any intervention upon Bowman-Birk inhibitor, although allowing a reduction of processing costs (*Friedman et al., 1991*) does not appear to solve a problem of direct livestock nutrition.

The index of average DWG was by 7.42% higher for pigs fed mixture containing extruded standard cultivar than for those fed mixture with raw KTI-free soybean. This suggests that Kunitz-free varieties may present good solution for small farms with direct feed production and raising livestock, especially for the regions where the processing industry is not developed.

**Table 2. Average daily weight gain (g) of groups of pigs fed different mixtures**

|         | Mixture 1<br>(extruded standard cult.) | Mixture 2<br>(extruded KTI-free) | Mixture 3<br>(raw KTI-free) |
|---------|--|----------------------------------|-----------------------------|
| 1 Stage | 641                                    | 623                              | 562                         |
| Index % | 100.00                                 | 97.19                            | 87.67                       |
| 2 Stage | 794                                    | 897                              | 759                         |
| Index % | 100.00                                 | 112.97                           | 95.59                       |
| Average | 728                                    | 778                              | 674                         |
| Index % | 100.00                                 | 106.87                           | 92.58                       |

Furthermore, the average DWG of pigs fed Mixtures 1, 2 and 3 differed in various stages of the pig's development (Stage 1 and Stage 2). The average daily weight gain (DWG) achieved by pigs fed raw soybean in Stage 2 slightly depressed by only 4.41% as compared with average DWG of pigs in same stage fed extruded standard soybean. Average DWG of pigs in early stage of development (Stage 1) showed a strong depression by 12.33% for group fed Mixture 3, as compared to those fed Mixture 1. These results suggest that the effect of Kunitz trypsin inhibitor depends on age, and might be more harmful for young animals than for adults, which is in accordance with the results obtained by *Baker (2000)*. On the contrary, *Walker et al. (1987)* reported that replacing heated soybean meal with raw soybeans similarly reduced performance of both growing and finishing pigs.

The average daily feed intake varied less than 3% among dietary treatments. The absence of significant variations of this parameter was reported also in the studies of *Cook et al. (1988)* and *Tagliapietra et al. (2007)* (Table 3).

**Table 3. Average daily feed intake (kg)**

|          | Mixture 1<br>(extruded standard<br>cult.) | Mixture 2<br>(extruded KTI-free) | Mixture 3<br>(raw KTI-free) |
|----------|---|----------------------------------|-----------------------------|
| Stage I  | 1.63                                      | 1.65                             | 1.64                        |
| Index %  | 100.00                                    | 101.23                           | 100.61                      |
| Stage II | 2.76                                      | 2.82                             | 2.80                        |
| Index %  | 100.00                                    | 102.17                           | 101.45                      |
| Average  | 2.23                                      | 2.28                             | 2.29                        |
| Index %  | 100.00                                    | 102.24                           | 102.69                      |

The values of food conversion ratio observed for three groups of pigs showed that the highest average conversion value (3.40) was obtained by group of pigs fed mixture containing raw Kunitz-free soybean cultivar (Mixture 3) (Table 4).

**Table 4. Food conversion ratio**

|          | Mixture 1<br>(extruded standard<br>cult.) | Mixture 2<br>(extruded KTI-free) | Mixture 3<br>(raw KTI-free) |
|----------|---|----------------------------------|-----------------------------|
| Stage I  | 2.54                                      | 2.65                             | 2.92                        |
| Index %  | 100.00                                    | 104.33                           | 114.96                      |
| Stage II | 3.48                                      | 3.14                             | 3.69                        |
| Index %  | 100.00                                    | 90.23                            | 106.03                      |
| Average  | 3.06                                      | 2.93                             | 3.40                        |
| Index %  | 100.00                                    | 95.75                            | 111.11                      |

Average food conversion calculated for the group fed Mixture 2 (extruded Kunitz-free soybean) showed the lowest value (2.93). This group of pigs consumed in average 15.36% less feed for the unit of weight gain compared to the group fed Mixture 3.

The lower level of performance (DWG and G:F) of the group of pigs fed raw Kunitz-free soybean showed that the nutritional value of raw soybean, although higher than that of the standard variety, is still too low to sustain normal growth and development of animals. Nevertheless, KTI free soybean cultivars can offer nutritional advantages, since they need a shorter heating time for inactivation of trypsin inhibitors (*Friedman et al., 1991*). Furthermore, such varieties might be processed more economically into human foods as well.

## Conclusion

Although the nutritional value of raw Kunitz trypsin inhibitor-free soybean varieties is diminished by other heat-labile factors present in grain, such varieties might be processed more economically with shorter heating time and lower temperature, or utilized in extensive farming systems.

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## Nutritivna vrednost zrna sorti soje bez Kunitz-tripsin inhibitora u zrnu

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## Rezime

Upotreba zrnastih mahunarki u sirovom stanju u ishrani ljudi i domaćih životinja ograničena je prisustvom inhibitora proteaza u zrnu. Oplemenjivanje soje na smanjen sadržaj antihranljivih materija u Institutu za kukuruz Zemun Polje rezultiralo je stvaranjem dve nove sorte soje bez Kunitz tripsin inhibitora – Lana i Laura. U cilju upoređivanja efekata ishrane koja sadrži sirovo ili ekstrudirano zrno soje standardnog kvaliteta zrna i soje bez Kunitz tripsin inhibitora, postavljeni su ishranbeni ogledi sa svinjama u različitim fazama tova. Najveći napredak u pogledu brzine porasta je ostvaren kod grupe hranjene ekstrudiranim zrnom soje

bez Kunitz tripsin inhibitora. Ova grupa postigla je najveće vrednosti prosečnog dnevnog porasta i porasta po jedinici konzumiranog hraniva. Parametri rasta kod grupe svinja hranjene sirovim zrnom soje bez Kunitz tripsin inhibitora bili su blago umanjeni u odnosu na ostale ispitivane grupe.

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