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Interaction of salt content and processing conditions drives the quality response in streaky rashers

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1 Abstract

2 Response surface methodology was utilised to explore the relationship between processing 3 conditions, including cooking temperature and drying time, and ingredients in reduced-salt 4 streaky rasher formulations. The goal of this project was to assess the impact of reducing salt content on physicochemical and sensory properties. Salt levels above 2.44 g/100 g did not 5 affect cooking loss. Cooking temperature (240°C) was negatively correlated with lightness 6 7 and redness, n-3 fatty acids, and sensory acceptance, and positively correlated with hardness and monounsaturated fatty acids. Salt content was highly correlated with perceived saltiness 8 and both were identified as negative attributes by the sensory panel. Results indicate that 9 optimised reduced-salt streaky rashers with acceptable technological and sensory 10 11 performance could be achieved under the following conditions: 2 g/100 g salt, 94 min of drying and grilling at 190°C. 12

13

14 Keywords: Salt reduction, bacon, response surface methodology, sensory, multiple factor15 analysis

16 **1. Introduction**

Bacon, originally developed as a method for pork preservation, has become an economically
important portion from the pig carcass (Sheard, 2010; Soladoye, Shand, Aalhus, Gariépy, &
Juárez, 2015). While in countries like the United Kingdom and Ireland, the most popular
bacon product is back bacon (from cured pork loin), elsewhere in Europe and North America,
streaky rashers (from cured pork belly) are the most widely available (Sheard, 2010).

The overconsumption of meat products have been related to several diseases, including 22 cardiovascular disease (CVD), obesity, type 2 diabetes and cancers of multiple organs 23 (Klurfeld, 2015). Excessive salt content and some saturated fatty acids have been tagged as 24 the unhealthy components of meat products. Sodium—with salt being the main dietary source 25 of this mineral—increases blood pressure, and a reduction in the diet of hypertensive people 26 27 leads to blood pressure reduction and thus, less risk of CVD (Cook, Appel, & Whelton, 2016; Mozaffarian et al., 2014). On the basis of this evidence, numerous countries, under the World 28 Health Organisation policies, have adopted strategies for dietary salt reduction (Trieu et al., 29 2015). The Food Standards Agency from UK (FSA) and the Food Safety Authority of Ireland 30 (FSAI) have agreed guidelines for the meat industry in order to reduce the salt content of 31 different meat products. The agreed targets for bacon products are 2.88 g salt /100 g product. 32 The primary approach for developing reduced-salt meat products is based on salt substitution 33 and/or inclusion of flavour enhancers (Desmond, 2006). Nonetheless, the increasing market 34 35 shift towards clean label food products makes necessary the search for novel salt alternatives. We can define strategies aligned with this goal based on approaches such as use of herbs and 36 spices, flavourings from plant origin, varying fat levels, and the application of high pressure, 37 among others (Fellendorf, O'Sullivan, & Kerry, 2017; Saricoban, Yilmaz, & Karakaya, 2009; 38 Viuda-Martos, Ruiz-Navajas, Fernandez-Lopez, & Perez-Alvarez, 2011; Yang et al., 2015). 39

40 All of these strategies can be easily applied to comminuted meat products, but not all are41 technically feasible in whole-muscle cured products.

Processing variables, such as cooking and drying conditions, can affect the physicochemical 42 properties, fatty acid composition and sensory acceptance of meat products (Alfaia, Lopes, & 43 Prates, 2013; Gou, Comaposada, & Arnau, 2003; Sánchez del Pulgar, Gázquez, & Ruiz-44 Carrascal, 2012). Response Surface Methodology (RSM) has been widely used by meat 45 scientists as an effective tool to examine the interactions of processing conditions and 46 formulation levels to determine quality, and can also permit optimisation through maximising 47 48 and minimising specified technological outcomes (Lowder et al., 2013; Resconi et al., 2015; Saricoban et al., 2009). 49

50 In this study we aimed to deepen the understanding of the relationship between processing 51 conditions (drying time and cooking temperature) and quality in streaky bacon rashers, and 52 evaluate if processing conditions can be defined which permit salt levels to be reduced to 53 meet or better the aforementioned guidelines without affecting the physicochemical and 54 sensory characteristics.

55

56 2. Materials and Methods

57 2.1. Experimental design

A split-plot D-optimal point exchange RSM experiment was designed using Design Expert v10 (Stat Ease Inc., USA) generating a total of 14 runs (Table 1). Three numerical factors were included in the design: salt content (g/100 g), drying time (min) and cooking temperature (°C). Minimum and maximum levels were: 2 to 2.88 for salt, 60 to 120 min for drying time and two discrete values for cooking temperature 190°C and 240°C, as intermediate values proved not to be meaningful in previous experiments. Two additional

64 model groups were included generating 5 additional model points. The whole experiment was65 replicated twice and the means for each run were used for the statistical study.

66

67 2.2. Streaky rashers processing

Fourteen pork bellies were purchased from a meat supplier (Rosderra Irish Meats, Edenderry, 68 Ireland) and transported to the meat processing facility at Teagasc Food Research Centre 69 Ashtown. Three different brines were prepared with varying levels of salt (Table 1) and 150 70 ppm of sodium nitrite. Maximum salt level of 2.88 g/100 g was selected as in line with the 71 recommendations from both The Food Standards Agency from UK and the Food Safety 72 Authority in Ireland for this type of products. Each belly was cut in half and was randomly 73 74 assigned to a different formulation; hence, each of the fourteen runs was repeated. The halfbellies were pumped to 113 % of their green weight using a 20-needle brine injector (Inject-75 O-MAT type PSM-21, Dorit Maschinen, Handels AG, Switzerland). The injected bellies 76 were weighed, vacuum packed and left to mature at 0-4 °C for 48 h. After the maturing stage 77 the bellies were dried at 55 °C for the respective time according to each formulation (Table 78 1). The bellies were cooled, weighed again, and chilled up to -5 °C when they were sliced 79 (3mm). The streaky rashers were cooked on an electric grill (Velox Grill CG-3.71, Velox 80 Ltd., Wantage, UK) for 2 min each side at the designated temperature (Table 1), left to cool 81 down and weighed again. The cooked slices were then vacuum packed and stored at 2±1 °C 82 for future analysis. 83

84

85 **2.3. Physicochemical properties**

Samples were homogenised in a Robot Coupe (R101, Robot Coupe SA, France). Fat and
moisture were determined using the Smart System 5 microwave and NMR Smart Trac rapid
Fat Analyser (CEM Corporation USA) using AOAC Official Methods 985.14 & 985.26.

89 Protein concentration was determined using a LECO FP328 (LECO Corp., MI, USA) according to AOAC method 992.15,1990. Salt was determined by titrating chloride anions in 90 ashed (by furnace) samples with silver nitrite using the Mohr method (Vogel, 1961). pH was 91 92 measured in the brines, green muscle, dried muscle and cooked samples. All these analyses were performed in at least duplicates. Cook loss was calculated from the initial and final 93 weight before and after cooking of at least six slices per formulation. Shear force (N) was 94 assessed on streaky bacon cooked rashers using an Instron Universal Testing Machine with a 95 Warner-Bratzler shear force cell at a crosshead speed of 5 cm/min. Colour was analysed 96 using a Ultrascan XE spectrophotometer (CIE L*a*b system) on the lean part of the rasher. 97

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99 2.4. Fatty acid analysis

Fat was extracted from samples and methyl esters of fatty acids were prepared by basecatalysed trans-esterification methodology (Christie & Han, 2012). The fatty acid methyl esters were analysed using gas chromatography with flame ionization detector (GC-FID) in accordance with a UKAS accredited methodology (Cam Nut003) as in Kirk and Sawyer (1991). Samples were analysed in duplicate and results were expressed as percentage of total fat.

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107 **2.5. Sensory analysis**

The sensory acceptance test was conducted using untrained panellists (n = 24, 14 females) in the age range of 21–65 following the same approach as in Delgado-Pando et al. (2018). The twenty four panellists (14 female) were asked to evaluate on a 9-point hedonic scale the following attributes: liking of appearance, texture, flavour and overall acceptability. The assessors then participated in a ranking descriptive analysis (RDA) using a list of sensory attributes (crunchiness, saltiness and meaty flavour) measured on an intensity line scale

(Richter, de Almeida, Prudencio, & de Toledo Benassi, 2010). Due to the great amount of samples to test and to avoid sensory fatigue, the sensory analysis was split in four different sessions according to a balanced incomplete block design. Each panellist assessed each sample twice, in both the hedonic and RDA tests.

118

119 2.6. Statistical Analysis

Statistical analysis of physicochemical and sensory properties was performed using Design
Expert software. Pearson correlations were calculated using "Hmisc" package in R studio
(Harrell & Dupont, 2016; R, Core Team 2015). Sensory and instrumental data were also
analysed using FactomineR and factoextra packages (Kassambara & Mundt, 2017; Le, Josse,
& Husson, 2008) by means of a multiple factor analysis.

125 **3. Results and Discussion**

126 **3.1. Physicochemical properties**

127 Variations in the levels of cooking temperature, drying time and salt content affected the128 physicochemical properties of the streaky rashers.

As expected, cooking temperature significantly affected moisture, protein and fat content 129 (Table 2). Moisture ranged between 19.6-33.5 g/100 g, protein between 25.6-39.2 g/100 g 130 and fat between 30.0-45.8 g/100 g. In the case of moisture, the higher the temperature the 131 lower the water retained in the sample. However, a significant interaction between salt and 132 drying time was also observed. The maximum content of moisture appeared at the longest 133 drying time (120 min) and from salt content ≥ 2.5 g/100 g (Fig. 1a,b). Salt impact on moisture 134 content was more significant at higher drying times, the more salt the higher the moisture 135 after cooking. During the drying process first stage, water losses are expected to be rapid, 136 because of the evaporation from the surface, but as time passes the resistance to moisture 137

138 movement becomes higher. According to Gou et al. (2003) the binding strength between water and the meat matrix increases as the moisture decreases. The same authors also 139 concluded that the effect of salt on moisture increased with drying time during the process of 140 dry-cured pork ham; the higher the salt content the higher the moisture. In the case of the 141 protein content the model was not significant (Table 2) and only the cooking temperature had 142 a significant increasing impact (Fig. 1c). Fat content was also significantly affected by 143 cooking temperature, but in an opposite way (Table 2); it was lower with increasing cooking 144 temperature. On the other hand, drying time was a significant factor too, the higher the drying 145 time the lower the fat content after cooking (Fig 1d,e). Moisture reduction and protein 146 concentration was reported on different pork roast with increasing end-point temperature 147 (Heymann, Hedrick, Karrasch, Eggeman, & Ellersieck, 1990). Fat and moisture had a 148 significant and negative correlation with protein, -0.53 and -0.68 respectively. Moisture and 149 fat were released as a result of drying and cooking, increasingly affecting the protein 150 concentration. 151

Streaky rashers had a mean salt content of 4.62 g/100 g, with 3.56 g/100 g the lowest and 6.37 g/100 g the maximum. As expected, the higher the initial salt concentration the higher its final salt concentration after cooking. The drying time also affected the final salt concentration as can be seen in the contour figure (Fig 1e,f); the maximum appeared after 90 min of drying but significantly varied depending on the initial salt level and cooking temperature. Generally, as the drying time increased the effect of the cooking temperature increased, final salt content was higher at 240 °C than at 190 °C (Fig 1e,f).

Cooking loss ranged from 50.1-59.3 % and was affected by the three studied parameters. A
high salt level and drying time and lower cooking temperature exerted the minimum losses.
Even though salt was the main parameter influencing cooking loss, between 2.442.88 g/100 g the impact was minimal (Fig 2). Within this salt range, the effect of drying time

became more important and below that the cooking temperature showed a bigger effect. In 163 agreement with the results of moisture composition, the longer the drying time the lower the 164 cook loss as water got more bound to the meat matrix. Cooking loss was significantly 165 correlated with final protein content (0.71) and negatively with moisture (-0.74). From these 166 results and Fig. 2 we could infer that an initial salt level above 2.44 g/100 g was enough to 167 maintain the cooking loss values irrespective of the drying and cooking conditions under 168 study. In sausages, it has been reported a salt level at around 1.5 g/100 g as the minimum to 169 prevent negative functional properties (Aaslyng, Vestergaard, & Koch, 2014; Ruusunen et al., 170 2005). Several authors have reported increases in cooking loss when reducing the salt content 171 in different meat products (Puolanne, Ruusunen, & Vainionpää, 2001; Ruusunen et al., 2005; 172 Tobin, O'Sullivan, Hamill, & Kerry, 2013). 173

The texture of the cooked streaky rashers was measured by means of shear force (N/g). This 174 parameter was primarily affected by cooking temperature and initial salt content, whereas 175 drying time effect was not significant (Table 2). Important differences appeared when 176 varying these parameters, the lowest shear force (8.77 N/g) was recorded in the sample with 177 highest salt level and lowest cooking temperature and drying time, while the maximum 178 (22.59 N/g) appeared at the lowest salt content and highest cooking temperature and drying 179 time. As mentioned earlier, salt is related to the water holding capacity (WHC) of meat as the 180 chloride ions are thought to be responsible for the swelling of the myosin shaft and thus 181 increasing its WHC; on the other hand, the sarcomere length of the meat is known to decrease 182 with increasing cooking temperature (Ertbjerg & Puolanne, 2017). Reductions in WHC and 183 sarcomere length (low salt and high temperature), along with the protein denaturation, are 184 then related to an increase in the hardness (as measured by shear force) of the meat. 185

186 The response surface models for the colour parameters were not significant, although the187 effect of cooking temperature was significant for lightness and redness (Table 2). The streaky

188 rashers appeared darker and less red with increasing cooking temperature. The effect of cooking conditions on colour is complex because of the biochemical changes in the muscle 189 pigments (myoglobin and haemoglobin) but also the Maillard reactions occurring at 190 temperatures above 140 °C. As the temperature increases the meat gets drier, the myoglobin 191 degrades and gives more greyish-brown pigments and Maillard reactions will be more 192 numerous giving a darker and less red colour. Accordingly, lightness and redness values of 193 streaky rashers were significantly and negatively correlated (-0.84, -0.53) with the protein 194 content. Similarly, Sánchez del Pulgar et al. (2012) and Oz and Celik (2015) found 195 decreasing L* and a* values with increasing cooking temperature in pork chops and goose 196 meat, respectively. 197

198

199 **3.2. Fatty acid composition**

Fatty acid composition of cooked streaky rashers was analysed, average results were 200 calculated as a percentage of total fat and the response surface models were calculated (Table 201 3). The main components of the lipid profile of the streaky rashers observed were oleic acid 202 (31.5-36.6 %), palmitic acid (23.1-25.0%), linoleic acid (12.9-17.6%) and stearic acid (11.2-203 13.1%), in accordance with existing literature of fat from pork traits (Douny et al., 2015; Li et 204 al., 2016). The processing conditions significantly affected the concentration of some of the 205 fatty acids (Table 3). None of the individual saturated fatty acids (SFA) was significantly 206 affected by any of the studied parameters, and thus the surface response models for total or 207 individual SFA were not significant. Variation in SFA within the different rashers was low 208 (36.6-39.5 %) with palmitic and stearic acids accounting for almost 95 % of the total SFA. 209 Similarly, no differences in fatty acid composition were observed when comparing grilling, 210 microwaving and boiling in beef muscle (Alfaia et al., 2013). However, Li et al. (2016) 211

observed higher quantities of SFA in stewed pork bellies when compared with pre-fried andstewed ones.

Total monounsaturated fatty acids (MUFA) concentration ranged between 34.7 %- 40.0 % 214 and were mainly oleic (>90%) and palmitoleic acids (>5%). Oleic acid and total MUFA 215 significantly increased with cooking temperature (Table 3). In pork patties, MUFA 216 significantly increased when pan-fried as compared to an electric grill (Salcedo-Sandoval, 217 Cofrades, Ruiz-Capillas, & Jiménez-Colmenero, 2014) but this could be attributed to the 218 transference of MUFA from the frying oil to the piece of meat. Heymann et al. (1990) 219 observed an increase of oleic and palmitoleic acids with increasing endpoint temperatures in 220 different pork roasts. 221

Total content of polyunsaturated fatty acids ranged from 14.0 %-20.8 %, where linoleic acid 222 accounted for more than 85 %. Surprisingly, the response surface models for PUFA were not 223 significant and only a trend (p=0.08) was observed where the PUFA content decreased with 224 increasing cooking temperature. Douny et al. (2015) found that the PUFA fraction of pork 225 meat was affected by the cooking type, being higher when cooked in a pan as opposed to 226 oven cooking. Conversely, Turp (2016) found no significant differences in fatty acid 227 composition between oven, grill and pan cooked Turkish beef meatballs. n-3 fatty acids 228 concentration ranged from 1.4 %-2.2 % and were significantly affected by the cooking 229 temperature, the higher the temperature the lower the n-3 concentration (Table 3). Alpha 230 linolenic acid accounted for more than 80 % of the total observed n-3 while eicosatrienoic 231 acid (ETA) around 10%. This fatty acid, ETA, was the only one significantly affected by the 232 drying time, and with a significant interaction of salt and cooking temperature. Low salt 233 content and high drying time at 190 °C gave the highest values. After linolenic acid, ETA is 234 the main source of n-3 fatty acids in pork fat, has been shown to promote eicosanoid 235 precursors of long chain n-3 fatty acids and has also exhibited a photo-protective effect in 236

human skin (Dugan et al., 2015). The results demonstrate that through altering the processing
conditions, it is possible to achieve higher quantities of n-3 fatty acids, specifically ETA, and
hence improve the healthier lipid fraction of the rashers.

Discrepancies in the effect of cooking on the fatty acid fraction can be attributed to the type of cooking, total heating time, different cut and animal species (Alfaia et al., 2013). In general, the cooking temperature was the main factor affecting some of the lipids from the streaky rashers, with salt having no significant effect and the drying time only on ETA. This temperature effect could be partially attributed to the fat concentration and retention of specific fatty acids.

246

247 **3.4. Sensory Analysis**

Response Surface models were tested for the seven sensory attributes (liking of appearance, 248 texture, and flavour, overall acceptability, crunchiness, saltiness and meaty flavour) but only 249 three of them had any significant term (Table 4). Streaky rashers with the highest salt content 250 were preferred in flavour when lower drying times were applied and for rashers with the 251 lowest salt content medium drying times (~90 min) were scored the highest in flavour (Fig. 252 3). As expected, the cooking temperature significantly affected the crunchiness of the 253 samples, the higher the temperature the higher the score for this attribute. In general, 254 panellists were able to perceive the differences in saltiness according to the formulation as in 255 the model we can see the significance of this factor (Fig 3). 256

In order to delve into the correlation between the sensory characteristics and the physicochemical properties, a multiple factor analysis (MFA) was performed. MFA helps to analyse several data sets measured on the same observations. In our case, we structured our data set into one supplementary and three active groups: formulation (salt content, drying time and cooking temperature) as supplementary, hedonic characteristics (liking of

262 appearance, texture, flavour and overall acceptability), intensity characteristics (crunchiness, saltiness and meaty flavour) and instrumental properties (cook loss, shear force and colour). 263 Most of the variables were highly correlated to the first dimension irrespective of the active 264 group they belong to (Fig. 4). Nonetheless, whereas hedonic and instrumental colour 265 attributes were positively correlated, cook loss crunchiness and shear force do correlate with 266 first dimension negatively. Saltiness intensity and liking of flavour were more correlated with 267 the second dimension, although in an opposing way. Attending to the supplementary group, 268 we can clearly observe that both drying time and salt content are associated with perceived 269 saltiness and that cooking temperature relates to an increase of cook loss, shear force and 270 perceived crunchiness. With regards to the individual plot (Fig. 5) we can see that is not the 271 high salt samples but some of the medium and low salt the ones that are correlated with 272 positive liking attributes. In addition, with the exception of sample S8, samples cooked at 273 190°C were positively correlated with the first dimension and thus with positive hedonic 274 scores and higher instrumental colour. As mentioned earlier, temperature plays a role in the 275 Maillard reactions, generating some desirable flavour compounds, but high temperatures can 276 also degrade the proteins into peptides and amino acids contributing to sour, umami and bitter 277 taste and also undesirable burnt off-flavours (Alfaia et al., 2013; Hilmes & Fischer, 1997). 278

279

280 3.5. Optimisation of responses using RSM

Using the optimisation module of the RSM software and with the selection criteria of minimising salt content, shear force and cooking loss, and maximising the flavour preference, the optimised sample will be that with 2 g/100 g initial salt level, 94 min of drying time and grilled at 190 °C. This solution generated the highest desirability value (0.648). The optimised sample was manufactured and assessed for the physicochemical characteristics, obtaining a salt content of 3.9 g/100 g, a shear force of 16.1 N/g and a cooking loss of

52.8 %. Compared to the predicted values the differences were: +0.4 in salt and shear force
values and +1.5 in cook loss.

289

290 **4. Conclusions**

This study confirmed the relevance of the processing conditions on the physicochemical and 291 sensory properties of streaky rashers. Despite the importance of salt level in manufacturing 292 streaky rashers—and any other meat products—this level should be re-evaluated as our 293 results showed that lower salt concentrations are preferred and technically feasible. When 294 295 evaluating a product that needs to be cooked before consumption, the cooking temperature, frequently neglected, should be taken into consideration. In our case, the use of lower 296 temperatures increased the sensory acceptance, the tenderness and the PUFA levels of the 297 streaky rashers irrespective of the salt level. Cooking temperature also doubled the initial salt 298 content and should be a piece of information to consider disseminating when labelling the 299 product. The use of RSM proved to be a helpful tool in evaluating the optimal processing 300 conditions of streaky rashers. 301

302

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307

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Figure Captions

Figure 1. Response surface model for moisture (g/100 g) (a, b), fat (g/100 g) (c), protein (g/100 g) (d) and final salt content (g/100 g) (e, f) in streaky rashers. The remaining factors were fixed as follows: a) cooking temperature 190°C, b) cooking temperature 240°C, c) cooking temperature 190°C, d) salt 2.44 g/100 g and drying time 90min, e) cooking temperature 190°C, and f) cooking temperature 240°C.

Figure 2. Response surface model for cooking loss (%) in streaky rashers. Left: cooking temperature fixed at 190°C, right: salt content fixed at 2 g/100 g,

Figure 3. Response surface model for sensory properties in streaky rashers. Left: liking of flavour score (cooking temperature fixed at 190 °C), right: perceived saltiness intensity (cooking temperature fixed at 190 °C)

Figure 4. Multiple Factor Analysis (MFA) variable plot. Active groups: instrumental colour, cooking loss and shear force; hedonic sensory attributes (liking of flavour, liking of texture, liking of appearance and overall acceptability); intensity sensory attributes (meaty flavour, saltiness and crunchiness). Supplementary group: salt content, cooking temperature, drying time.

Figure 5. Multiple Factor Analysis (MFA) individual plot.S1-S14 streaky rashers as formulated in Table 1. Salt levels as final salt content, High salt: >5 g/100g, Medium salt: 4-5 g/100g, Low Salt: <4 g/100g

Sample	NaCl (g/100 g)	Drying Temp. (°C)	Cooking Temp. (°C)	
S 1	2	60	190	
S 2	2.44	90	190	
S 3	2.88	60	190	
S 4	2.88	120	190	
S5	2.88	120	240	
S 6	2.88	60	240	
S 7	2	90	240	
S 8	2	120	190	
S9	2.88	90	190	
S10	2.44	60	190	
S11	2.88	90	240	
S12	2	120	240	
S13	2.44	60	240	
S14	2	60	240	

Table 1. Processing conditions according to response surface split-plot D-optimal design

	Moisture	Protein	Fat	Salt	Cook Loss	Shear Force	L*	a*	b*
Model	Quadratic	Linear	2FI	Quadratic	Quadratic	2FI	Linear	Linear	Linear
p whole-plot	0.026	< 0.001	0.002	0.371	0.011	0.010	0.004	0.050	0.178
p subplot	0.007	0.590	0.052	0.010	0.034	0.034	0.9372	0.8136	0.372
\mathbf{R}^2	0.98	0.80	0.87	0.97	0.93	0.85	0.60	0.36	0.32
Coefficients:									
CT	-2.01*	4.04**	-3.29**	0.26ns	1.43**	2.25**	-1.65**	-0.23*	-0.35ns
S	0.96*	-0.72ns	0.51ns	0.61**	-2.02**	-3.01**	0.18ns	0.06ns	0.37ns
DT	3.34**	0.38ns	-3.27**	0.07ns	-1.13*	0.80ns	0.02ns	-0.05ns	0.16ns
S x DT	1.56*		1.03ns	-0.06ns	-0.75ns	-0.96ns			
S x CT	0.41ns		-0.98ns	0.12ns	-0.61ns	-0.47ns			
DT x CT	-0.51ns		0.06ns	0.28*	-0.26ns	-1.14ns			
S^2	-2.88*			0.31ns	2.20*				
DT^2	-0.57ns			-0.53*	-0.30ns				

Table 2. Response surface models split-plot design for composition, cook loss, texture and instrumental colour in streaky bacon

ns: p>0.05, *:p≤0.05, **:p≤0.01. 2FI: two level full factorial; CT: cooking temperature; S: salt; DT: drying time.

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	SFA	MUFA	PUFA	OA	w3	ETA w3
Model	Linear	Linear	Linear	Linear	Linear	2FI
p whole-plot	0.468	0.034	0.080	0.047	0.038	0.315
p subplot	0.922	0.603	0.359	0.562	0.253	0.0161
R^2	0.11	0.41	0.38	0.38	0.47	0.88
Coefficients:						
CT	0.24	0.78**	-0.73*	0.74**	-0.11**	-0.02
S	0.12	0.22	-0.02	0.25	< 0.01	0.02
DT	0.01	-0.32	0.68	-0.35	0.10	0.03**
S x DT						-0.04**
S x CT						0.03**
DT x CT						< 0.01
*	<0.05					

Table 3. Response surface models split-plot design for fatty acid composition of streaky bacon

*:p≤0.1, **:p≤0.05.

SAF: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; OA: oleic acid; ETA: eicosatrienoic acid; 2FI: two level full factorial; CT: cooking temperature; S: salt; DT: drying time.

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	Liking	Liking	Liking	Overall	Crunchinoss	Saltingen	Meaty
	appearance	texture	flavour	acceptability	Crunchiness	Sattilless	flavour
Model	Linear	Linear	Quadratic	Linear	2FI	2FI	Linear
p whole-plot	0.319	0.121	0.670	0.106	0.008	0.532	0.670
p subplot	0.530	0.384	0.025	0.562	0.059	0.018	0.130
R^2	0.50	0.65	0.96	0.31	0.83	0.85	0.61
Coefficients:					\sim		
СТ	-2.08ns	-4.58ns	-1.05ns	-1.51ns	3.41**	1.15ns	-0.57ns
S	1.21ns	2.08ns	-1.17ns	-0.05ns	-0.94ns	6.67**	0.32ns
DT	-0.15ns	-0.32ns	-1.81*	-1.12ns	-3.49*	3.69*	-1.20ns
S x DT			-2.87**		0.81ns	1.69ns	
S x CT			1.86*		-1.57ns	-1.23ns	
DT x CT			0.39ns		-2.37ns	-1.52ns	
\mathbf{S}^2			4.07*				
DT^2			-2.51*				

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Table 4. Response surface model split-plot design for sensory attributes of streaky bacon

ns: p>0.05, *:p≤0.05, **:p≤0.01. 2FI: two level full factorial; S: salt; DT: drying time











c: Cooking T(C)

| 240



A: Salt (g/100 g)



B: Drying time (min)

A: Salt (g/100 g)







- Interaction of salt and processing conditions impacts quality of streaky rashers
- Fatty acids are affected by processing conditions
- Cooking temperature is a main factor in the sensory acceptance of rashers
- RSM proved to be a useful tool for optimising reduced-salt streaky rashers