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Original scientific paper

Is food oral processing a new meat quality dimension?

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ABSTRACT

This study gives an overview of food oral processing of meat. Literature review in the last two decades shows three perspectives of research. First, the perspective known as 'ex ante' studies serves to analyse mechanical and textural properties of meat and enable correlation between these instrumental testing and food oral processing parameters. The second is clearly associated with the mastication process revealing the following parameters: number of chews, mastication duration, chewing and eating rates, saliva incorporation, food breakdown, particle number and size throughout the mastication process. The third 'ex post' perspective is associated with the post-swallowing period, focused on digestibility, satiety and energy intake.

The main conclusion of this study is that food oral processing studies pave the way for understating mastication of meat and widen meat science research perspectives in terms of modelling mastication (from the first bite to swallowing) and simulating meat breakage and flavour release.

1. Introduction

Food oral processing is a novel scientific approach that analyses changes that are associated with food from the first bite until swallowing, covering food breakdown, saliva incorporation and in-mouth sensations (*Chen*, 2014). This discipline generates a variety of different indicators such as number of chews needed for mastication, bite size and eating rate (Koç et al., 2014), saliva incorporation (*de Lavergne et al.*, 2015), and particle number and size distribution at pre-defined mastication time (*Rizo et al.*, 2019). A Kano model study on the importance of oral processing indicators has revealed that food breakdown in the mouth, eating rate and bite size are very important quality dimensions (*Djekic et al.*, 2020). The importance of mastication was studied in the perspective of efforts required to masticate a bite of food (*Ilic et al.*, 2021), where authors developed an 'ease of mastication index' that may be considered as a new food characteristic, similar to the total quality index as depicted in works of *Djekic et al.* (2017) and *Režek Jambrak et al.* (2018). The importance of mastication is even pronounced in some types of food, such as meat, where different mastication patterns were identified between humans of good health, the elderly population, people with dysphagia and denture wearers (*Mioche et al.*, 2002).

Wider perspectives of food oral processing have supported sensory analysis through promotion of "temporal dominance of sensations" as a tool that enables researchers to distinguish sensation that dominates throughout the mastication process (*Rizo et al.*, 2019). In parallel, scholars have analysed food intake and acceptance (*Aguayo-Mendoza et al.*, 2019) and the role of food in satiation and satiety (*Campbell et al.*, 2017).

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The objective of this paper is to give an overview of food oral processing studies performed with meat and to identify potential breakthroughs in future studies.

2. Materials and methods

In order to perform a literature review associating food oral processing and meat, a text mining concept was applied by using VOSViewer tool for the bibliometric analysis. This enables users to understand what are the main research flows among scholars. The input data were captured from academic papers indexed in the Web of Science, with the use of the two keywords: "meat" and "food oral processing". The research revealed 140 articles/review papers that were published in the period 2005 to date. The 'cut-off criteria' was to include keywords mentioned more than five times.

3. Results

Figure 1 shows the created network visualization of titles, abstracts and keywords of the most relevant manuscripts that were published in the last 20 years, covering the selected two keywords. As can be observed, four clusters (depicted in different colours) were revealed.

The green cluster is associated with food oral processing indicators covering the mastication process (bite size, consumption time and sensory sensations). The yellow cluster covers bolus and its characteristics, saliva incorporation and textural properties, while the blue cluster is more focused on digestibility and bolus features after swallowing. Finally, the red cluster is mostly linked with meat intake and potential risks associated with it.

4. Discussion

Djekic et al. (2022) have identified three main evaluation phases in meat oral processing: (i) *ex ante*, consisting of testing physical and mechanical properties of meat prior to mastication, (ii) ongoing, comprising of analysing mastication and food oral processing parameters, and (iii) *ex post,* focused on swallowing, digestibility, satiety and energy intake. As observed in Figure 1, this was mainly confirmed in our current study. In order to understand the complexity of meat oral processing, it is important to understand meat and its physical characteristics. Meat is considered as a postmortem skeletal muscle tissue (*Matarneh et al.*, 2017). After slaughtering, it undergoes various changes, mainly physiological and biochemical (*Bekhit et al.*, 2014). However, its complexity is highly dependent on the species, age, meat part from the carcass and meat cut (*Purslow*, 2005). From basic material science, depending on load, different materials behave differently — as isotropic, orthotropic or anisotropic (*Berthaume,* 2016). Although meat inclines towards being anisotropic, in many studies it has been considered as orthotropic, such as in modelling the first bite of meat (*Djekic et al.*, 2022; *Djekic et al.*, 2021).

In order to understand the oral processing parameters associated with meat, it is necessary to look at its main quality characteristics such as sensory attributes or meat texture from a different perspective. These intrinsic quality cues have been revealed by (*Rajic et al.*, 2022) in their literature review of pork and beef meat. When a sufficient number of panellists is used in food oral processing studies, clear correlations between instrumental texture and some mastication parameters and even saliva incorporation may be revealed (*Ilić et al.*, 2022).

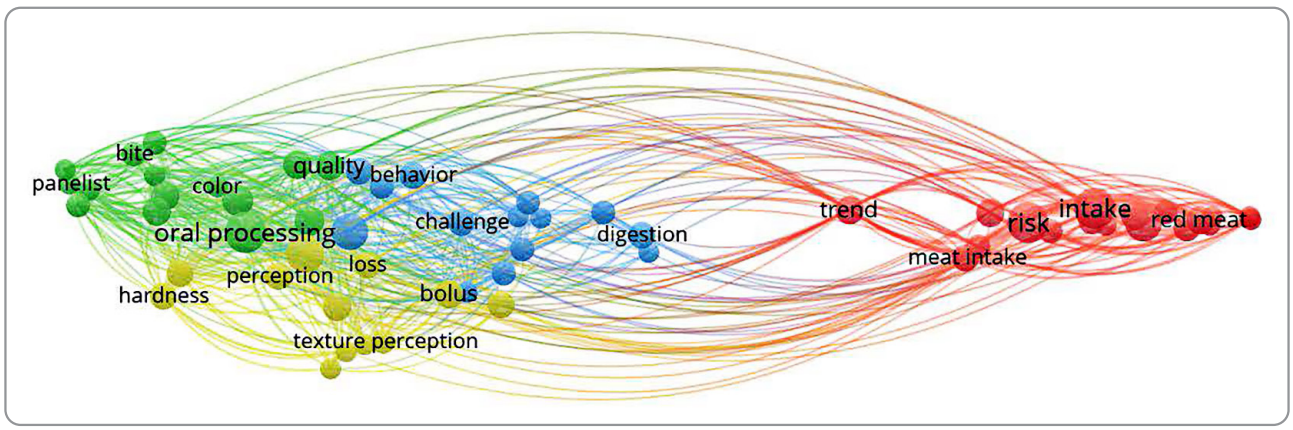

Figure 1. Network visualization of inter-linkage between meat and food oral processing

In addition to abovementioned meat characteristics, culinary methods also play a great role in oral processing characteristics of meat. In the study of pork ham prepared with three culinary methods, number of chews associated with cooked ham was statistically higher contrasted to *sous-vide* or grilled meat (*Djekic et al.*, 2021). Also, the same study revealed the higher number of chews, the more saliva is incorporated. The influence of different culinary techniques affecting food oral processing and dynamic sensory perception of wild boar ham has been studied by *Ilic et al.* (2022). Results revealed that *sous-vide* and grilled meat demanded less effort for mastication and absorbed less saliva, opposed to boiling. An interesting study on food oral processing of meat was performed by *Djekic et al.* (2021), associating grilled meat coated with hot sauces to achieve pungency sensations. There was a slight trend of an increased number of chews and a longer duration of consumption time correlated with pungency intensity. The study showed that after 10 chews, saliva decreases in relation to the pungency intensity while after 25 chews and before swallowing, this trend changes. The role of saliva is that it enables cohesiveness between particles and lubricates the bolus, so aiding swallowing (*Prinz & Lucas*, 1997; *Rizo et al.,* 2019). Also, low eating rates are in correlation with high chew number and long mastication duration (*Aguayo-Mendoza et al.*, 2019). To avoid large discrepancies in-between mastication patterns of human subjects, it is necessary to define characteristics of oral processing panels, similar to strict rules that apply for sensory panels (*Djekic et al.*, 2021).

Particle number and size distribution during mastication (after a pre-defined number of strokes) and just before swallowing depends on mechanical properties of meat and its water content (*Rizo et al.*, 2019). At the middle of mastication process, below 20% of the bolus consists of big particles while at the end of mastication smaller pieces prevail, whereby grilled ham prevailed in number of small particles compared to *sous-vide* (*Djekic et al.*, 2021). Regardless of the type of culinary method applied to meat, the number of large particles decreases while the number of small particles increases during mastication (*Djekic et al.*, 2021).

A new dimension associated with food oral processing is to analyse emotions during mastication. When studying pungency sensations associated with grilled meat, results revealed a clear correlation between increase in non-neutral emotions (angry, happy, sad and surprise) and the increase in pungency intensity (*Djekic et al.*, 2021). Meat samples marinated with pungent spices are being promoted lately in line with their antimicrobial effects (*Vasilijević et al.*, 2019).

Finally, oral processing studies on meat have paved a way for the development of different meat analogues, as some preliminary studies on boluses, particle size distribution and the number of chews before swallowing of plant-based and beef burgers still show a great discrepancy (*Ilić et al.*, 2022).

5. Conclusion

The two main conclusions of the study are that application of food oral processing can help in better understanding mastication of meat and that it brings new research perspectives. Future research should focus on modelling meat mastication (from the first bite to swallowing) to enable simulation of meat breakage and flavour release.

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