IMPACT OF MASTICATION ON THE GASTRIC DIGESTION OF FRANKFURTERS : CASE OF ELDERLY

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Abstract – This work was designed to evaluate the impact of deficient food oral processing and aging digestive conditions on a model food: frankfurters.

Food boluses were prepared for normal mastication or deficient chewing by programing a mastication simulator (AM2). Gastric digestion was simulated using a dynamic in vitro digester (DIDGI®) of adult and elderly physiological conditions. Lipids, proteins and peptides kinetic release were assessed by Infrared spectroscopy. We observed a low impact of chewing on normal gastric digestion, mainly compensated by the activity of gastric enzymes and the acidic conditions. However, in elderly digestive conditions, a delay in release of macronutrients with a less extent occur. This study can be considered as a proof of concept with a purpose for developing specific food for elderly, adapted to their ability for oral processing and digestive physiology.

Key Words – chewing, digestion, meat products

I. INTRODUCTION

Many developed countries show changes in population demographics with an increasing proportion of elderly and therefore an emerging set of specific nutritional needs for that population. The population of elderly with higher care needs is associated with a higher prevalence of malnutrition and health status.

Chewing efficiency declines strongly with aging. Mouth is the first compartment of the digestive tract and is designed to prepare the food bolus suitable to be safely swallowed [1] once adequately comminuted and lubricated by saliva. In addition with aging less acidification occurs in the stomach and gastric enzymes often show reduced secretion [2]. In a recent international cohort study, it was recommended 1.0 to 1.5 g protein/kg body weight/day for individuals older than 65 years compared to 0.8 g protein/kg body weight/day for healthy adults with proteins as 15-20 % of total energy intake [3]. Meat and meat products are considered as a good source of proteins, highly digestible [4, 5]. However, there is a lack of information about the impact of combining oral deficiency and digestive conditions of elderly on this nutritional potential of meat products. The aim of the study was to evaluate this combination on a model food: frankfurters.

II. MATERIALS AND METHODS

Frankfurters processing

Pork frankfurters were prepared with pig muscle (*Triceps brachii*) and fat (backfat and throat fat) obtained from a local market. Sodium nitrite, lactose, spices, freeze-dried pig plasma). Prior to the cuttering step, visible fat and connective tissue were trimmed from the meat, and lean meat and fat were separately ground through a 4.5 mm plate and stored at 0°C ± 1°C. Minced meat was added into a chilled bowl cutter and homogenized for 1 min. Then sodium nitrite, spices and lactose were added and homogenized for 1 min. The plasma solution and crushed ice were then added and the mixture was homogenized for another minute. Finally, the fat was added. Then all ingredients were mixed until a final temperature of 12°C. Each meat batters were stuffed by a piston stuffer into a 22-24 mm diameter sheep gut. Sausages were hand-linked at nearly 10 cm intervals. They were pre-cooked in a steam room for 15 min at

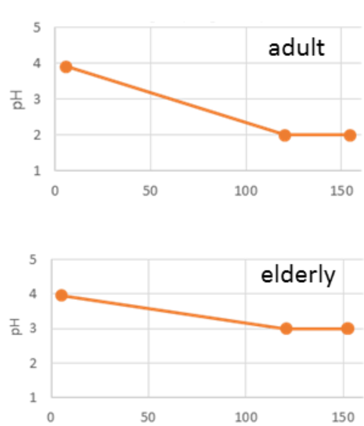
50°C, and then 60 min at 60°C. Then they were steamed using a water-bath at 67°C during 40 min. Finally sausages were cooled in an ice water-bath for 1 h. They were vacuum-packed and stored at 4°C ± 1°C until use.

Masticatory experiments

In vitro masticatory experiments were performed with a masticatory apparatus [5, 6] programmed to produce food boluses of granulometric properties similar to those observed *in vivo* for this kind of food matrix. In these conditions, boluses were collected after 27 masticatory cycles which was the mean number of masticatory cycles observed *in vivo* in normal mastication to prepare a ready-to-swallow bolus of Frankfurter or after 9 masticatory cycles observed *in vivo* in elderly mastication. After in vitro mastication, the food bolus was immediately collected for in vitro digestion.

In vitro digestion

A dynamic digester available at QuaPA (DIDGI®, INRA Clermont Ferrand, France) was used to perform digestions on the two samples (adult bolus and elderly bolus) in triplicate. The digestion system and the software (SToRM: stomach regulation and monitoring) were previously described for infant digestion by [8]. The half-time of gastric emptying used in the present study was set at 95 min. An exponential equation as described by [9] was used to monitor the gastric emptying and the coefficient (β) has been set up at 2. The acidification curve occurring in the gastric compartment was controlled by the software SToRM (see below).



Compared to adult digestive conditions, the pepsin quantity was reduced by 40% and lipase by 80% in elderly digestive conditions. Samples were collected at 30, 60, 90, 120 and 150 min of digestion for further analysis.

Proteins, peptides and lipids assessment

Protein concentration was measured using Bradford method. For peptides, TCA was added (final concentration 15%), after centrifugation (4000g) were collected and analyzed at 1650 cm^{-1} using mid infrared spectroscopy (Direct detect, Merck Millipore). Lipids were analyzed with the same method at 2840-2870 cm^{-1}.

Statistical analysis

Two-way analysis of variance (ANOVA) was applied to proteins, peptides and lipids data using Statistica Software (v12.0). The effect of digestion time was included as repeated measure. The mean values are presented with the standard error of mean (SD), and the effects were found significant at $p \leq 0.05$.

III. RESULTS AND DISCUSSION

Chewing efficiency

The kinetics of proteins release from the frankfurters was measured in the gastric compartment after normal (M3/3) and deficient (M1/3) mastication (Fig 1). The maximum of protein release was obtained more rapidly with normal mastication (M3/3)

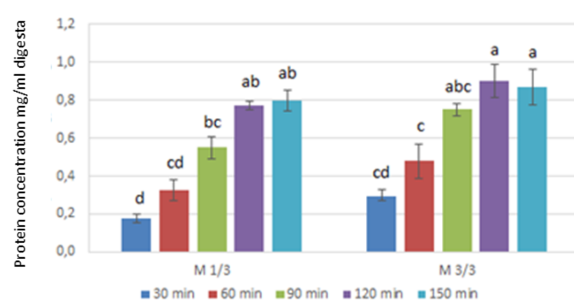


Figure 1: Protein release from Frankfurter during digestion as a function of chewing efficiency

The peptides release traduced the protein hydrolysis occurring in the stomach. No difference was observed whatever the mastication ability (Fig 2). Moreover a gradual increase was noted, showing an independent evolution from protein release.

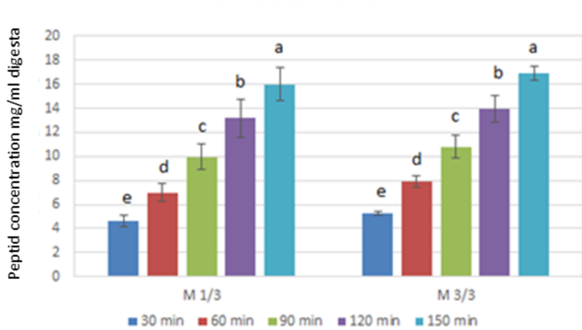


Figure 2: Peptide release from Frankfurter during digestion as a function of chewing efficiency

Lipids release was limited at the beginning of the gastric digestion and a significant step was observed at 90 min in both mastication conditions (Fig 3).

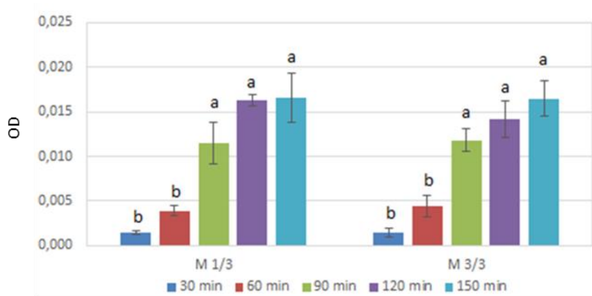


Figure 3: Lipid release from Frankfurter during digestion as a function of chewing efficiency

Chewing efficiency slightly impacted the kinetics of the nutrients studied.

Adult and elderly digestion

The kinetics of proteins release from the frankfurters was measured in the gastric compartment after adult or elderly digestive conditions (Figure 4). A delay in proteins release was observed the elderly digestive conditions. The maximum was obtained between 60 and 90 min for adult while it was after 120 min for the elderly digestive conditions.

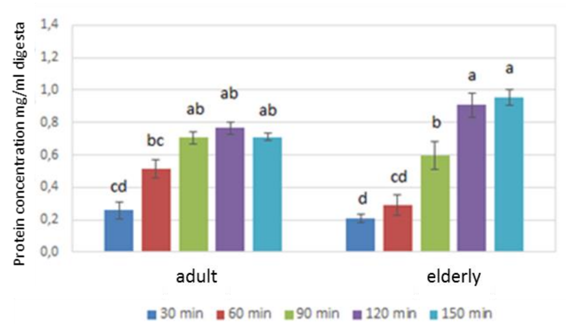


Figure 4: Protein release from Frankfurter during digestion as a function of chewing efficiency

The peptides release traduced the protein hydrolysis occurring in the stomach. A gradual increase was noted in both conditions but with a slower rate of 15% in elderly digestive conditions (Fig 5). The rate of peptides release was 6.5 mg/h and 5.5 mg/h for adult and elderly digestive conditions, respectively. Moreover the quantity of peptides release in elderly digestive conditions was reduced by 20%.

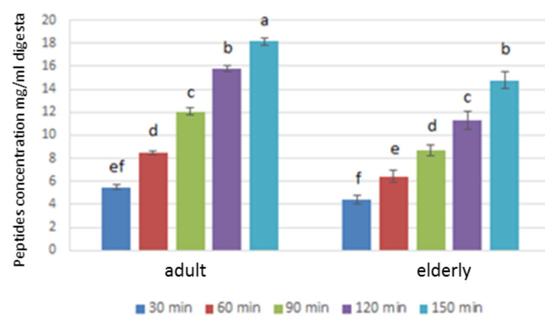


Figure 5: Peptide release from Frankfurter during digestion as a function of chewing efficiency

Lipids release increased drastically between 60 and 90 min for adult digestive conditions while a gradual increase was observed for elderly digestive conditions (Fig 6).

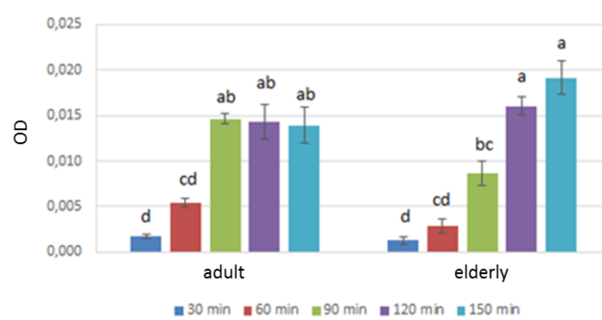


Figure 6 : Lipid release from Frankfurter during digestion as a function of chewing efficiency

This study enabled coupling chewing / gastric digestion and characterizing the release of compounds of interest in the chyme. Little information is available in the literature on the coupling chewing / digestion and bioavailability of macronutrients because these analyzes require specific designs. Few studies have been done on milk and the release of proteins and lipids, after oral processing, gastric and intestinal steps [10, 11]. Both studies went up to the identification of peptides and lipids released. However this topic has not been treated for elderly, which limits us in comparison with the work done. The use of in vitro models to study the mastication and digestion is an advantage, because analyzes are less difficult than in the experiment in vivo.

IV. CONCLUSION

The study allowed to combine two main processes of digestion on a model food Frankfurter. The release of macronutrients was strongly impacted by the aging digestive conditions. However, one can speculate that elderly with deficient chewing ability will have a delay in the gastric digestion of proteins and less availability of peptides and amino acids, potentially in situations of deficiencies. As far as we know, this study is the first one taking in account the oral processing and digestive physiology of elderly and the potential cumulative effect. This concept will be applied for developing specific food for elderly.

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