PORK QUALITY IN CENTRAL EUROPE

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Abstract: The article aims to assess meat quality in Central Europe between 2005 and 2022. Using descriptive statistics, correlation and a student's paired t-test, we found a substantial quantity decline but a tremendous quality increase in the monitored categories. Meat quality mostly suffered at the beginning of the period, witnessing an enormous improvement later on. Our article confines to annual pork value, lacking an analysis of weekly statements and SEU quality of the SEUROP classification.

Keywords: quality, pork, live weight, correlation, t test.

1 Introduction

The meat industry is essential for agricultural and food production, supplementing incomes in less-developed regional economies (Benus, 2019). The sector also relates to the food and beverage industry, the most significant energy consumer and return on sales maker in the European Union (Iten et al., 2021).

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People know about potential hazards related to meat manufacturing as they consume the commodity daily (Bateman et al., 2019). Clare et al. (2022) suggest reducing the risks from processing red meat to recover human and planetary health and appease eco-active politicians. Humane slaughtering involves stunning that lasts until death, reducing the pain and fear throughout procedures (Coelho et al., 2022). Slaughtering and processing of poultry may occur in a slaughterhouse or farm in three phases (Saxmose et al., 2019). Increased chicken meat consumption raises production volumes (Copley and Wiedemann, 2023). Piewthongngam et al. (2019) argue that pork meat processing resembles disassembly planning, as a planner must decide on the pig size and the amount for a slaughterhouse and meat quantity and size needed to meet orders. The slaughtering procedure and change to dead meat are essential because its taste depends on the animal's treatment during the slaughter (Hultgren et al., 2020; Davydova & Davydov, 2021). A short distance to the abattoir will relieve stress from transportation (Hultgren et al., 2020).

People consume pork, rich in proteins, fat and other natural substances, almost daily (Tinh et al., 2020), (Milczarek et al., 2019). The demand for pork meat relies heavily on extensive swine breeding (Kovacikova et al., 2022).

In some countries, enterprises may suffer tremendous economic losses, as slaughtering animals relates to religious ceremonies and rituals (Mroczek, 2021). A slaughter may also involve a charitable act to produce leather clothes (Strawn, 2022). The church, bar trade union coalitions and non-government organizations have long been trying to mobilize national media and politicians to impose regulations on the meat industry (Ban et al., 2022).

The article aims to assess the quality development of pork meat in Central Europe between 2005 and 2022.

The meat quality of carcasses determines the price and assesses the effectiveness of adopted procedures. Muscle mass percentage of total slaughter weight per piece is an essential factor for the assessment. The per cent limits observe the objective criteria of the European Commission (SEUROP). We formulated the following research questions:

RQ1: How does meat quality change according to the criteria over the monitored period?

Materials, including pork meat, face enormous pressure and requirements for continuous quality increase.

RQ2: Can we notice accelerating trends in the meat quality of carcasses over the monitored period?

Although meat production must maintain quality, separate pieces may lose substantial waste body parts useful for further processing.

RQ3: Does the quantity of slaughtered animals indicate a bigger difference between live weight and carcasses?

2 Literary research

Conventional methods of calculating value changes involve descriptive statistics. Subanji et al. (2021) assess vast differences in creative statistical models of students based on sex, revealing that descriptive statistical activities show no sharp divergencies. Descriptive statistics is the first step for data analysis. Scholars do statistical inference tests after descriptive statistics to have a reliable dataset (Mondal et al., 2022). Mirsha et al. (2019) argue that descriptive statistics is integral for a professional study, characterizing research data and specifying the dataset. Descriptive statistics also include a median minimizing the sum of distances between all elements in the sample (Panov & Savvateev, 2020).

A rough estimate of the least squares is essential for working with inaccurate data and effectively solving linear regression (Shi et al., 2022). These models are sensitive to distant values (Kundu et al., 2023), relying heavily on mixed methods of the least squares to estimate linear parameters (Zheng and Yang, 2019). This estimate can be inaccurate unless including variables outside the model (Gatto and Marcuzzi, 2020). Random sampling is the simplest way of data acquisition where there are problems with the least squares (Guo et al., 2020). Xie et al. (2022) argue that the partial least squares regression is applicable even if the variables far exceed the samples. The simulations of two existing datasets show that the technique is efficient and robust. Okwuashi et al. (2020) compare the partial least squares regression with the conventional model, revealing that the former makes the cut.

We commonly use the Pearson correlation to quantify the dependence between the time series pairs. If dependent and time-autocorrelated, we reduce them. Afyouni et al. (2019) suggest a practical method involving a different autocorrelation and immediate and delayed correlation in each time series. Jaganathan and Hassibi (2019) deal with reconstructing two signals from autocorrelated measurements. Kiran et al. (2019) point to different meat quality and indicate essential proteins relative to the meat structure and pre-slaughter stress of sheep slaughtered with or without electronarcosis. Based on these methods, Sun et al. (2023) examine favorable conditions for extracting the rotation mode and speed. We used time series to explore whether the exposition time makes the analyses more accurate.

We use multiple methods to examine the datasets and identify possible repeated cycles. Leng and Zhu (2020) argue that regression is often applicable for measuring a linear relationship between two inaccurate variables, reliably assessing the influence of one or more independent variables on the outcome. The drawbacks are inaccuracies when using a small dataset (Chukhrova and Johannssen, 2019) or datasets with remote values (Panagopoulos et al., 2019). Various graphs suggest

regression outcomes (Ovedele, 2021). Xu and Huang (2020) suggest maximal correlation regression, a new approach to regression analysis. We commonly combine various analyses and methods to achieve hybrid and upgraded outputs, e.g. a t-test and ANOVA, widely used in experimental studies (Liu and Wang, 2021). Mishra et al. (2019) apply the analysis of variance and covariance for testing, although they use a t-test to compare two means. Sarkar et al. (2021) employ the Student's t-test for testing normally distributed means with an unknown population correlation and variances. The one-way ANOVA explores the influence of a factor on the variable (Traneva et al., 2022). The results of the ANOVA are valid upon meeting all requirements for the model (Pineda Becerril et al., 2019). Alassaf and Qamar (2022) explore the one-way ANOVA for selecting features to reduce the number of elements when classifying tweeted opinions. Xavier de Carvalho et al. (2023) examine and assess a preliminary analysis of variance when interpreting experimental data. Although the t-test is the most used statistical test in all scientific publications (Cahusac and Mansour, 2022), it may sometimes be misleading (Novak, 2022).

Qualitative content analysis is applicable in small and simple experiments (Vears and Gillam, 2022). Boettger and Friess (2020) use a quantitative content analysis on 672 journal articles, coding them according to the required variables. Bouko et al. (2021) use content analysis to measure citizens' reactions to Brexit, analyzing the strength and polarity of the opinions. The textual analysis based on coding schemes is suitable for processing secondary data (Myers et al., 2019).

We use the content analysis of data and documents for the secondary data collection, which gives us answers to all research questions. The first RQ relies on descriptive statistics, the second involves correlation, and the third depends on the student's paired t-test for data processing.

3 Data and methods

Our research questions, except for the first, require hypotheses. Their p-value is set to 0.05 and are as follows:

RQ2: Can we notice accelerating trends in the meat quality of carcasses over the monitored period?
H0a: The carcass does not see a quality increase over the monitored period.
RQ3: Does the quantity of slaughtered animals indicate a bigger difference between live weight and carcass?
H0b: The increased quantity of slaughtered animals with the difference between live weight and carcass.
H0c: The difference between the pork live weight and carcass is increasingly bigger.

3.1 Data

The datasets and information on percentage meat quality, average cut yield, quantity of slaughtered pigs, quality categories and average live weight and carcass are available on the internet portal of the State Agricultural Intervention Fund in the News section and 'Tržní informační systém' in 'tržní zprávy' (szif.cz, 2023 – Czech version). We will select the bulletin called 'Beef and pork'. The webpage contains the year for which we want to display PDF files with relevant data in the upper right corner. The bulletins come out biweekly and fall into quarters. The information in the files observes weekly reports, including two periods in each biweekly. The research questions reflect a total annual overview of values issued as biweekly expansions at the beginning of the following year.

We respect only the categories with the highest representation, the SEU group, regarding the overall quality ratio of the SEUROP classification. All hypotheses will mimic the classes. The remaining groups indicate an average amount only of 3.5%, containing detailed and confidential information. The suggested prices do not include GNP or shipping costs.

We will transfer the collected data to MS Excel 2019 for further processing. All monitored periods involve columns with corresponding values for a formal and logical preparation for a follow-up manipulation and application. This data collection method will apply to all research questions and related hypotheses.

3.2 Methods

Descriptive analysis will answer the first research question, focusing on average, sum, min and max ratios. The method will summarize all values from all quality categories in the SUMA Excel, comparing results from each class for each year. The findings will show which quality categories were mass-produced in which period, compiling the outcomes into a graph.

The correlation will respond to the second question, using the Pearson correlation coefficient to determine the linear relationship between quality and production. The coefficient's symbol is r in the interval between -1 and 1. If r equals zero, there is no connection between the variables. Its closeness to 1 shows a positive linear correlation, indicating a growth of both quantities. The proximity to -1 implies a negative linear relationship, displaying a reverse effect.

The coefficient is calculated as follows:

$$r=(\sum(x-\bar{x})(y-\bar{y}))/\sqrt{(\sum(x-x^{-})^{2}\sum(y-\bar{y})^{2})}$$

Where:
r is a resultant correlation coefficient,
x is the first variable,
y is the second variable,
$\bar{x}$ *a* $\bar{y}$ are averages of the observed values

The resultant coefficient is not always accurate, so we must precisely specify the limits of the resulting values as follows:

Table 1 The definition of the correlation

	from	to
Very weak correlation	0.01; -0.01	0.20; -0.20
Weak correlation	0.20; -0.20	0.40; -0.40
Average correlation	0.40; -0.40	0.60; -0.60
Strong correlation	0.60; -0.60	0.80; -0.80
Very strong correlation	0.80; -0.80	0.99; -0.99

Source: Author.

The student's two-sample paired t-test will answer the third research question, using MS Excel for the data analysis. We will choose the Paired Two-Sample t-Test for Means and select both datasets with source data necessary for the calculation. We will input Alfa: 0.05 into the table and choose an output area. Then, we only click on 'confirm'.

The second possibility directly involves the t-test, including required cells with Matrix 1 and 2 in the first two and the tail (1) in the third place. The last, fourth place, picks the 1-paired test. Upon confirming, the test will generate a value informing whether the difference between the observed pairs is statistically significant.

We assume an increase in the overall average pork quality over the monitored period, arguing that the number of slaughtered pigs does not affect the difference between the live weight and carcass.

4 Results

Now, we will verify and answer the research questions and related hypotheses. The summarized annual values, foundational quality indicators and selected S, E and U categories indicate substantial percentage and value changes. The following table suggests a detailed overview of the most significant alterations over the monitored period.

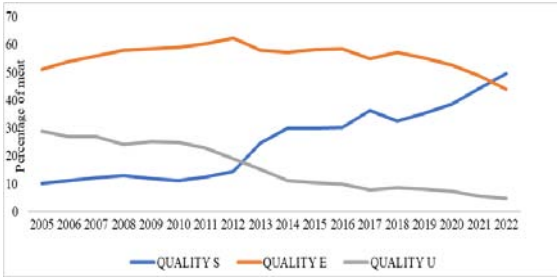
Table 2 Changes in quality

	MINIMUM		MAXIMUM		AVERAGE
S Category	10	2005	49.6	2022	24.82
E Category	44	2022	62.4	2012	55.74
U Category	4,7	2022	29	2005	15.95

Source: Author, based on www.szif.cz.

The average cut yields show increasing quality standards in the categories over the years, indicating the highest value of 55.74 in the E Quality, which is more than half of the production. The mean values peaked in 2012. The S Class topped U Quality between 2012 and 2013, showing a steady trend. S eclipsed E Class between 2021 and 2022, displaying the lowest quality of cut yields in all categories in 2005. The second research question also provides a graphical depiction of our findings.

Graph 1 Individual quality categories over the monitored period



Source: Author based on www.szif.cz

Although the numbers of slaughtered animals show a declining trend over the period, pork quality increases, which is visible in all categories. The correlation coefficient between average cut yields according to the SEU and the total carcasses indicates negative values of -0.8921873, implying a strong negative linear correlation. We can then reject the H0a and accept the alternative, confirming a carcass quality improvement over the monitored period.

The average annual data suggest a 25-kg difference between the live weight and carcass until 2015. The weight increases from 2016 to 2020, topping 28 kg, indicating values higher by 3 kg. We confirm these facts by the student's paired t-test with a result of 1.06332E-13, rejecting H0b.

The average cut yield of slaughtered animals grows from 56.24% to 59.75% over the monitored period. The student's t-test suggests a difference of 2.23302E-28 between the yields of live weight and carcass, indicating no statistically significant discrepancy between the carcass percentage and the mass of slaughtered pigs over the period. We may reject H0c, suggesting a growing disparity between the live weight and carcasses.

5 Discussion

Based on the results, we can answer the research questions.

RQ1: How does meat quality change according to the criteria over the monitored period?

Our findings suggest a substantial quality increase according to the criteria over the period, indicating the lowest quality in the U category in the early years. The last observed year, 2022, witnessed the finest pork quality. The quality of the S and the U categories overlaps between 2012 and 2013, stretching out to E class between 2021 and 2022. Subanji et al. (2021) used descriptive statistics to focus on differences between students according to sex, revealing no statistically significant dissimilarities. Our study proves, on the contrary, considerable disparities in the values over the monitored period.

RQ2: Can we notice accelerating trends in the meat quality of carcasses over the monitored period?

The findings from the previous chapter confirm the alternative hypothesis of a quality increase over the period, despite the diminishing numbers of slaughtered animals. Given the contrast between the quality improvement and lessening quantities, the correlation is -0.892187, indicating a negative relationship between the observed variables. Kiran et al. (2019) employed the same method for testing the proportion of essential proteins in different meat quality structures.

RQ3: Does the quantity of slaughtered animals indicate a bigger difference between live weight and carcass?

The number of slaughtered animals decreased over the monitored period, indicating a 25-kg difference between the live weight and carcass until 2015. The following years saw a weight difference grow by three kilograms. The student's t-test equaled 1.06332E-13, rejecting the second zero hypothesis. The third hypothesis concerns increasing dissimilarities in the cut yield. The student's t-test for the conjecture was 2.23302E-28, suggesting no statistically significant variance between the cut yield percentage and weight variations (live weight and carcass) of slaughtered pigs. Based on these findings, we dismiss the third assumption. Cahusace and Mansour (2022) used the t-test in their experiments.

6 Conclusion

Meat involves essential nutrients, requiring high-quality production. We have recently paid increased attention to quality criteria, imposing safety measures on food processing. The article aimed to assess pork quality in Central Europe between 2005 and 2022. Based on annual reports from a publicly available database, we found dwindling pork production quantities but a tremendous quality improvement in the tested categories over the monitored period. We used descriptive statistics, the Pearson correlation coefficient and the student's paired t-test to answer the research questions and confirm or reject related hypotheses. Our findings proved alternative assumptions, dismissing the formulated theories. The study revealed gradual beneficial qualitative changes in pork carcasses, leaving the difference between the live weight and carcass intact. Our analysis illustrates and evaluates the full development of pork quality in the Czech Republic, indicating an enormous year-to-year quality increase over the period. The article may also be seminal to people involved in the meat industry or ordinary consumers interested in the ingredients. The study lacks a longer monitored period, confinement to the Czech Republic and annual values and includes only pork in SEU categories. Further research may focus on assessing beef or chicken, conducting in-depth analyses of weekly reports in another country and for a longer time. Follow-up surveys may also involve beef and pork export/import ratios over a period or exploring changes in the production and consumption of various meat types.

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