

Evaluation of the prevalence of stomach ulcers in slaughtered pigs in a Swiss abattoir

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Prävalenz von Magengeschwüren bei geschlachteten Schweinen in einem Schweizer Schlachthof

Die Entstehung von Magengeschwüren bei Schweinen hat verschiedene Gründe. In der Schweiz wurde die letzte Erhebung zur Prävalenz von Magengeschwüren und möglichen Risikofaktoren im Jahr 2005 durchgeführt. Heute, 2021, bewerteten wir die Prävalenz von Magengeschwüren neu.

In einem Schweizer Schlachthof wurden 1005 Mägen von Mastschweinen aus 136 Chargen und rund 87 Beständen beurteilt. Die *Pars oesophagea* des Magens wurde von 0 = gesund bis 10 = schwere Ulzerationen und Strikturen bewertet. Die Bewertungen der Schweinemägen wurde zwischen den Labels «Integrierte Produktion Schweiz» (IPS, n=242 Mägen, 18 Betriebe) und «Qualitätsmanagement-Schweizerfleisch» (QM, n=649, 58 Betriebe) und anderen (n=114) verglichen.

Die Untersuchungen zeigten eine Prävalenz von 27,2% leichten Schleimhautveränderungen (Bewertungen 1–3), 14,9% moderaten Schleimhautveränderungen (Bewertungen 4–6) und 19,1% schweren Schleimhautveränderungen (Bewertungen 7–10). Nur 38,8% der Mägen wurden mit 0 bewertet und gelten somit als gesund. Im Vergleich zu den Ergebnissen von 2005 gibt es keinen Unterschied zwischen den niedrigsten Werten (0–2) und den höchsten Werten (9–10). Allerdings gab es eine Verschiebung von den mittleren Werten (3–4) zu höheren Werten (5–8). Die Magenwerte erwiesen sich als herdenspezifisch. Zwischen den Labels gab es Unterschiede ($p < 0,01$) mit dem Hinweis, dass IPS-Schweine weniger betroffene Mägen hatten. Mägen, die bei der Schlachtung leer waren, zeigten höhere Werte ($p < 0,001$). Das mittlere Schlachtkörpergewicht war negativ korreliert ($p < 0,05$) mit ihrem mittleren Magenwert. Es bestand kein Zusammenhang zwischen Magenwerten und Beschlagnahmen.

Summary

The development of gastric ulcers in pigs has various reasons. In Switzerland, the last survey on the prevalence of gastric ulcers and possible risk factors was performed in 2005. We aimed to reassess gastric ulcers prevalence today, in 2021.

A total of 1005 stomachs from fattening pigs from 136 batches and around 87 herds were evaluated at a Swiss abattoir. The *Pars oesophagea* of the stomach was scored from 0=healthy to 10=severe ulceration and strictures. Scores were compared between pigs produced under the labels «Integrierte Produktion Schweiz» (IPS, n=242 stomachs, 18 farms) and «Qualitätsmanagement-Schweizerfleisch» (QM, n=649, 58 farms) and others (n=114).

The results showed a prevalence of 27,2% mild mucosal changes (Scores 1–3), 14,9% moderate mucosal changes (Scores 4–6) and 19,1% severe mucosal changes (Scores 7–10). Only 38,8% of the stomachs were rated 0 and thus considered healthy. Compared to the results from 2005, there is no difference concerning the lowest scores (0–2) and the highest scores (9–10). However, there was a shift from the medium scores (3–4) to higher scores (5–8). Stomach scores turned out to be herd specific. There were differences ($p < 0,01$) between labels, indicating that IPS pigs had less affected stomachs. Stomachs that were empty at slaughter showed higher scores ($p < 0,001$). The mean carcass weight of the pigs in the slaughter groups was negatively correlated ($p < 0,05$) to their median stomach score. Confiscations were not related to stomach scores.

The results suggest that pig stomach health has not improved since 2005. The differences between labels seem to have resulted from different regulations prescribing a minimum particle size of enrichment material in IPS. The reasons for gastric ulcer development, including those on the individual herd within label, still have to be further clarified in order to allow targeted counter-

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Die Ergebnisse zeigen, dass sich die Magengesundheit von Schweinen seit 2005 nicht verbessert hat. Die Unterschiede zwischen den Labels könnten auf unterschiedliche Vorschriften der Mindestpartikelgröße der Verhaltenanreicherungsmaterialien in der IPS zurückzuführen sein. Um prophylaktische Massnahmen zu ermöglichen, sollten in den einzelnen Herden innerhalb der Labels die Gründe für die Entstehung von Magengeschwüren weiter abgeklärt werden. Während des Schlachtprozesses könnte eine Untersuchung einer begrenzten Anzahl Mägen pro Herde die Einrichtung eines Feedback-Systems ermöglichen.

Schlüsselwörter: Magenschleimhaut, Schweinefleisch, Magengesundheit, Tierschutz, Tierhaltung

measures. Given apparent farm-specificity, scoring of a limited number of stomachs per herd during the slaughter process could facilitate the establishment of a feedback scheme.

Keywords: gastric mucosa, pork, stomach health, welfare, husbandry

Introduction

Although meat consumption per person in Switzerland has decreased in the last years, the worldwide consumption is still rising due to the increase of the population.³⁹ One of the reasons for the decreased per head consumption in Switzerland is the increased awareness for animal welfare in production systems.¹³ Consumer decisions based on animal welfare are typically related to labels or to direct acquaintance with local farmers. Two major Swiss labels for the present study are «Integrierte Produktion Schweiz» (IPS) and «Qualitätsmanagement-Schweizerfleisch» (QM). QM ensures that meat originates from Switzerland. Meeting the Animal Welfare Law in Switzerland, QM pigs need to be provided with manipulable enrichment material.⁴⁰ For the IPS label, all QM regulations must be met, and additional

conditions with regard to animal welfare, biodiversity and nutrient cycles must be fulfilled.²¹ Accordingly, IPS fattening pigs must be granted access to an outdoor area and must have an enriched environment, with manipulable material with particles longer than 10 cm, or additional enrichment material such as straw, branches or silage.²²

In Switzerland, several steps in the slaughter process ensure that the slaughtered animals are healthy and their welfare is granted. Prior to slaughter, each animal is externally examined for signs of disease, neglect or bruises by a veterinarian. If a violation of the Animal Welfare Act is suspected, the veterinary office is notified and will investigate the farm in question. If pigs are too sick for the slaughter process, emergency slaughter is ordered. After slaughter, a meat inspection of the carcass is always

Table 1: Summary of different studies that investigate the prevalence of porcine gastric ulcers in the *Pars oesophagea*. Expanded from Canibe et al. (2016).⁷

Reference	Year	Country	Pigs [n]	Lesions [%]			
				Mild	Moderate	Severe	Total
Elbers et al. (1995) ¹²	1995	Netherlands	288	58,5	26,4	14,3	99,2
Guise et al. (1997) ¹⁷	1997	England	1242	9,5		13,4	22,9
Melnichouk (2002) ³⁰	2002	Canada	1021	42,5	36	15,5	94
Robertson et al. (2002) ⁴¹	2002	Australia	15741	50		30	80
van den Berg et al. (2005) ⁴⁶	2005	Switzerland	1897	44	5	10	59
Amory et al. (2006) ²	2006	England	800			19	–
Kopinski & McKenzie (2007) ²⁶	2007	Australia	280	35	30	31	96
Proietti et al. (2010) ³⁸	2010	Italy	400				93
Swaby & Gregory (2012) ⁴⁵	2012	England	9827	49	24	6,4	79,4
Laryea et al. (2016) ²⁸	2016	Ghana	75	18,6		6,6	25,2
Rutherford et al. (2018) ⁴³	2018	Denmark	447	28	43	22	93
Rutherford et al. (2018) ⁴³	2018	Scotland	78	61	14	3	78
Cybulski et al. (2021) ⁸	2021	Poland	329	1,2	15,8	49,5	66,6
Peralvo-Vidal et al. (2021) ³⁶	2021	Denmark	210	27,6	14,5	12	54,1

carried out to determine whether organs such as heart, liver, lungs or other body parts show signs of disease.⁵ If there are any findings relevant for the consumer of the pork, the organ in question is confiscated and disposed of, and in certain cases reductions of the financial revenue of the carcass are made according to the abattoir's regulations. Conditions compromising animal welfare that are not evident in terms of behavioural abnormalities or outward or organ lesions are not detected in this system. In particular, gastric ulcers will go unnoticed.^{3,11,30,48}

The relevance of stomach ulcerations in domestic pigs has been long recognized. According to various literature reports, on average only about 30% of slaughtered pigs have a healthy stomach mucosa (Table 1). Gastric ulcers typically occur in the *Pars oesophagea* of the pig stomach, which is the only region of the stomach not equipped with glands that produce protective mucus.^{11,47,48} Gastric ulcers can be triggered by stressors, such as social confrontation, isolation,¹⁹ or exclusive indoor housing.¹⁰ The prevalence of gastric ulcers is positively correlated to other external signs of stress such as tail biting or bursitis.^{44,46} The potentially best-established cause for stomach ulcers in pigs is feed with a high proportion of finely ground material,^{3,4,16,34,35} including pelleted feed.^{4,16,34,35,41} This is mainly considered an effect of acid reflux from the fundic stomach part, leading to a reduction in pH in the *Pars oesophagea* when more finely ground material is fed.^{6,24,27,29,33,34} This reflux may occur more easily in the more liquid stomach content triggered by finely ground feed; finer feed may also pass through the stomach more quickly, so that no feed residues hinder the reflux of gastric acid.²⁸ To what extent stomach ulcers of varying severity represent not only indicators of poor welfare, but are a welfare issue in themselves, and to which degree they represent a potential compromise of food safety, remains to be evaluated.

The last study assessing the prevalence of gastric ulcers in a Swiss abattoir was performed more than 15 years ago.⁴⁶ The present study aimed to record the prevalence of gastric ulcers today in order to assess whether progress in the prevention can be demonstrated. In addition, the magnitude of the variability in stomach health of pigs across farms and the importance of the conditions prescribed by major Swiss labels were evaluated.

Material and methods

Scoring system

For the evaluation of gastric mucosa changes in pigs, an 11-level scoring system was designed (Table 2; Figure 1), taking inspiration from multiple previously used scoring systems.^{20,43,46} To make this scoring system comparable

to others, the 11 levels themselves were summarized in four classifications: healthy (Score 0), mild changes (Scores 1–3), moderate changes (Scores 4–6) and severe changes (Scores 7–10). Furthermore, to be able to com-

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Figure 1: *Pars oesophagea* examples for the Scores 0 to 10 as explained in Table 2. Scores 0 to 2 are shown once without bile staining (left) and once with bile staining (right).

Table 2: Scores used to rate the mucosa changes in the *Pars oesophagea* region and their descriptions.

Examples are illustrated in Figure 1.

Score	Description
0	Healthy, white or bile stained
1	Signs of parakeratosis, finely granulated, < 1 mm thick or < 25% of the surface area
2	Parakeratosis, 1 – 3 mm thick, < 50% of the surface area
3	Hyperkeratosis, > 3mm thick, < 75% of the surface area
4	Severe hyperkeratosis without erosions, > 75% of the surface area
5	Superficial tissue erosions, < 0,5 cm, less than 5
6	Superficial tissue erosions, > 0,5 cm, more than 5
7	Superficial ulcerations < 0,5 cm, less than 5
8	Deep ulceration < 0,5 cm or superficial ulcerations > 0,5 cm, more than 5, or scar tissue forming a soft circular structure
9	Deep ulceration > 0,5 cm or more superficial ulcerations > 2 cm, or scar tissue forming a stronger circular structure
10	Scar tissue leading to stenosis of the oesophageal opening

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pare the findings specifically with the results previously obtained in a Swiss abattoir by van den Berg et al. (2005) (<vdb>),⁴⁶ the scores were further matched with the scores from that study: vdB0 = Score 0, vdB1 = Scores 1–2, vdB2 = Scores 3–4, vdB3 = Scores 5–6, vdB4 = Scores 7–8 and vdB5 = Scores 9–10.

Sampling

1005 stomachs of fattening pigs from 136 slaughter groups and 87 farms were evaluated on 18 days over a period of four consecutive months in the spring of 2021 at an abattoir in Switzerland. A random sample of about 10 stomachs, originating from one herd, was taken at a time. The time for every 10 stomachs sample was noted. Stomachs were cut open along the greater curvature, it was noted whether they were filled with digesta or empty, and they were gently washed in warm water and photographed. The *Pars oesophagea* of the stomachs was scored according to the 11-level scoring system. Data provided by the abattoir, and linked to the stomachs on the basis of the time of sampling, comprised the affiliation of label and farms, carcass weight, lean meat proportion, and the occurrence of confiscated hearts, livers,

parasitic livers and lungs per slaughter group. Given the logistics of the slaughtering process, it was possible to use the time to link the ten stomachs sampled at a time to a herd, but not to an individual animal. Therefore, scores for a herd were linked to the average carcass weight, lean meat proportion and percentage of confiscated organs per slaughter group for a herd and the day of investigation. It was also not possible in the course of this investigation to obtain information on the duration of transport, the waiting time between arrival and slaughter, or whether tail biting occurred in a herd.

Data analysis

Data was analysed using RStudio version 3.6.3.⁴² The prevalence of the individual scores was validated by using a binomial test with a 95% confidence interval between one specific score and the total sample. Differences among herds were evaluated using a Kruskal Wallis test. Differences among all labels represented, and between the two labels «Integrierte Produktion Schweiz» (IPS; n = 242 stomachs from 18 farms) and «Qualitätsmanagement-Schweizerfleisch» (QM; n = 649, 58 farms) and «others» that could not be connected to a herd and are either IPS or QM (n = 114) were compared using Kruskal Wallis and Dunn's Bonferroni post hoc test. The stomachs that were empty at slaughter were compared to those containing digesta using a Wilcox test. To assess the relationship between body weight, lean meat proportion, percentage of confiscated hearts, livers, parasitic livers and lungs, and stomach scores, linear regressions were performed, and the residuals were tested for normality using a Shapiro Wilk test. Residuals did not follow normality with the percentages of confiscated organs. Thus, nonparametric (Spearman's) correlations were tested. The significance level was set to $p < 0,05$.

Results

Overall there were 39% inconspicuous stomachs, 27% stomachs with mild mucosa changes, 15% stomachs with moderate and 19% with severe changes (Table 3). The distribution of the Scores 0–10 showed a wave-like pattern with peaks at Score 0 and Score 7. Scores with the smallest prevalence were 4 (3,5%) and 10 (2,5%) (Table 3; Figure 2A). The prevalence of inconspicuous stomachs was similar to that reported previously in Switzerland,⁴⁶ but among the affected stomachs of the present study, there were higher percentages of more severe ulcerations (Figure 2B).

Stomach health differed ($p < 0,001$) between herds. In general, the 10 stomachs examined from one herd on a certain day were, with only few exceptions, in a certain score range; i.e., all stomachs from one herd were either

Table 3: Prevalence of stomach ulcers recorded in the present examination classified in the different scoring systems.

Score	Prevalence [%]	lower 95% CI [%]	upper 95% CI [%]
0	38,81	35,78	41,90
1	14,03	11,94	16,33
2	7,06	5,56	8,83
3	6,07	4,67	7,73
4	3,58	2,52	4,92
5	4,88	3,63	6,39
6	6,47	5,03	8,17
7	7,26	5,74	9,05
8	5,47	4,15	7,06
9	3,88	2,77	5,27
10	2,49	1,62	3,65
Lesion severity			
healthy (0)	38,81	35,78	41,90
mild (1–3)	27,16	24,43	30,03
moderate (4–6)	14,93	12,78	17,28
severe (7–10)	19,10	16,72	21,67
Score vdB*			
vdB0	38,81	35,78	41,90
vdB1	21,09	18,61	23,75
vdB2	9,65	7,90	11,65
vdB3	11,34	9,45	13,47
vdB4	12,74	10,74	14,96
vdB5	6,37	4,94	8,06

*Comparable to Van Den Berg et al. (2005)⁴⁶; CI = confidence interval

scored more or less healthy, mildly, moderately or severely affected (Figure 3). The IPS herds showed a general consistency of low stomach scores. Also around 35% of the QM herds were in that category, but there was a large variation among QM herds (Figure 3). For this reason, stomachs from the IPS label had a lower ($p < 0,01$) average score than the QM pigs and that of «others» (Figure 4).

The mean carcass weights of the pigs of the different batches were negatively correlated with their median stomach scores ($r = -0,22, p = 0,037$); i.e., pig groups with healthier stomachs had a higher average slaughter weight. Neither the mean lean meat proportion of the slaughter group or the proportions of confiscated hearts, lungs, livers or parasitic livers showed a correlation to the median stomach score (Table 4). Empty stomachs had higher ($p < 0,001$) ulceration scores (Figure 5).

Discussion

Prevalence of stomach ulcers

The results of the prevalence assessment are in the same order of magnitude as in previous studies. Compared to scorings in other countries, 39% of inconspicuous stomachs is relatively high, as the mean healthy stomachs from the other studies were only around 30%. At 19%, severe lesions were in the same range as found in other countries (mean 15%) but there seem to be more mild and moderate changes (Table 1). Compared to the only data available for Switzerland, a slight increase in more severe lesions appears evident (Figure 2B). However, our limited sample size, and the lack of a representative sampling in other abattoirs located in different Swiss regions, recommends a conservative interpretation of the results. Nevertheless, the data indicate no improvement in pig stomach health over the last 15 years.

As the aetiology of stomach ulcers in pigs is not conclusively known,^{36,48} it is difficult to give specific reasons

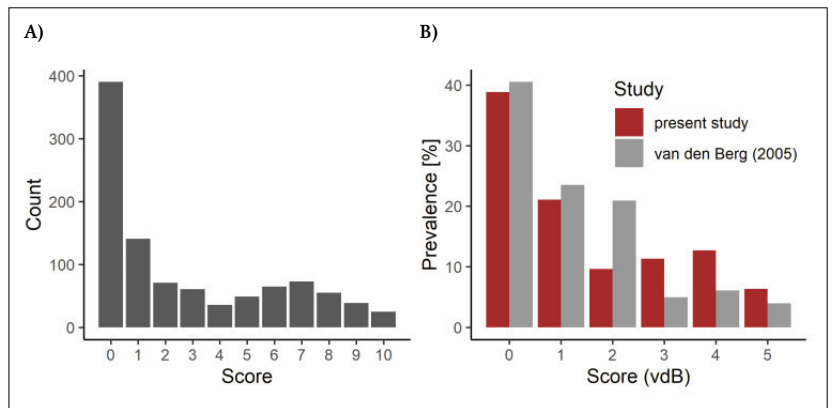


Figure 2: The distribution of the rated stomachs from fattening pigs between Scores 0 and 10 (A), Prevalence of pig stomach ulcers in Switzerland from the present study (red) compared to the prevalence in 2005 (grey) from the study van den Berg et al. (2005).⁴⁶ Scores of the present study were re-categorized for this illustration to match the previous study's score (B).

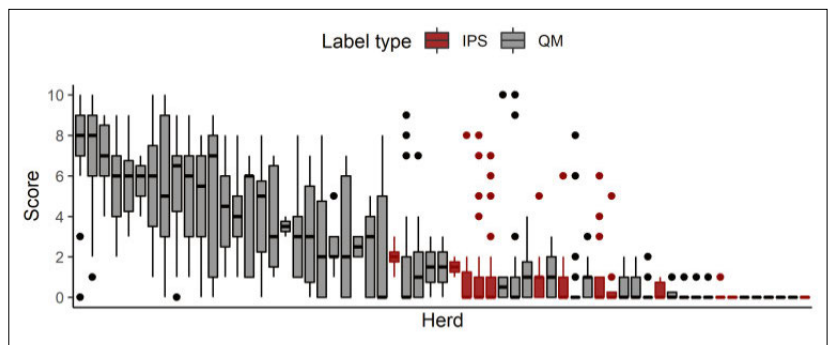


Figure 3: Boxplot: Median, box = 25%–75% quantiles, lining = 95%, dots = outliers. Distribution of scores per herd (n=61). Each boxplot represents one herd. Results that could not be assigned to a specific herd are not displayed. Colours indicate the label type. Median sample size per herd is 10 with first quartile at 5 and third quartile at 19.

Table 4: Correlations of various herd-level slaughter characteristics with the median stomach ulceration score.

	median score	
	r° / ρ^*	p
lean meat content [°]	0,13	0,23
carcass weight [°]	-0,22	0,04
hearts% [*]	0,12	0,25
livers% [*]	0,06	0,56
parasitic livers% [*]	-0,10	0,33
lungs% [*]	0,10	0,34

[°]Pearson's correlation; ^{*}Spearman's correlation; **p<0,05** is considered significant

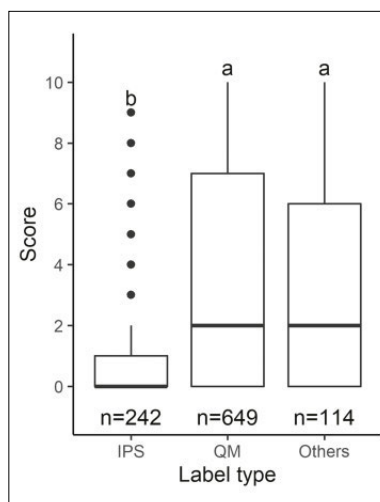


Figure 4: Evaluation of the labels IPS and QM. Others include the stomachs that could not be connected to a farm, they are either IPS or QM. Letters of significance at $p < 0,01$ according to Dunn's Bonferroni post hoc test.

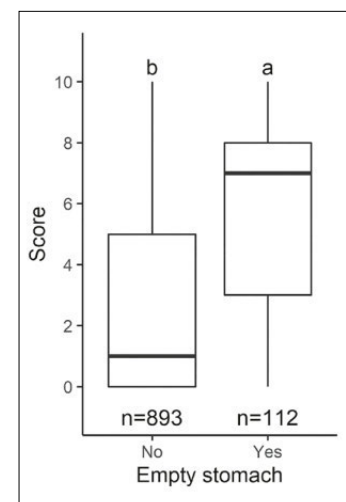


Figure 5: Comparison of the distribution of scores found with pigs having an empty stomach or not. Letters of significance according to Wilcoxon test ($p < 0,001$).

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for this lack of improvement. As an intensive grinding of the components of commercial pig feeds is considered an important contributing factor to pig stomach ulcers,^{3,4,16,34,35} one reason for this could be that particle size in commercial pig feed is generally too small and not ideal. As long as no data on the particle size distribution in historical and present-day pig feeds is available, this remains speculative. In addition to the grinding intensity, the sheer fibre level in pig feed may play an additional role, with higher fibre levels being more protective.³²

The wavelike distribution of the scores in Figure 2A possibly indicates that the state of a Score 4-stomach is unstable or transient; as soon as a stomach reaches this state of hyperkeratinisation, erosions are very likely to happen. This could explain why only few stomachs were detected in this state. A similar wave-like pattern of score prevalence, although not evident in the previous Swiss study,⁴⁶ was detected in two studies in Denmark.^{36,43} While detailed differences between scoring systems and scoring habits may partially explain discrepancies between individual studies, this does not depreciate the value of comparing the prevalence of roughly categorized states (healthy, mild-severe scores) between countries and time points. More detailed studies on the time course of, and influence factors on gastric ulcer development, would be welcome. Current data indicate that while ulcers may already develop in nursery pigs, and in particular in individuals of low birth weight, the prevalence in finisher pigs is higher,³⁶ and in sows, the proportion of particularly severe lesions can be very high.⁸ Thus, conditions during all production stages as well as accumulative effects likely play a role in ulcer development.

Effect of herd and label affiliation

In the present study, as in another recent one,³⁷ the herd had a very strong impact on the stomach condition. The presence of a continuous herd effect was confirmed by the much lower variation in stomach health among pigs slaughtered from the same herd on the same day. A herd effect was expected, since herd management, including feeding and handling as well as other aspects of animal welfare is one of the driving forces of pig stomach health.^{9,48} Since the farmer makes the management choices, it can be hypothesised that farmers who are interested in animal-friendlier farming are also more likely to participate in a corresponding label program – a consistent finding between 2005⁴⁶ and the present study in Switzerland. On the other hand, management practices obligatory under the label IPS, such as the pigs having an enriched environment, with manipulable material with particles longer than 10 cm, or additional enrichment material such as straw, branches or silage,²² most likely also had an effect on the stomach health. It

was previously shown, for example, that silage had a positive effect on stomach health in pigs.²⁰

However, while it is unlikely that participants of a stricter label will not adhere to the required management practices and overall orientation, not all farmers willing to do so will necessarily join such a label. This explains the farms with excellent stomach scores among the QM farms. In these cases, the membership in a less strict label may mean that these farms cannot be easily identified among their putatively less health-aware colleagues.

Relationship of stomach health with carcass weight, stomach content and prevalence of confiscates

The question whether stomach ulcers are linked to management affecting feed intake, feed conversion efficiency, average daily weight gains, and slaughter weight, is not only of economical but also of aetiological interest. The feeding management of pigs is often conceptualized as a dilemma, where particularly finely ground feed is considered to increase digestibility, feed conversion and average daily weight gain,^{1,23,32} but on the other hand triggering stomach ulcers.^{3,4,16,23,34,35,41} Findings that heavier slaughter pigs are affected by the more severe stomach ulcers, as found previously in Switzerland,⁴⁶ support this concept. By contrast, several studies did not find a correlation between weight gain or carcass weight and ulceration,¹⁷ which matches other observations that finely ground diets do not improve daily weight gain.^{3,23,32,34} Yet, other studies even suggest a negative effect of stomach ulcers on carcass weights or average daily weight gains;³ the negative association with carcass weight was also found in the present study. One possible mechanism could be a reduced feed intake in animals with ulcers (at no change in feed conversion efficiency).³ Indeed, a theoretical consequence of severe stomach ulceration is a reluctance to eat³ as well as a proclivity to regurgitate feed,¹⁴ both of which could explain the finding of more severe lesions in empty stomachs (Figure 5).²⁸ The observation that a low birth weight increases the risk of gastric ulcers as compared to animals with a higher birth weight under the same conditions³⁶ indicates that more work is necessary to disentangle the effects that ulcers can have on intake and weight gain, and that factors associated with low birth weight have on ulcer development.

Another explanation is that more finely ground diets, putatively triggering stomach ulcers, also pass from the stomach faster than diets of larger particles.^{9,18} One of the aetiological scenarios for the development of ulcers is that acid from the fundic region of the stomach can move backwards to the *Pars oesophagea* of the stomach more easily in the case of a finely ground diet that caus-

es a rather liquid stomach content, or in the case of an empty stomach. Recent findings that pigs affected with stomach ulcers have a more fluid gastric content and a lower pH support this etiological concept.^{36,37} Clearly, studies are required that weigh the economic costs of producing and feeding finely ground feeds, and the welfare consequences for the animals.

Another question is whether empty stomachs are just another symptom of a less animal-oriented husbandry. For instance, could farmers who do not care as much about their animals' welfare be more likely to fast the animals earlier before slaughter? Fasting as a money saving tactic may make sense: A study that tested the impact of different fasting strategies on carcass attributes found that 24-h feed withholding could decrease the feed expenditure per pig by 2 kg without compromising carcass yield.²⁵ In the context of stomach health, several studies suggest that fasting can favour gastric ulceration.^{15,31,45} Therefore, prolonged fasting immediately prior to slaughter may be a contributing factor to ulcer development. This is confirmed by observations that the prevalence of gastric lesions is higher when pigs stay at the abattoir overnight before slaughter.⁴⁵

A correlation of stomach ulcers with confiscated organs could indicate that the ulcers are just one of many symptoms of careless pig management. With respect to the latter question, the results of the previous⁴⁶ and the present Swiss study show a general absence of a correlation with confiscate prevalence, indicating that factors compromising other indicators of carcass health are due

to different management issues than stomach ulcers. In terms of a potential improvement of the ulceration situation, this finding, however, also indicates that the inspection of other body parts offers no proxy information for stomach health, and that stomachs themselves would have to be investigated routinely if measures are to be based on a feedback loop.

Conclusion

The results indicate that pig stomach health has not improved since 2005 and thus there is still much room for improvement in pig feeding and handling to ensure animal welfare. The label IPS seems to promote boundary conditions for good stomach health. The reasons for gastric ulcer development have to be further clarified in order to allow targeted countermeasures. It might be good practice for abattoirs to randomly test stomachs for lesions and lower carcass values for moderate to severely changed stomach as means to improve pig management. As groups of pigs from the same herd are similar in stomach health, spot sampling of about 10 individuals per herd might be sufficient to achieve this goal.

Acknowledgements

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Évaluation de la prévalence des ulcères gastriques chez les porcs abattus dans un abattoir suisse

Le développement d'ulcères gastriques chez les porcs a des causes diverses. En Suisse, la dernière enquête sur la prévalence des ulcères gastriques et les facteurs de risque possibles a été réalisée en 2005. Nous avons voulu réévaluer la prévalence des ulcères gastriques en 2021.

Un total de 1005 estomacs de porcs d'engraissement provenant de 136 lots et d'environ 87 troupeaux ont été évalués dans un abattoir suisse. La *Pars oesophagea* de l'estomac a été notée de 0=sain à 10=ulcérations et sténoses sévères. Les scores ont été comparés entre les porcs produits sous les labels «Production Intégrée Suisse» (IPS, n=242 estomacs, 18 exploitations) et «Assurance Qualité Viande Suisse» (QM, n=649, 58 exploitations) et les autres (n=114).

La prevalenza delle ulcere gastriche nei maiali macellati in un macello svizzero

Vi sono vari motivi che spiegano lo sviluppo delle ulcere gastriche nei maiali. In Svizzera, nel 2005 è stata effettuata l'ultima indagine sulla prevalenza delle ulcere gastriche e sui possibili fattori di rischio. In questo studio del 2021, abbiamo rivalutato la prevalenza delle ulcere gastriche.

In un macello svizzero, sono stati esaminati 1005 stomaci di maiali da ingrasso provenienti da 136 lotti e circa 87 mandrie. La *Pars oesophagea* dello stomaco è stata valutata da 0 = sana a 10 = grave ulcerazione e stenosi. Le valutazioni degli stomaci dei suini sono state confrontate tra i marchi Integrated Production Switzerland (IPS, n=242 stomaci, 18 aziende), Quality Management Swiss Meat (QM, n=649, 58 aziende) e altre (n=114).

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Les résultats ont montré une prévalence de 27,2% de modifications muqueuses légères (scores 1–3), 14,9% de modifications muqueuses modérées (scores 4–6) et 19,1% de modifications muqueuses sévères (scores 7–10). Seuls 38,8% des estomacs ont été classés 0 et donc considérés comme sains. Par rapport aux résultats de 2005, il n'y a pas de différence entre les scores les plus bas (0–2) et les scores les plus élevés (9–10). Cependant, on constate un glissement des scores moyens (3–4) vers les scores plus élevés (5–8). Les scores d'estomac se sont avérés être spécifiques au troupeau. Il y avait des différences ($p < 0,01$) entre les étiquettes, indiquant que les porcs IPS avaient des estomacs moins affectés. Les estomacs qui étaient vides à l'abattage présentaient des scores plus élevés ($p < 0,001$). Le poids moyen de la carcasse des porcs dans les groupes d'abattage était négativement corrélé ($p < 0,05$) à leur score gastrique médian. Les confiscations n'étaient pas liées aux scores gastriques.

Les résultats suggèrent que la santé de l'estomac des porcs ne s'est pas améliorée depuis 2005. Les différences entre les labels semblent résulter de réglementations différentes prescrivant une taille minimale des particules de matériau d'enrichissement dans les IPS. Les raisons de l'apparition d'ulcères gastriques, y compris celles concernant un lot individuel au sein d'un label, doivent encore être clarifiées afin de permettre des contre-mesures ciblées. Étant donné l'apparente spécificité des exploitations, la notation d'un nombre limité d'estomacs par troupeau au cours du processus d'abattage pourrait faciliter l'établissement d'un système de retour d'information.

Mots clés: muqueuse gastrique, porc, santé de l'estomac, bien-être, élevage

I risultati hanno rilevato una prevalenza del 27,2% di lievi modifiche della mucosa (punteggio 1–3), del 14,9% di moderate modifiche della mucosa (punteggio 4–6) e del 19,1% di gravi modifiche della mucosa (punteggio 7–10). Solo il 38,8% degli stomaci è stato valutato 0 e quindi considerato sano. Rispetto ai risultati del 2005, non c'è differenza tra i punteggi più bassi (0–2) e quelli più alti (9–10). Tuttavia, c'è stata una variazione dai punteggi medi (3–4) ai punteggi più alti (5–8). I punteggi dello stomaco hanno dimostrato di essere specifici alle mandrie. Si sono rilevate differenze tra i marchi ($p < 0,01$) questo segnala che i maiali IPS avevano gli stomaci meno affetti. Gli stomaci che erano vuoti al momento della macellazione hanno mostrato valori più alti ($p < 0,001$). Il peso medio della carcassa era negativamente correlato ($p < 0,05$) al loro punteggio medio dello stomaco. Non si è trovata nessuna correlazione tra i valori dello stomaco e le confische.

I risultati mostrano che la salute dello stomaco dei maiali non è migliorata dal 2005. Le differenze tra i marchi potrebbero essere dovute ai diversi regolamenti della dimensione minima dei materiali di arricchimento comportamentale nell'IPS. Per consentire misure profilattiche mirate, le ragioni dello sviluppo delle ulcere gastriche dovrebbero essere ulteriormente chiarite includendo quelle delle singole mandrie all'interno dei marchi. Visto la chiara specificità, durante il processo di macellazione, il punteggio di un numero limitato di stomaci per mandria potrebbe facilitare la creazione di un sistema di feedback.

Parole chiave: Mucosa gastrica, maiale, salute dello stomaco, benessere degli animali, zootecnia

Literaturnachweis

- ¹ Al-Rabadi GJ, Hosking BJ, Torley PJ, Williams BA, Bryden WL, Nielsen SG, et al.: Regrinding large particles from milled grains improves growth performance of pigs. *Animal Feed Science and Technology* 2017: 233: 53–63.
- ² Amory JR, Mackenzie AM, Pearce GP: Factors in the housing environment of finisher pigs associated with the development of gastric ulcers. *Veterinary Record* 2006: 158: 260–264.
- ³ Ayles HL, Friendship RM, Ball RO: Effect of dietary particle size on gastric ulcers, assessed by endoscopic examination, and relationship between ulcer severity and growth performance of individually fed pigs. *Journal of Swine Health and Production* 1996: 4: 211–216.
- ⁴ Betscher SJ: Untersuchungen zum Einfluss der der Vermahlungsintensität und Konfektionierung des Mischfutters auf morphologische, histologische und immunologische Parameter im Magen-Darm-Trakt von jungen Schweinen. Doctoral Thesis: Tierärztliche Hochschule Hannover, 2010.
- ⁵ BLK: Tierschutz und Fleischkontrolle in Schlachtbetrieben. *Bundeseinheit für die Lebensmittelkette* 2020.
- ⁶ Bornhorst GM, Rutherford SM, Roman MJ, Burri BJ, Moughan PJ, Singh RP: Gastric pH distribution and mixing of soft and rigid food particles in the stomach using a dual-marker technique. *Food Biophysics* 2014: 9: 292–300.
- ⁷ Canibe N, Blaabjerg K, Lauridsen C: *Gastric ulcers in pigs*. DCA – Nationalt Center for Fødevarer og Jordbrug, Aarhus Universitet, Tjele Denmark. 2016.
- ⁸ Cybulski P, Woźniak A, Urban J, Stadejek T: Gastric lesions in culled sows: an underestimated welfare issue in modern swine production. *Agriculture* 2021: 11: 927.
- ⁹ Davies PR: Gastric ulcers in pigs and humans: comparative aspects of etiology and risk factors. *Proceedings of the Allen D Leman Swine Conference, Minnesota University* 1993: 129–135.
- ¹⁰ Davies ZE, Guise HJ, Penny RHC, Sibly RM: Effects of stone chewing by outdoor sows on their teeth and stomachs. *Veterinary Record* 2001: 149: 9–11.
- ¹¹ Doster AR: Porcine gastric ulcer. *Veterinary Clinics of North America: Food Animal Practice* 2000: 16: 163–174.
- ¹² Elbers AR, Vos JH, Dirkwager A: A survey of the relationship between bile staining and oesophagogastric lesions in slaughter pigs. *Veterinary Quarterly* 1995: 17: 106–107.
- ¹³ European Commission: *Attitudes of Europeans towards animal welfare. Special Eurobarometer 442*. TNS Opinion and Social, Brussels, BE. 2016.
- ¹⁴ Friendship RM: Gastric ulceration in swine. *Journal of Swine Health and Production* 2004: 12: 34–35.
- ¹⁵ Friendship RM, Melnichouk SI, Dewey CE: The use of omeprazole to alleviate stomach ulcers in swine during periods of feed withdrawal. *Canadian Veterinary Journal* 2000: 41: 925–928.
- ¹⁶ Grosse Liesner V, Taube V, Leonhard-Marek S, Beineke A, Kamphues J: Integrity of gastric mucosa in reared piglets – effects of physical form of diets (meal/pellets), pre-processing grinding (coarse/fine) and addition of lignocellulose (0/2,5%). *Journal of Animal Physiology and Animal Nutrition* 2009: 93: 373–380.
- ¹⁷ Guise HJ, Carlyle WWH, Penny RHC, Abbott TA, Riches HL, Hunter EJ: Gastric ulcers in finishing pigs: Their prevalence and failure to influence growth rate. *Veterinary Record* 1997: 141: 563–566.
- ¹⁸ Guise HJ, Penny RHC, Baynes PJ, Abbott TA, Hunter EJ, Johnston AM: Abattoir observations of the weights of stomachs and their contents in pigs slaughtered at known times after their last feed. *British Veterinary Journal* 1995: 151: 659–670.
- ¹⁹ Holinger M, Früh B, Stoll P, Graage R, Wirth S, Bruckmaier R, et al.: Chronic intermittent stress exposure and access to grass silage interact differently in their effect on behaviour, gastric health and stress physiology of entire or castrated male growing-finishing pigs. *Physiology and Behavior* 2018: 195: 58–68.
- ²⁰ Holinger M, Früh B, Stoll P, Kreuzer M, Hillmann E: Grass silage for growing-finishing pigs in addition to straw bedding: Effects on behaviour and gastric health. *Livestock Science* 2018: 218: 50–57.
- ²¹ IP-Suisse: *Richtlinien Gesamtbetrieb. Grundanforderungen für sämtliche IP-SUISSE Labelprogramme*. IP-Suisse, Zollikofen CH. 2020.
- ²² IP-Suisse: *Richtlinien Tierhaltung. Grundanforderungen für sämtliche IP-SUISSE Labelprogramme*. IP-Suisse, Zollikofen CH. 2020.
- ²³ Jong JAD, DeRouchey JM, Tokach MD, Dritz SS, Goodband RD, Woodworth JC, et al.: Evaluating pellet and meal feeding regimens on finishing pig performance, stomach morphology, and carcass characteristics. *Journal of Animal Science* 2016: 94: 4781–4788.
- ²⁴ Kamphues J: *Untersuchungen zu Verdauungsvorgängen bei Absetzferkeln in Abhängigkeit von Futtermenge und -zubereitung sowie von Futterzusätzen*. Tierärztliche Hochschule Hannover, Hannover DE. 1987.
- ²⁵ Kephart KB, Mills EW: Effect of withholding feed from swine before slaughter on carcass and viscera weights and meat quality. *Journal of Animal Science* 2005: 83: 715–721.
- ²⁶ Kopinski JS, McKenzie RA: Oesophagogastric ulceration in pigs: A visual morphological scoring guide. *Australian Veterinary Journal* 2007: 85: 356–361.
- ²⁷ Lang J, Blikslager A, Regina D, Eisemann J, Argenzio R: Synergistic effect of hydrochloric acid and bile acids on the pars esophageal mucosa of the porcine stomach. *American Journal of Veterinary Research* 1998: 59: 1170–1176.
- ²⁸ Laryea MA, Emikpe BO, Attoh-Kotoku V, Omotosho OO, Asare DA, Asenso NT, et al.: The occurrence of gastric lesions in slaughtered pigs at the Kumasi abattoir, Ghana. *Bangladesh Journal of Veterinary Medicine* 2016: 14: 85–91.
- ²⁹ Maxwell CV, Reimann EM, Hoekstra WG, Kowalczyk T, Benevenga NJ, Grummer RH: Effect of dietary particle size on lesion development and on the contents of various regions of the swine stomach. *Journal of Animal Science* 1970: 30: 911–922.
- ³⁰ Melnichouk SI: Mortality associated with gastric ulceration in swine. *Canadian Veterinary Journal* 2002: 43: 223–225.

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- ³¹ Melnichouk SI, Friendship RM, Dewey CE, Bildfell RJ: Evaluation of lansoprazole (An H⁺/K⁺-ATPase inhibitor) and azithromycin (an antibiotic) for control of gastric ulceration in swine during periods of feed deprivation. *Canadian Journal of Veterinary Research* 1999; 63: 248–252.
- ³² Millet S, Kumar S, De Boever J, Meyns T, Aluwé M, De Brabander D, et al.: Effect of particle size distribution and dietary crude fibre content on growth performance and gastric mucosa integrity of growing-finishing pigs. *The Veterinary Journal* 2012; 192: 316–321.
- ³³ Mösseler A, Köttendorf S, Grosse Liesner V, Kamphues J: Impact of diets' physical form (particle size; meal/pelleted) on the stomach content (dry matter content, pH, chloride concentration) of pigs. *Livestock Science* 2010; 134: 146–148.
- ³⁴ Mösseler A, Wintermann MF, Beyerbach M, Kamphues J: Effects of grinding intensity and pelleting of the diet – fed either dry or liquid – on intragastric milieu, gastric lesions and performance of swine. *Animal Feed Science and Technology* 2014; 194: 113–120.
- ³⁵ Nielsen EK, Ingvarsten KL: Effect of cereal type, disintegration method and pelleting on stomach content, weight and ulcers and performance in growing pigs. *Livestock Production Science* 2000; 66: 271–282.
- ³⁶ Peralvo-Vidal JM, Weber NR, Nielsen JP, Bache JK, Haugegaard S, Pedersen AØ: Risk factors for gastric ulceration in nursery pigs. *Preventive Veterinary Medicine* 2021; 189: 105298.
- ³⁷ Peralvo-Vidal JM, Weber NR, Nielsen JP, Denwood M, Haugegaard S, Pedersen AØ: Association between gastric content fluidity and pars oesophageal ulcers in nursery pigs: a cross-sectional study of high-risk Danish herds using commercial feed. *Porcine Health Management* 2021; 7: 1–7.
- ³⁸ Proietti PC, Bietta A, Brachelente C, Lepri E, Davidson I, Franciosini MP: Detection of *Helicobacter* spp. in gastric, fecal and saliva samples from swine affected by gastric ulceration. *Journal of Veterinary Science* 2010; 11: 221–225.
- ³⁹ Proviande: *Der Fleischmarkt im Überblick*. Proviande Genossenschaft, Bern CH. 2020.
- ⁴⁰ QM Schweizer Fleisch: *Produktionsrichtlinie und Allgemeine Geschäftsbedingungen*. QM-Schweizer Fleisch, Brugg CH. 2021.
- ⁴¹ Robertson ID, Accioly JM, Moore KM, Driesen SJ, Pethick DW, Hampson DJ: Risk factors for gastric ulcers in Australian pigs at slaughter. *Preventive Veterinary Medicine* 2002; 53: 293–303.
- ⁴² RStudioTeam: RStudio: Integrated development environment for R. 3.6.3 ed. RStudio, Inc.; Boston, MA; 2019.
- ⁴³ Rutherford KMD, Thompson CS, Thomson JR, Lawrence AB, Nielsen EO, Busch ME, et al.: A study of associations between gastric ulcers and the behaviour of finisher pigs. *Livestock Science* 2018; 212: 45–51.
- ⁴⁴ Schumacher S: Retrospektive Feldstudie bei Schlachtschweinen zu den Risikofaktoren der Caudo-phagie. Doctoral Thesis: Freie Universität Berlin, 2019.
- ⁴⁵ Swaby H, Gregory NG: A note on the frequency of gastric ulcers detected during post-mortem examination at a pig abattoir. *Meat Science* 2012; 90: 269–271.
- ⁴⁶ van den Berg A, Brülisauer F, Regula G: Prävalenz von Veränderungen der kutanen Magenschleimhaut bei Schlachtschweinen in der Schweiz. *Schweizer Archiv für Tierheilkunde* 2005; 147: 297–303.
- ⁴⁷ Van Ginneken C: Gastrointestinal tract. In: McNulty PA, Dayan AD, Ganderup N-C, Hastings KL (eds.), *The minipig in biomedical research*. CRC Press, London, 2011: 211–236.
- ⁴⁸ Wolf P, Kamphues J: Magenulcera bei Schweinen – Ursachen und Massnahmen zur Vermeidung. *Übersichten zur Tierernährung* 2007; 35: 161–190.

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