Antibiotics are currently used as growth promoters to ensure productivity and safety, resulting in increased antibiotic resistance both for animals and humans. This is what led Europe to ban the use of antibiotics as growth promoters in feed, and today India is thinking of taking the same path. Important research is being conducted to find acceptable alternatives to ensure safety without compromising productivity.

In a recent project reported here, the effects of probiotic Saccharomyces cerevisiae boulardii I-1079 (Levucell® SB; Lallemand) on broilers performance and health was assessed. It appeared that both growth rate and carcass quality were improved after only 14 days of supplementation. A pathogen challenge study showed that S. boulardii I-1079 also conferred good resistance against S. gallinarum infection (Fowl Typhoid), and prevented the detrimental effects of salmonella infection on growth. All these findings are illustrated by new proofs of the action of S. boulardii I-1079 on gut structure and haematology.

**Improved growth and feed efficacy**

In the first part of the study, 75 day-old broiler chicks of Vencob breed were supplemented or not with S. boulardii I-1079 live yeast (two concentrations were used, 1X10^9, or 2X10^9 CFU/kg feed. For the first three weeks, the birds were fed broiler starter feed, followed by broiler finisher feed for the following three weeks. Feed was free of any antibiotic or anticoccidistats. Feed and fresh water were supplied ad libitum.

Average body weight showed improvement from the second week of supplementation with probiotic SB (+16% and +21%, with 1X10^9 and 2X10^9 CFU/kg feed, respectively). Overall weight gain was significantly enhanced with both concentrations of the probiotic (P<0.05) (Figure 1).

These findings were correlated with an improved feed conversion ratio (FCR) (Figure 2) due to the probiotic. FCR improvement has been demonstrated before in broilers with live yeast supplementation and could be attributed to a better nutrient digestibility and nitrogen retention due to the activity of the probiotic. One of the well-demonstrated effects of S. boulardii I-1079 in the gut is the inhibition of pathogen growth, so that more nutrients and energy are available for the host. This is measured in the case of protein by a significant (P<0.01) increase in metabolic protein (Figure 3), linked to better nitrogen utilisation. Ultimately, improved digestion and absorption in the intestine results in better feed efficacy and increased productivity for the farmer.

**Effect on carcass quality**

Carcass quality was also assessed in order to measure the effects of live yeast supplementation. At 42 days of age, the weights of the evisceration (dressed weight) as well as of the head, shank, liver, gizzard, lungs, heart, wings, back with neck, legs, and breast were measured by digital weighing balance and expressed as percentages of the birds live weights (Figure 4). The average dressing percentages (evisceration) were significantly improved with the probiotic treatment. Head percentages were significantly lower with Levucell SB, and both criteria clearly stated that Levucell SB-supplemented diet represents a good industrial approach, increasing meat part in broilers. Average shank, gizzard and heart percentages did not differ significantly with probiotic treatment. The weights of the wings, back with neck, legs and breast were also expressed as the percentages of eviscerated weights, but no significant differences were noticed in that case.
to AGP in broiler chickens

Resistance to fowl typhoid
Fowl typhoid (Salmonella gallinarum) is an important problem in poultry rearing; the associated weight loss, morbidity and mortality represent important financial loss in India. In a second part of the research project, we studied the efficacy of S. boulardii I-1079 against S. gallinarum, in the absence of any therapeutic treatment. For this experiment, 105 day-old broiler chicks were divided into three different groups: one group was kept as a healthy control and two were experimentally challenged with S. gallinarum by individual oral contamination at day 18. Among the 2 contaminated groups, one received the control, untreated feed, and the other was supplemented with 2.10^9 CFU/Kg feed of S. boulardii I-1079, from day 1 to 42.

We could observe that healthy control birds were very active, alert, freely moving and were fed normally throughout the 42-days period, while the salmonella infected birds of the second group showed clinical signs like dullness, decreased appetite, reduced growth rate, ruffled feathers, diarrhoea and an inclination to huddle together, from the day of salmonella challenge. However, the group receiving Levucell SB, and challenged with salmonella at day 18, did not show any abnormal clinical signs throughout the period of the study, except for dullness for the initial 2-3 days. The absence of clinical signs in this group could be attributed to the effective elimination of salmonella organisms in the gut by S. boulardii I-1079, as shown in Figure 5: 4 days after the infection, the live pathogen count in the birds liver was already extremely low with the probiotic treatment, and only 8 days after the infection, no more pathogen was detected, while the untreated animals remained infected until the end of the study. This is certainly due to the “shield effect” of the probiotic in the intestine of monogastric animals, largely demonstrated in scientific publications. S. boulardii I-1079 is known to agglutinate pathogenic flagellate bacteria within the gut, such as Salmonella, preventing them from adhering and colonizing the intestinal epithelium. The big yeast-pathogen complexes are then flushed through the gut and expelled via the faeces. Additionally, researchers have previously explained that S. boulardii blocks the Salmonella receptor sites on the epithelial surface, preventing the attachment of pathogens to the gut surface.

Fowl typhoid is linked to mortality, but also decreased feed intake and loss of body weight, with important financial consequences. In the present study, we have observed that supplementation with the probiotic not only compensates the detrimental effect of S. gallinarum infection on growth, but also increased body weight compared to healthy, uninfected birds (Figure 6).

Effects on the gut
The goal of this study was also to determine some of the mechanisms underneath the measured benefits of S. boulardii I-1079 on broiler performances. Physiological effects of the live yeast supplementation have been observed in the study.

First, the probiotic supplementation numerically increased liver weight percentage, which might have helped aid digestion (Figure 4). In the same way, average lung weight percentage was significantly higher with the probiotic, and we can link increased lung weight to an increased availability of oxygen for the tissues, resulting in improved growth.

Additionally, some haematological parameters were measured at 40 days of age, showing a significant increase in haemoglobin level and total erythrocyte count in the Levucell SB-treated birds. Again, this is in favour of increased oxygen availability for optimal tissue metabolism in presence of S. boulardii I-1079.

In the second experiment, the height and number of duodenal and jejunal vilis were recorded at week 2, 4 and 6. Additionally, the pH of various intestinal segments like duodenum, jejunum, ileum, jejunum were measured with 2.10^9 CFU/Kg feed of S. boulardii I-1079, from day 1 to 42. Additionally, some haematological parameters were measured at 40 days of age, showing a significant increase in haemoglobin level and total erythrocyte count in the Levucell SB-treated birds. Again, this is in favour of increased oxygen availability for optimal tissue metabolism in presence of S. boulardii I-1079.

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and caecum was recorded in-situ at the end of the study. Both the number and the length of gut villi were affected by *S. gallinarum* infection: after infection, both parameters are lower for infected birds compared to healthy ones. By colonising the gut, *S. gallinarum* affects proper gut development, reducing the absorption surface, leading to lower feed efficacy and decreased growth. When the broilers were fed Levucell SB from their first day of life, the number and height of intestinal villi were significantly higher than in non-supplemented birds, and was not affected by *S. gallinarum* challenge (Figure 7). It appeared that the probiotic improved intestine maturation and villi formation, increasing significantly the surface for nutrient absorption, which was reflected in a higher body weight for those birds.

Figure 8 shows that the probiotic treatment also acts on the gut environment, lowering the pH in various intestine segments. A low pH creates a hostile environment for pathogens, reducing their chance of survival and colonisation of the gut. It has been stated that the low pH could be due to the hydrolysis of starch by live yeast, with production of extra lactic acid, hydrogen peroxide and acetic acid.

In conclusion, *S. bouardii* I-1079 represents a natural and sustainable solution to control broilers growth and safety in India. Its action in the gut (improved microvillis development, improved gut environment, increased feed digestion and absorption, etc) is well documented and reflected in animal performance.

**Figure 7 a & b - Effects of *S. gallinarum* infection and Levucell SB treatment on villi heights and numbers for different intestinal segments at 2, 4 and 6 weeks.**

**Figure 8 - Mean pHs in various intestinal segments.**

<table>
<thead>
<tr>
<th>Intestinal segment</th>
<th>Control</th>
<th><em>S. gallinarum</em> non treated</th>
<th><em>S. gallinarum</em>/Levucell SB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duodenum</td>
<td>6.61**</td>
<td>6.78**</td>
<td>5.48*</td>
</tr>
<tr>
<td>Jejunum</td>
<td>6.51**</td>
<td>6.76**</td>
<td>5.59*</td>
</tr>
<tr>
<td>Ileum</td>
<td>7.03**</td>
<td>7.05*</td>
<td>5.44*</td>
</tr>
<tr>
<td>Caecum</td>
<td>6.64**</td>
<td>6.62*</td>
<td>5.62*</td>
</tr>
</tbody>
</table>

**Means bearing same superscript in a row do not differ significantly (p<0.01)**