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## An in silico model to study the impact of the age-related weakening of masticatory and gastric functions on meat digestibility

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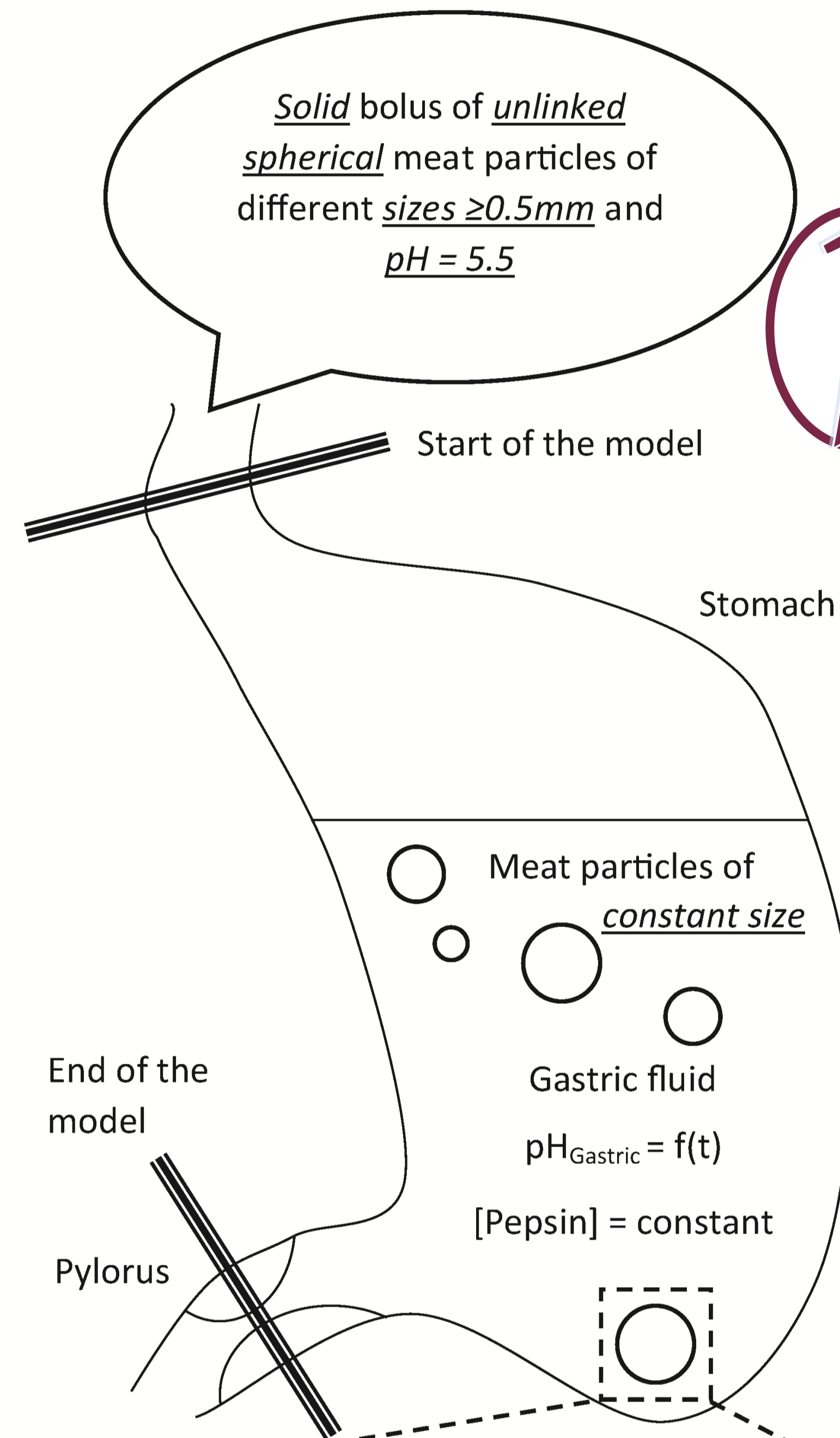
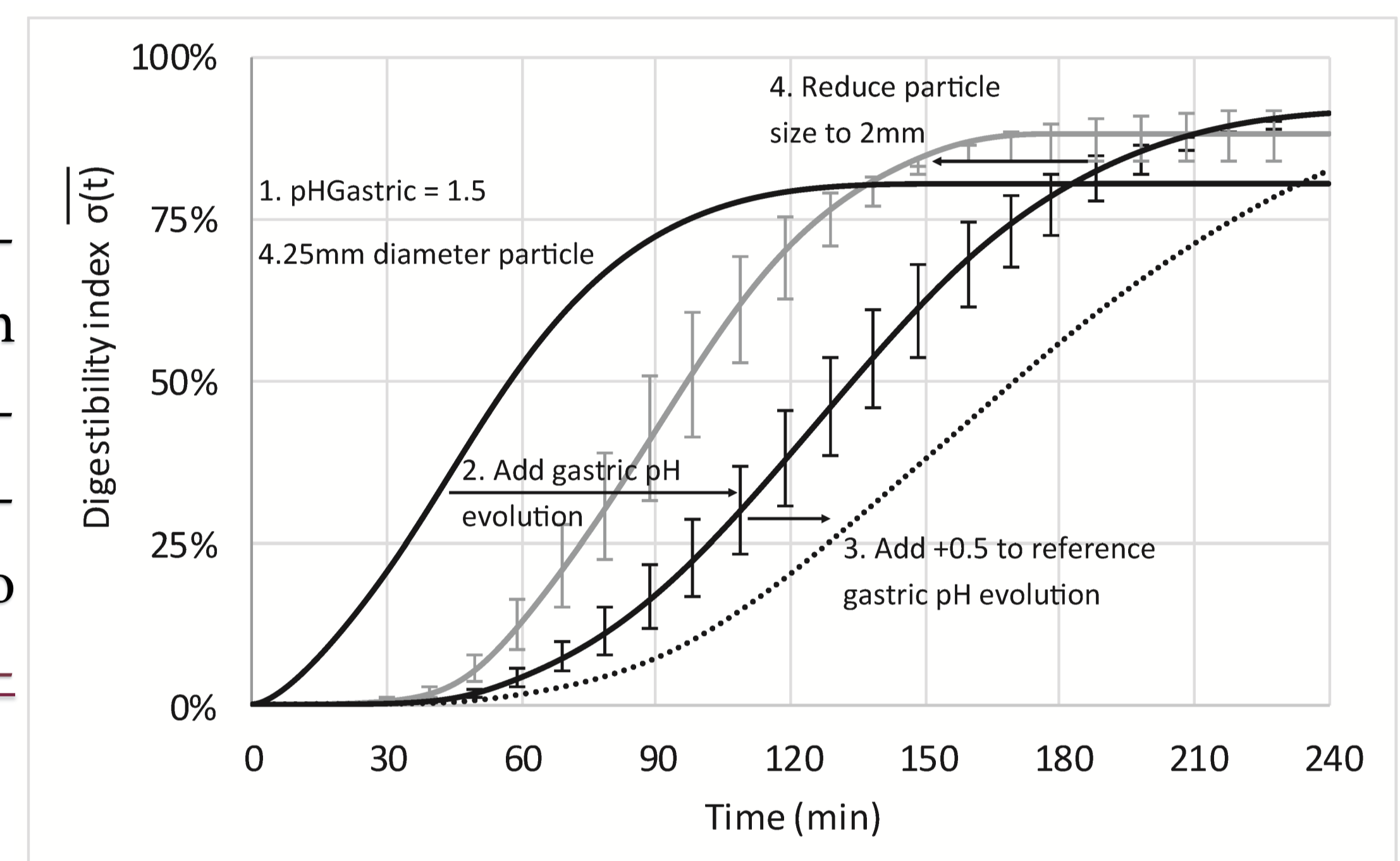
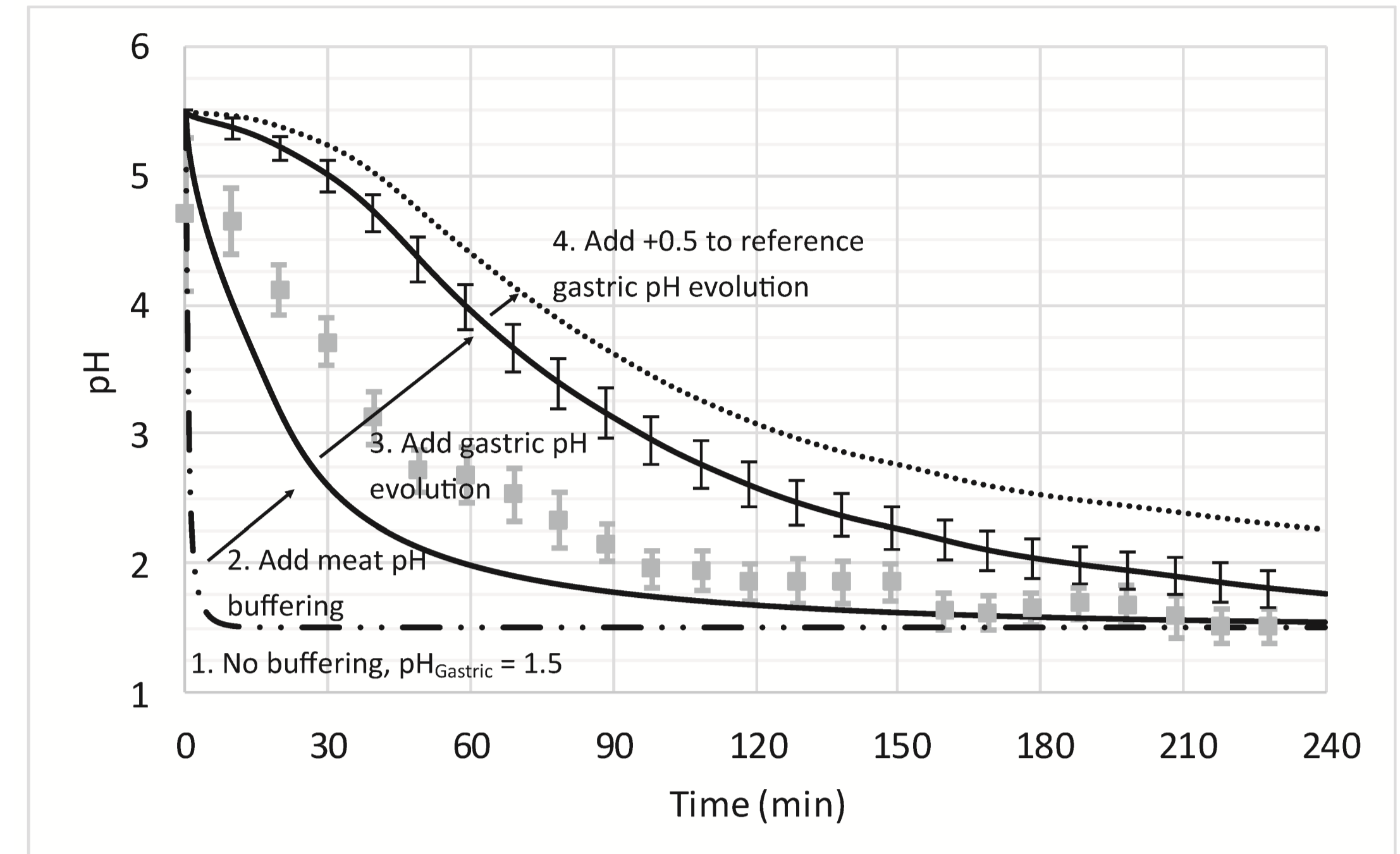
Model Parameters

are formatted this way.

## INTRODUCTION

Sarcopenia is a degenerative loss of skeletal muscle mass and strength associated with ageing. The regular nutritional solution is to increase protein intake, however elderly people also have a lower appetite for meat and are thus refractory to an increased intake. An alternative way to slow down those effects is to improve the digestion of proteins. However, the respective impacts of the different phenomenon involved are difficult to determine experimentally. Mathematical modelling offers an alternative.

Components of meat have a buffering effect on pH, hence the meat pH is reduced slowly.



## 1 Mastication and Gastric pH

Cut, ripped and crushed meat forms a bolus characterized by a distribution of particles diameters. When you ingest food, the pH in the stomach increases sharply. Cells along the sides of the stomach produces hydrochloric acid in order to reduce that pH back to around 2. After ingestion, there is hence a time-evolution of pH within the stomach.

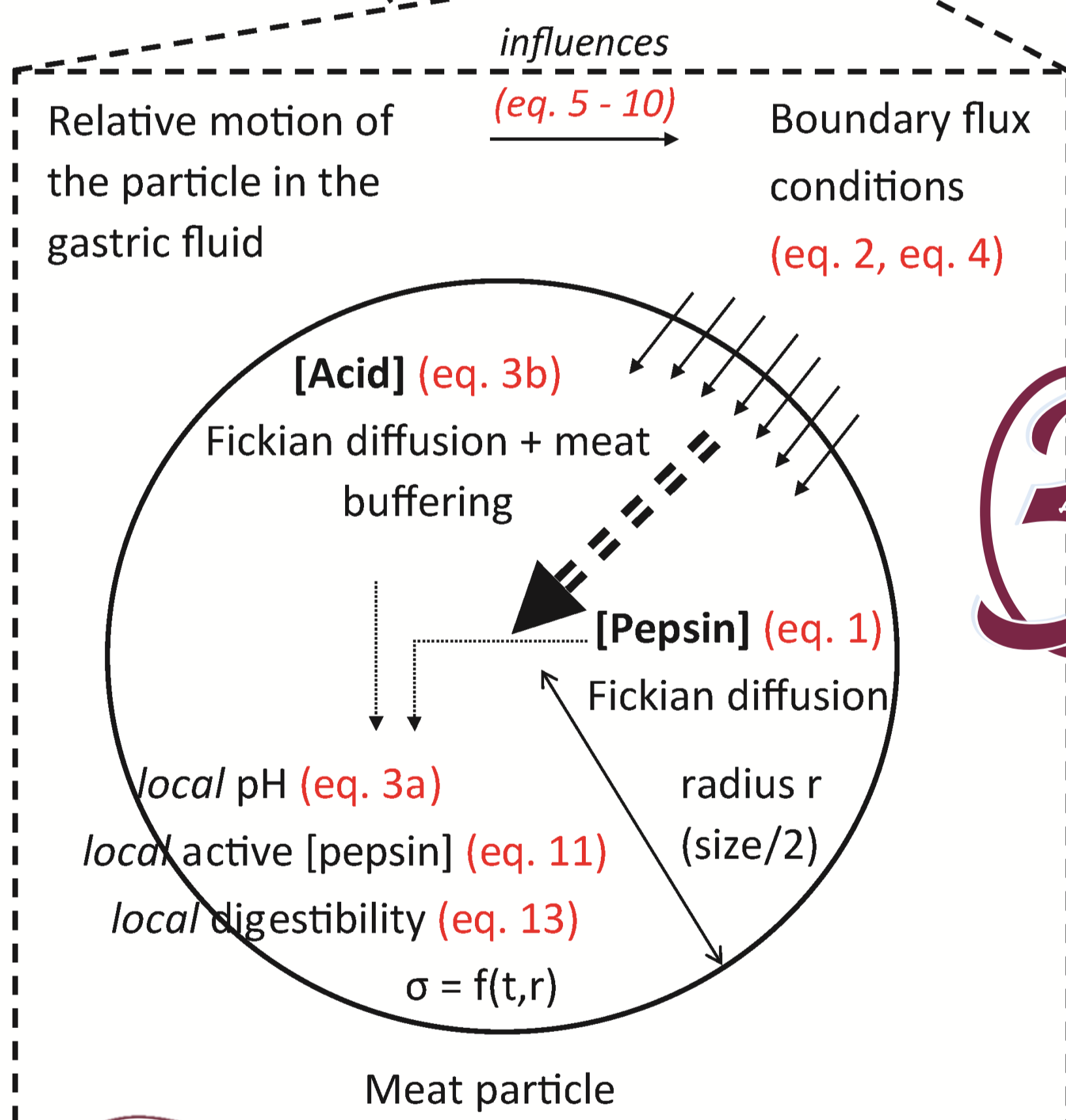
## 2 pH-dependent pepsin activity

Glands in the stomach emit a proenzyme : pepsinogen, which upon mixing with the hydrochloric acid activates to become pepsin, a protease whose activity is maximal at pH 2.

## 3 Fluid dynamics

Muscles in the stomach wall squeeze food around to mix it.

This movement accelerates the surface convective flux of acid and pepsin into the meat particles. Correlations relate those mass transfers to the dynamic viscosity, Reynolds number and velocity of the gastric fluid.



## Diffusion, degradation and expulsion

When the diffusion of pepsin and the pH (diffusivities) within the meat particles are compatible, pepsin breaks down (kinetics) the proteins into their components, i.e., peptides and amino acids. The semi-fluid mass of partly digested food, the chyme, is progressively expelled into the duodenum (beginning of the small intestine), through the pyloric valve. The gastric residence time depends on the meal composition ; emptying is generally complete after 2 to 5 hours.

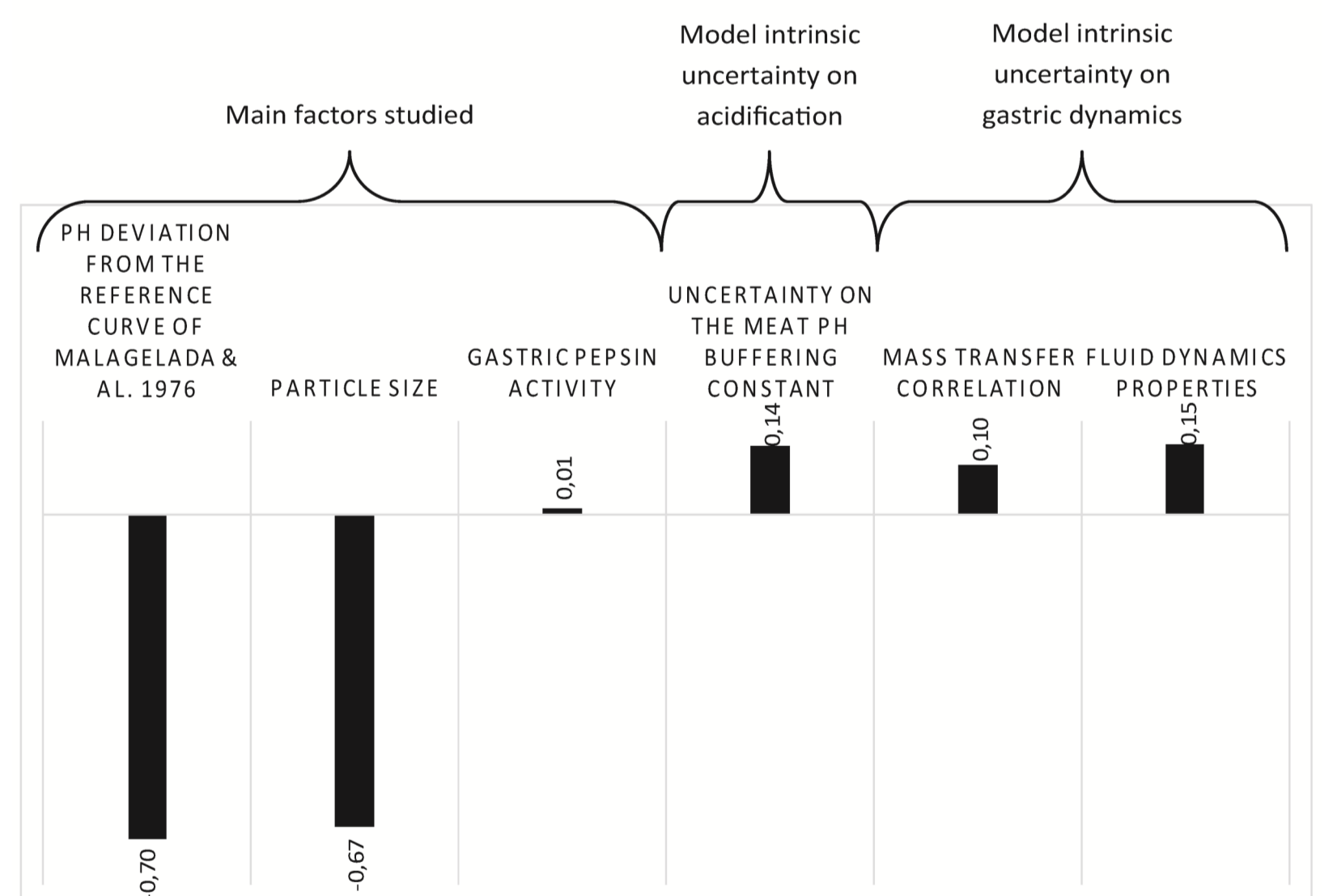
J. Sicard, P. S. Mirade, S. Portanguen, S. Clerjon and A. Kondjoyan; Simulation of the gastric digestion of proteins of meat bolus using a reaction-diffusion model, *Food Funct.*, 2018, 9, 6456-6470.

## THE RESULTS

Average digestibility over a full stomach emptying

Particle Size	Difference in gastric pH to physiological reference (0)								
	Healthy fasted pH range				Abnormal fasted pH				
	-0,2	0	0,2	0,4	0,6	0,8	1	1,2	1,4
0,5	75 + 0 - 4	77 + 0 - 5	76 + 0 - 6	72 + 0 - 7	64 + 0 - 8	53 + 0 - 7	41 + 1 - 6	31 + 0 - 6	21 + 1 - 4
1	74 + 0 - 8	75 + 1 - 12	74 + 1 - 16	70 + 1 - 20	61 + 2 - 20	51 + 1 - 20	39 + 1 - 16	29 + 1 - 13	20 + 1 - 10
2	70 + 2 - 21	70 + 2 - 29	67 + 3 - 34	62 + 3 - 37	53 + 4 - 35	43 + 3 - 26	33 + 3 - 25	24 + 2 - 19	16 + 2 - 13
3,5	62 + 4 - 40	59 + 5 - 42	54 + 6 - 42	46 + 7 - 38	38 + 6 - 33	29 + 6 - 26	21 + 5 - 19	15 + 4 - 14	10 + 3 - 9
5	50 + 6 - 39	45 + 7 - 37	39 + 8 - 34	32 + 8 - 29	25 + 7 - 23	18 + 6 - 17	13 + 5 - 12	9 + 3 - 9	6 + 2 - 6
6	41 + 8 - 34	36 + 8 - 31	30 + 9 - 27	24 + 8 - 22	19 + 7 - 18	14 + 5 - 13	10 + 4 - 10	7 + 3 - 7	4 + 3 - 4

Influence of the model's factors (within physiological range of variation)



While meat protein digestibility in the stomach is high in normal physiological conditions, it gets heavily reduced when masticatory capacity, hydrochloric acid secretion or gastric mobility in the stomach decline. These factors all pull in the same direction and tend to be appear concomitantly with advancing age.

