Quality control parameters for commercial full-fat soya beans: **Processed by two different methods and fed to broilers**

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Considerable knowledge has been accumulated over the years to quantify the need and the effects of heat treatment in soya bean meal (SBM) for animal feeding. Although full-fat soya beans (FFSB) as an animal feed ingredient may appear fairly related to SBM, in practice FFSB is a different ingredient with different nutritional composition and processing conditions than SBM.

Therefore, in the quality control (QC) of FFSB processing, the parameters are not necessarily the same as those used to estimate optimum SBM quality.

Matrai and co-workers, as well as Waaijenberg, have reported practical QC parameters for FFSB, which are specified according to the intended animal species and age of feeding. However, limited information is available correlating specific QC or *in vitro* estimators with actual performance of broiler chickens to market age. Therefore, the objective of this paper is to correlate *in vitro* determinations in representative samples of FFSB used in *in vivo* feeding trials with broiler chickens.

Two different experiments were conducted at the National University of Colombia to determine the optimum processing conditions to produce commercial FFSB by two different methods: wet extrusion and dry toasting. In both experiments, treatments consisted of raw soya beans processed at different temperatures and lengths of time, formulated in a single broiler mash feed and fed to broiler chickens from 1 to 42 days of age.

Experiment 1
In vitro data versus growth data

The growth data from Perilla *et al*. show that body weight (BW) gain between 8 and 42 days was not significantly different for the 122, 126, and 140°C treatments. The BW obtained with these three treatments were not significantly different than for the soya bean meal treatment. However, feed conversion was more efficient in the SBM treatment. The raw soya beans treatment was significantly different than the 118 and 120°C treatments, confirming the improvement in animal performance due to heating of soya beans.

The BW and feed conversion data indicate that performance was maximised for treatments 122, 126, and 140°C.

Trypsin inhibitor activity dropped consistently from 50,800 (raw FFSB) to 4,700 TI units/g as temperature treatment increased to 140°C. The 17,700 to 4,700 range for treatments 122, 126, and 140°C appears consistent with the 14,000 to 7,000 TI units/g range considered typical in the US for adequately processed FFSB.

Urease activity as measured by the pH rise method is another *in vitro* test widely used by industry to assess the adequacy of heat treatment of SBM and FFSB. Raw soya beans and treatments 118 and 120°C had the highest UA values, which corresponded to suboptimal bird performance. In this experiment the range of pH values that corresponded with maximum performance was 0,07 to 0,03 pH units for treatments 122, 126, and 140°, respectively.

Soy-Chek is a trademark for a ready-to-use colour test to evaluate UA. It was included as another *in vitro* test because it is fairly well correlated to pH rise and because it is a very quick and simple test to run. The data for Soy-Chek indicate that this quick method clearly differentiated the under-processed FFSB treatments from the adequate ones.

The Soy-Chek manufacturer indicates that the product is applicable to both SBM and FFSB; however, for FFSB the time to evaluate results is 10 minutes as opposed to SBM, for which the time is 5 minutes. It is possible that the fat content in FFSB slows the wetting of the sample by the reagent.

All of the above *in vitro* tests are valid to detect underprocessing, that is, insufficient heating of SBM or FFSB. The results for TI and UA follow similar trends as those reported by Perilla *et al*. on different samples of the same treatments and conducted in a different laboratory.

The KOH protein solubility (KOHPS) test has been suggested as a method to evaluate overprocessing, that is, excessive heat treatment of SBM and other oilseed meals. With the exception of the report by Perilla and co-workers, we are not aware of specific publications evaluating the value of the KOHPS test to predict overprocessing for FFSB.

The data for KOHPS show that solubility was above 90% for raw soya beans, which is in agreement with the data of Anderson-Hafermann *et al*. For the heat treatments, all values were in

the upper 80s with only the treatment of 140°C at 79%. The KOHPS data do not agree with the data reported by Perilla *et al*. on different samples of the same treatments since they reported solubilities as low as 72% and 67% for treatments 126 and 140°C, respectively.

However, it is important to emphasise that a major limitation of the solubility test is that it is very empirical with various factors, such as the particle size of SBM or FFSB, and agitation intensity among other factors affecting the interlaboratory variability for the test. For the FFSB samples used for this report, the average particle size expressed as the average geometric diameter ranged from 480 to 650 µm, whereas for the SBM sample it was 250 µm. The FFSB samples do not grind very well in laboratory mills because of its oil content.

In vivo amino acid digestibility versus growth data

Total amino acid (TAA) values standardised at 88% DM are presented. Although a single analysis was run for each sample, it should be noted that the FFSB treatments were all derived from the same original lot of raw soya beans. Except when overprocessing conditions occur, TAA values are normally not affected by processing. Therefore, for practical purposes the TAA values for the different treatments are six replicated analyses.

As temperature increased during wet extrusion, the digestible amino acid (DAA) coefficients increased, indicating the gradual destruction of TI and other antinutritional factors that may affect amino acid absorption. The highest numerical values for DAA coefficients were obtained at 126°C.

However, because each DAA coefficient was determined with a single set of birds (three birds) per sample, and excreta were pooled together for one analysis, there is no variability data to statistically differentiate treatments 122, 126, and 140°C as far as DAA coefficients are concerned. Nevertheless, the performance data were not statistically different for these three treatments, and, consequently, it is possible to infer that the small variation among the DAA coefficients for these three treatments was not enough to change performance.

Although in general there was a small decrease in the DAA coefficients for the 140°C treatment relative to the 126°C treatment, performance data do not support the concept of overprocessing in the experiment of Perilla *et al*.

The effects of overprocessed SBM on broiler performance are well documented, digestible lysine being the single most damaged amino acid. However, an additional indication of overprocessing is the net destruction of total lysine, which could also be expected to occur in overprocessed FFSB, and it was not observed for treatment 140°C.

Experiment 2

In vitro data versus growth data

The growth data from Ordoñez and Palencia show that the BW at 42 days of age were not significantly different for the 120, 130, 135, and 150°C treatments. The BW for the raw soya bean and 113°C treatments were significantly different ($P < 0,05$). The highest numerical BW at 42 days was for the 130°C treatment, followed by the 120°C treatment.

The TI activity dropped dramatically from raw FFSB to the 113°C treatment, that is, from 56,300 to 8,850 TI units/g. Thereafter, additional heating (higher temperatures and longer residence times) resulted in a smooth decrease of the TI activity.

The UA also dropped dramatically from 2,01 to 0,03 pH units at the 113°C treatment, and Soy-Chek also reflected the large drop in UA at 113°C. Soy-Chek data were consistent with pH rise data. The KOHPS data show a consistent decrease in the protein solubility of FFSB as temperature and retention time increased.

All of the *in vitro* data changes corresponded with an improvement in the BW of broilers at 42 days up to the 130°C treatment. However, as discussed in the next paragraphs, the growth data for the 113°C treatment cannot be explained with the *in vitro* data obtained for the FFSB sample of that treatment.

In vivo amino acid digestibility versus growth data

As in the case of experiment 1, one TAA analysis was conducted per sample, but because the six samples of this experiment are derived from the same original lot of raw soya beans, the TAA

Table 1: Pearson correlation coefficients between *in vivo* parameters in broiler chickens (BW and feed conversion ratio) and *in vitro* quality control analyses in full-fat soya beans processed by two different methods.

	Experiment 1 Wet-extruded FFSB		Experiment 2 Toasted FFSB	
	BW gain day 8 to 42	Feed conversion ratio	BW at 42 days	Feed conversion ratio
Trypsin inhibitor activity (U/g)	-0,91*	0,93**	-0,98**	0,99**
Urease activity (pH U)	-0,85*	0,82*	-0,98**	0,99**
KOH solubility (%)	-0,73	0,81*	-0,61	0,57

*P < 0,05; **P < 0,0.

values are very similar, demonstrating that there was no damage to any of the nine analysed TAA as a consequence of dry toasting.

As temperature and retention time increased during dry toasting, the DAA coefficients of FFSB increased to reach a numerical maximum at the 130°C treatment with very slight changes for the 135 and 150°C treatments. As already indicated, the maximum performance in the experiment of Ordoñez and Palencia was obtained with the 130°C treatment. Therefore, the growth data ran parallel with the increased DAA coefficients as a consequence of toasting.

Did the *in vitro* data predict *in vivo* performance of broilers fed FFSB in the two experiments? We have to divide the answer to this question in two parts: underprocessing, or the detection of insufficient heating, and overprocessing, or excessive heat treatment.

Underprocessing

For both experiments the TI activity and the UA of the FFSB samples analysed were significantly correlated with the performance parameters evaluated. The TI and UA were negatively correlated with BW and positively correlated with feed conversion ratio. These high correlation values suggest that these parameters are accurate predictors of the quality of FFSB. In experiment 1, TI activity below 18,000 TI units/g coincided with a pH rise value below 0,10 pH units for the 122, 126, and 140°C treatments, which, in turn, were not significantly different among them and not significantly different than the SBM positive control.

In experiment 2, the only exception is for the *in vitro* data for the 113°C treatment, which do not predict the significantly lower BW of broilers at 42 days, since TI activity was only 8 850 TI units/g, and pH rise was not higher than 0,03 pH units. However, a review of the *in vivo* DAA coefficients suggests that indeed the FFSB dry toasted at 113°C showed a pattern of overall lower digestibility typical of underprocessed FFSB. In other words, the *in vivo* DAA coefficients data help to explain the suboptimal performance of broilers fed FFSB dry toasted at 113°C.

We do not have an explanation for this inconsistency. Otherwise, the concept of TI activity of less than 18,000 TI units/g and UA activity lower than 0,10 pH units also applies to dry toasting of FFSB to maximise performance.

Overprocessing

The only *in vitro* criteria used in the evaluation of the FFSB samples for the two experiments was the protein solubility in KOH. However, neither the growth data nor the *in vivo* DAA coefficients support the concept that overprocessing of FFSB occurred in either of the two experiments. Therefore, no significant correlations were found between KOH protein solubility and the performance parameters evaluated except for feed conversion ratio in experiment 1 (*Table 1*).

This is an unexpected finding because of the widespread use of KOHPS to assess the overprocessing status of SBM. Although the validity of KOHPS has been documented mostly in laboratory models, it also has been tested with commercial SBM having different solubilities. Kang and co-workers fed broilers to three weeks with commercial soya bean meals, which differed in 15 points (percentage units) of KOHPS values. The BW at 21 days showed a difference of 5,75% between the highest and the lowest solubilities.

A controlled experiment conducted by Lee and co-workers with a commercially overprocessed soya bean meal demonstrated that a ten-point drop in solubility resulted in a significant growth depression of about 170g in growing turkeys at nine weeks of age. Therefore, there is sufficient evidence on the value of KOHPS to detect overprocessed SBM, but the results of the two experiments with FFSB analysed here do not support that overprocessing was detected *in vivo*. Even though there was a drop in solubility of 19 points in experiment 1 (98% vs 79%) and 25 points in experiment 2 (94% vs 69%), these decreases did not reflect overprocessing of FFSB.

It is possible that the value of protein solubility at which it becomes correlated with overprocessing of FFSB is much lower than in SBM. Anderson-Hafermann *et al.* found that processing of canola seeds to generate canola meal may result in canola meals displaying a wide range of KOHPS values from 80 to 40%, but only solubilities below 40% are correlated with overprocessing. A similar effect was reported by Jensen *et al.* in rapeseed meals.

The relevance of the data from the two experiments with FFSB is that in both experiments each FFSB processor (the Anderson expander and the thermal processor) were used beyond their normal operating conditions to generate the highest temperature treatment in each experiment. Therefore, this is a suggestion that overprocessing of commercial FFSB may be a difficult task.

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