**Carcass gain per kg feed intake: developing a stakeholder-driven benchmark for comparing grow-finishing pig performance**

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Supplementary Table S1. Knowledge input over feed conversion ratio (FCR) in pigs (preparatory literature searches)

|  |  |  |  |
| --- | --- | --- | --- |
| Input | Topic | Selected references | Motivation |
| Literature search 1 (to prepare interviews) | **FCR as a tool for:** |  | Highlight importance to engage stakeholders |
| * production efficiency
 | Douglas *et al.* (2015)1, Patience (2015)2 |
| * farm profitability
 | Hermersch *et al.* (2015)3, Andersson *et al.* (1997)4 |
| **Formulas used to calculate FCR** |  | Increase awareness to both farmers and the research team |
| * basic formula (no adjustments)
 | Pierozan *et al.* (2016)5, Agostini *et al.* (2014)6 |
| * revised formula ( w adjustments)
 | Goncalves *et al.* (2017)7, Berry and Pryce (2014)8 |
| **Factors influencing FCR** |  | Designate the main factors that seem to affect FCR. List search terms for literature search 2 |
| feed/water | Harris *et al.* (2012)9, Vukmirović (2017)10 |
| management/infrastructure | Gaines *et al.* (2012)11 |
| health/genetics | Dritz (2012)12 |
| Literature search 2 (to prepare focus group meetings) | **Factors influencing FCR related to:** |  | Prepare presentation with factors influencing FCR to communicate results to groups of experts that will prioritize afterwards the most important elements.  |
| * **feed/water intake**
 |  |
| feed processing (*e.g.* pellet) | Nemechek *et al.* (2016)13, Edge *et al.* (2005)14 |
| schema (*e.g. ad libitum*) | Colpoys *et al.* (2016)15, Patience (2012)16 |
| organoleptic qualities (*e.g.* taste) | Maciorowski *et al.* (2007)17 |
| contaminants (*e.g.* mycotoxins*)* | Richard *et al.* (2007)18, Maciorowski *et al.* (2007)17 |
| composition (*e.g.* amino acid) | Kerr and Shurson(2013)19 |
| feed wastage/spillage | Patience *et al.* (2015)2, Brumm (2010)20 |
| feed/water quality | Umar *et al.* (2014)21, Coleman *et al.* (2003)22 |
| feeder/drinker type | Brumm (2010)20 |
| * **management/infrastructure**
 |  |
| farmer’s competency | Tokach (2012)23, Florh *et al.* (2014)24 |
| pen density | Pierozan *et al.* (2016)5 |
| split sex pen | Pierozan *et al.* (2016)5 |
| floor type | Agostini *et al.* (2014)6 |
| antimicrobial use | Collineau *et al.* (2017)25, Postma *et al.* (2017)26 |
| climatic environment | Renaudeau *et al.* (2012)27 |
| biosecurity | Laanen *et al.* (2012)28 |
| * **health/genetics**
 |  |
| mortality | Oliveira *et al.* (2009)29, Maes *et al.* (2004)30 |
| gut health/microbiota | Quan *et al.* (2018)31, Yang *et al.* (2017)32 |
| breed | Reyer *et al.* (2017)33, Camara *et al.* (2016)34 |
| selection (*e.g.* low residual feed intake) | Saintilan *et al.* (2013)35, Harris *et al.* (2012)9 |
| body weight | Patience et al. (2015)2, Agostini et al. (2014)6 |

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Supplementary Table S2. Calculating steps for determining the “technical” feed conversion ratio (FCRtechnical) formula in pigs.

|  |  |
| --- | --- |
| Step | Calculating formula |
| I. Calculate daily chance to die | $$P\_{\frac{mortality}{day}}=1-\sqrt[fattening round duration]{1-mortality}$$ |
| II. Calculate average days present per pig | $$average nr days present=\sum\_{i=1}^{fattening round duration}\left((1-P\_{\frac{mortality}{day}})\right)^{i}$$ |
| III. Calculate corrected feed intake | $$Corrected feed intake per delivered (fattened) pig=  \frac{Total feed intake}{nr delivered pigs}\* \frac{average nr days present}{fattening round duration}$$ |
| IV. Calculate FCR corrected for mortality | $$FCR\_{mortality}=\frac{corrected feed intake per delivered pig}{final weight-initial weight}$$ |
| V. Standardize FCR for initial weight (FCRst. in.) | $$FCR\_{st. in.}=\frac{\begin{array}{c}FCR\_{mortality}\*\left(final weight-inital weight\right)+\\FCR\_{for 25kg liveweight¹}\*(initial weight-25kg)\end{array}}{final weight-standardized initial weight}$$ |
| VI. Assign a correction factor | $$correction factor=\frac{(FCR\_{st. in.}- FCR\_{for a 25kg liveweight})}{final weight-standardized final weight}$$ |
| VII. Standardize for a weight trajectory of 25kg to 115kg (live weight) | $$FCR\_{standardized}=FCR\_{st. in.}-(correction factor\* \left(final weight-standardized final weight\right))$$ |

Feed conversion ratio for a fattening pig weighing 25kg.

Supplementary Material S1. Calculating steps for determining the “FCRtechnical” formula and the “CGFstandardized“ formula . FCR stands for feed conversion ratio and CGF for carcass growth per kg feed

Explanation of the 7-step FCRtechnical formula.

Step I. As a first step, the “daily chance to die” is calculated as 1 minus the root of “1 - mortality rate” indexed by the duration of the fattening round.

Step II. The “average number of days present per pig” is calculated as the summation of “1- daily chance to die” indexed again by the duration of the fattening round.

Step III. The third step is the correction of feed intake per fattened pig by multiplying with the fraction of “average number days present per pig” to the duration of the fattening round.

Step IV. The result from Step III is used as the numerator to calculate the FCR that is now corrected for mortality.

Step V. For step 5, FCR corrected for deviating weaned weight is calculated. To calculate this, we first multiply the FCR corrected for mortality (Step IV) by the actual live weight growth of the animal during the fattening period. We then assign a fixed FCR value for a 25kg pig. After using the 2016 figures from the Flemish Government Agriculture report this value was set $\left(FCR\_{25kg liveweight}=1.8\right).$ Then we calculate how much the initial weight of the pig deviates from the standardized initial weight (25kg) in our formula. We multiply it with the $FCR\_{25kg liveweight}$. Then, the numerator expresses the feed used in the growth trajectory that deviates from the standardized initial weight. This results in adding the kg feed used in case the initial weight was lower than the standardized initial weight or subtracting the amount of feed used in case the initial weight was higher than the standard. We consequently divide this numerator again with the growth trajectory that has been standardized to the standard initial weight ($final weight-standardized initial weight).$ This formula informs of the FCR over the growth trajectory from the standard initial weight to the actual final weight of a pig.

Step VI. Here we estimate a farm specific correction factor to correct the feed used for the deviating mass of growth between the actual final live weight of the animal and the standardized final live weight. The correction factor is the slope of the linear regression between the standardized FCR from step V and the assumed FCR at the standardized initial weight (25kg liveweight) as function of the live weight growth. This parameter gives us a measure of the change in FCR per kg of live weight growth that deviates from the standard final live weight.

Step VII. In this step we calculate the deviation of the actual final weight and the standard final weight. This difference is multiplied with the correction factor from step VI to adjust the FCR for the deviating actual final weight from the standardized final weight. If the actual final weight is lower than the standard then we subtract the multiplication of the correction factor and the deviating weight to the FCRst. in. to get a lower FCR standardized for initial and final weight. Likewise if the actual final weight is higher than the standard final carcass weight the FCRst. in. will be higher since we add the deviating mass of carcass multiplied with the correction factor.

Explanation of the 7-step CGFstandardized formula.

Step I. As a first step, the “daily chance to die” is calculated as 1 minus the root of “1 - mortality rate” indexed by the duration of the fattening round.

Step II. The “average number of days present per pig” is calculated as the summation of “1- daily chance to die” indexed again by the duration of the fattening round.

Step III. The third step is the correction of feed intake per fattened pig by multiplying with the fraction of “average number days present per pig” to the duration of the fattening round.

Step IV. The carcass growth per kg feed (CGF) corrected for mortality is calculated at this step. As numerator, the carcass weight of the fattened pig minus the product of the weight of the piglet at the start of the fattening round (initial weight) with the piglet carcass yield. The result from Step III is used as the denominator.

Step V. At this step, we standardize CGF for initial weight. Regarding the numerator: First we calculate the feed used per pig (corrected for mortality) over the actual carcass growth trajectory of the pig. $CGF\_{mortality}\*\left(final weight\_{warm carcass}-initial weight\right)$. Then we calculate how much the initial weight of the pig deviated from the standardized initial weight in our formula $standardized initial weight-initial weight$. We multiply it with the assumed feed efficiency at the standardized initial weight to have the feed used in the growth trajectory that deviates from the standardized initial weight. This results in adding the kg feed used in case the initial weight was lower than the standardized initial weight or subtracting the amount of feed used in case the initial weight was higher than the standard. The numerator thus becomes the corrected amount of feed used standardized to the standard initial weight.

We consequently divide this numerator with the growth trajectory that has been standardized to the standard initial weight. ( $final weight\_{warm carcass}-standardized initial weight. $Resulting in a measure of feed efficiency over the growth trajectory from the standard initial weight to the actual final weight of the pig.

Step VI. Here we estimate a farm specific correction factor to correct the feed used for the deviating mass of growth between the actual final weight of the carcass and the standardized final carcass weight.

The correction factor is the slope of the linear regression between the standardized CGFin from step V and the assumed CGF at the standardized initial weight (25kg liveweight) as function of the carcass growth. This parameter gives us a measure of the change in CGF per kg of carcass growth that deviates from the standard final carcass weight.

Step VII. We calculate the deviation of the actual final weight and the standard final weight. This mass is multiplied with the correction factor from step VI to adjust the CGF for the deviating actual final weight from the standardized final weight. If the actual final carcass weight is lower than the standard then the multiplication of the correction factor and the deviating weight to the CGFst. in. is added resulting in a higher CGF standardized for initial and final weight. Likewise if the actual final weight is higher than the standard final carcass weight the standardized CGF will be lower since we subtract the deviating mass of carcass multiplied with the correction factor.

Supplementary Table S3. Two-variable data table sensitivity analysis for transforming a. pig carcass weight measurements to live weight measurements and b. piglet live weight measurements to carcass weight measurements to test the effects of variability due to varying carcass yield (horizontal axis) and varying weight (vertical axis) on the carcass growth per kg feed (CGF) formula.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | a) | Pig carcass yield |  |  |
|  |  | 0.75 | 0.76 | 0.77 | 0.78 | 0.79 | 0.8 | 0.81 | 0.82 | 0.83 | 0.84 | 0.85 |  | difference highest-lowest carcass yield |
| pig weight | 107 | 0.341 | 0.335 | 0.329 | 0.324 | 0.319 | 0.314 | 0.309 | 0.304 | 0.299 | 0.294 | 0.290 |  | 0.040 |
| 108 | 0.346 | 0.340 | 0.334 | 0.329 | 0.323 | 0.318 | 0.313 | 0.308 | 0.303 | 0.299 | 0.294 |  | 0.041 |
| 109 | 0.351 | 0.345 | 0.339 | 0.334 | 0.328 | 0.323 | 0.318 | 0.313 | 0.308 | 0.303 | 0.299 |  | 0.041 |
| 110 | 0.356 | 0.350 | 0.344 | 0.338 | 0.333 | 0.328 | 0.322 | 0.317 | 0.312 | 0.308 | 0.303 |  | 0.042 |
| 111 | 0.361 | 0.355 | 0.349 | 0.343 | 0.338 | 0.332 | 0.327 | 0.322 | 0.317 | 0.312 | 0.307 |  | 0.042 |
| 112 | 0.366 | 0.360 | 0.354 | 0.348 | 0.343 | 0.337 | 0.332 | 0.327 | 0.322 | 0.317 | 0.312 |  | 0.042 |
| 113 | 0.371 | 0.365 | 0.359 | 0.353 | 0.347 | 0.342 | 0.336 | 0.331 | 0.326 | 0.321 | 0.316 |  | 0.043 |
| 114 | 0.376 | 0.370 | 0.364 | 0.358 | 0.352 | 0.347 | 0.341 | 0.336 | 0.331 | 0.326 | 0.321 |  | 0.043 |
| 115 | 0.381 | 0.375 | 0.369 | 0.363 | 0.357 | **0.351** | 0.346 | 0.340 | 0.335 | 0.330 | 0.325 |  | 0.043 |
| 116 | 0.386 | 0.380 | 0.373 | 0.368 | 0.362 | 0.356 | 0.350 | 0.345 | 0.340 | 0.335 | 0.330 |  | 0.044 |
| 117 | 0.391 | 0.385 | 0.378 | 0.372 | 0.366 | 0.361 | 0.355 | 0.350 | 0.344 | 0.339 | 0.334 |  | 0.044 |
| 118 | 0.396 | 0.390 | 0.383 | 0.377 | 0.371 | 0.365 | 0.360 | 0.354 | 0.349 | 0.344 | 0.339 |  | 0.045 |
| 119 | 0.401 | 0.395 | 0.388 | 0.382 | 0.376 | 0.370 | 0.364 | 0.359 | 0.353 | 0.348 | 0.343 |  | 0.045 |
| 120 | 0.406 | 0.400 | 0.393 | 0.387 | 0.381 | 0.375 | 0.369 | 0.364 | 0.358 | 0.353 | 0.347 |  | 0.045 |
| 121 | 0.411 | 0.404 | 0.398 | 0.392 | 0.386 | 0.380 | 0.374 | 0.368 | 0.363 | 0.357 | 0.352 |  | 0.046 |
| 122 | 0.416 | 0.409 | 0.403 | 0.397 | 0.390 | 0.384 | 0.378 | 0.373 | 0.367 | 0.362 | 0.356 |  | 0.046 |
| 123 | 0.421 | 0.414 | 0.408 | 0.401 | 0.395 | 0.389 | 0.383 | 0.377 | 0.372 | 0.366 | 0.361 |  | 0.046 |
| differencehighest-lowest weight | 0.045 | 0.046 | 0.047 | 0.047 | 0.048 | 0.048 | 0.049 | 0.050 | 0.050 | 0.051 | 0.051 |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| b) |  | Piglet carcass yield |  |  |
|  |  | 0.67 | 0.68 | 0.69 | 0.7 | 0.71 | 0.72 | 0.73 | 0.74 | 0.75 | 0.76 | 0.77 |  | difference highest-lowest carcass yield |
| piglet weight | 17 | 0.306 | 0.305 | 0.304 | 0.304 | 0.303 | 0.302 | 0.302 | 0.301 | 0.300 | 0.300 | 0.299 |  | 0.006 |
| 18 | 0.303 | 0.302 | 0.302 | 0.301 | 0.300 | 0.300 | 0.299 | 0.298 | 0.298 | 0.297 | 0.296 |  | 0.007 |
| 19 | 0.301 | 0.300 | 0.299 | 0.298 | 0.298 | 0.297 | 0.296 | 0.296 | 0.295 | 0.294 | 0.294 |  | 0.007 |
| 20 | 0.298 | 0.297 | 0.297 | 0.296 | 0.295 | 0.294 | 0.294 | 0.293 | 0.292 | 0.291 | 0.291 |  | 0.007 |
| 21 | 0.296 | 0.295 | 0.294 | 0.293 | 0.292 | 0.292 | 0.291 | 0.290 | 0.289 | 0.289 | 0.288 |  | 0.008 |
| 22 | 0.293 | 0.292 | 0.291 | 0.291 | 0.290 | 0.289 | 0.288 | 0.287 | 0.287 | 0.286 | 0.285 |  | 0.008 |
| 23 | 0.291 | 0.290 | 0.289 | 0.288 | 0.287 | 0.286 | 0.286 | 0.285 | 0.284 | 0.283 | 0.282 |  | 0.009 |
| 24 | 0.288 | 0.287 | 0.286 | 0.285 | 0.285 | 0.284 | 0.283 | 0.282 | 0.281 | 0.280 | 0.279 |  | 0.009 |
| 25 | 0.286 | 0.285 | 0.284 | 0.283 | 0.282 | **0.281** | 0.280 | 0.279 | 0.278 | 0.277 | 0.276 |  | 0.009 |
| 26 | 0.283 | 0.282 | 0.281 | 0.280 | 0.279 | 0.278 | 0.277 | 0.276 | 0.275 | 0.275 | 0.274 |  | 0.010 |
| 27 | 0.281 | 0.280 | 0.279 | 0.278 | 0.277 | 0.276 | 0.275 | 0.274 | 0.273 | 0.272 | 0.271 |  | 0.010 |
| 28 | 0.278 | 0.277 | 0.276 | 0.275 | 0.274 | 0.273 | 0.272 | 0.271 | 0.270 | 0.269 | 0.268 |  | 0.010 |
| 29 | 0.276 | 0.275 | 0.274 | 0.273 | 0.271 | 0.270 | 0.269 | 0.268 | 0.267 | 0.266 | 0.265 |  | 0.011 |
| 30 | 0.273 | 0.272 | 0.271 | 0.270 | 0.269 | 0.268 | 0.267 | 0.265 | 0.264 | 0.263 | 0.262 |  | 0.011 |
| 31 | 0.271 | 0.270 | 0.268 | 0.267 | 0.266 | 0.265 | 0.264 | 0.263 | 0.262 | 0.260 | 0.259 |  | 0.011 |
| 32 | 0.268 | 0.267 | 0.266 | 0.265 | 0.264 | 0.262 | 0.261 | 0.260 | 0.259 | 0.258 | 0.256 |  | 0.012 |
| 33 | 0.266 | 0.265 | 0.263 | 0.262 | 0.261 | 0.260 | 0.258 | 0.257 | 0.256 | 0.255 | 0.254 |  | 0.012 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Difference highest and lowest weight | 0.040 | 0.040 | 0.041 | 0.041 | 0.042 | 0.043 | 0.043 | 0.044 | 0.044 | 0.045 | 0.046 |  |  |