SENSORY ACCEPTANCE AND FUNCTIONALITY OF REDUCED SALT BACK BACON RASHERS

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Abstract – Four different formulations of bacon back rashers were prepared with varying salt levels (2.88, 2.5, 2, and 1.5 %). Sensory acceptance and functionality were studied. A panel of 26 assessors was used for the sensory analysis, consisting of a hedonic test and a ranking descriptive analysis for all samples in duplicate. Composition, cooking yield, colour, texture and microbial stability were also assessed. Differences in the salt levels were appreciated by the assessors (in terms of saltiness). The hedonic attributes were significant and negatively correlated only with the sample with the lowest salt quantity. Texture in cooked samples was significantly different; samples with 2 and 2.5 % salt had the lowest shear force. No significant differences in colour and cooking yield were observed. Samples with 1.5 % salt had the highest growth rate of bacteria. Salt levels below the Food Standards Agency recommendations in bacon (2.88 %) can be applied without impairing their sensory and functionality properties.

Key Words – low salt, PLSR, meat product

I. INTRODUCTION

High sodium consumption increases systolic blood pressure and leads to hypertension, a major risk factor of cardiovascular disease; salt provides 90 % of the sodium consumption in the human diet [1]. In most European countries, meat and meat products are one of the main dietary sources of salt in conjunction with bread, cereals, bakery, and dairy products [1]. Diverse salt reduction policies have adopted in different European countries. The Food Standards Agency (UK) and the Food Safety Authority of Ireland (FSAI) have agreed guidelines for the industry in order to reduce the salt content of several products. Back bacon rashers are widely consumed in the UK and Ireland. Our group conducted a survey in order to establish the actual salt levels in this type of product several local retailers [2]. The mean salt declared content of back bacon rashers was 2.75 %, while the analysed content was 2.41 %. Both values were below the FSAI and FSA guidelines of 3% and 2.88 % respectively. Further salt reduction might affect the sensory, physicochemical and microbiological properties of meat products [3-5]. Thus, in this study we aimed to determine the differences in sensory acceptance and functionality of back bacon rashers with salt levels below the FSA guidelines.

II. MATERIALS AND METHODS

Design and sample preparation

Pork loins of 8 Landrace pigs were purchased from a meat supplier (Ballon Meats, Raheen, Carlow, Ireland) and transported to the meat processing facility at Teagasc Food Research Centre Ashtown. Four different brines were prepared containing only salt and sodium nitrite (150 ppm). Salt levels were as follows: 2.88 % (Control), 2.50 % (B2.5), 2 % (B2) and 1.5 % (B1.5). Each loin was cut in half and was randomly assigned to a different formulation; hence, each formulation was repeated four times. The half-loins were pumped to 113% of their green weight using a 20-needle brine injector (Inject-O-MAT type PSM-21, Dorit Maschinen, Handels AG, Switzerland). The injected loins were weighted, vacuum packed and left to mature at 0-4 ºC for 48h. The bacon was frozen to -5 ºC before slicing and vacuum packed for future analysis.

Sensory evaluation

The sensory acceptance test was conducted using untrained panellists (n=26) in the age range of 21-60. Sample presentation was randomized according to William Latin squares to balance the first-order carryover effects. The bacon slices were cooked on a grill (200 ºC) for 3 minutes on each side, cut (4x2.5cm) and kept warm until evaluation. The panellists were asked to evaluate in a 10cm hybrid hedonic scale the following attributes: liking of appearance, colour, texture, flavour and acceptability. The assessors then participated in a ranking descriptive analysis (RDA) using a consensus list of sensory attributes: redness, tenderness, juiciness, fibrous, saltiness, meaty flavour, metallic flavour and sweet aftertaste, measured on a 10 cm line scale. Assessors tested all samples in duplicate.

Physicochemical properties and microbial stability

Fat and moisture were determined using the Smart System 5 microwave and NMR Smart Trac rapid Fat Analyser (CEM Corporation USA). Protein concentration was determined using a LECO FP328 (LECO Corp., MI, USA). Salt was determined by titrating chloride anions in ashed (by furnace) samples with silver nitrite using the Mohr method. Bacon colour was analysed using a Ultrascan XE spectrophotometer (CIE L*a*b system). The samples were weighted and then cooked on a grill (200 ºC) for 3 minutes on each side, the cooking yield was calculated. Cooked samples were left at room temperature to cool down, cut (6x2.5cm) and weighted. Shear force (N/g) of the cooked samples was assessed using an Instron Universal Testing Machine with a 10 blade Kramer shear cell. All values were the average of triplicates for each of the four replicates per formulation. Vacuum packed slices of bacon were stored at 4±2 ºC prior to microbiological analysis (day 0, 5, 17 and 31). The ISO 4833-2:2013 and 15214:1998 were followed for the analysis of total viable counts (TVC) and lactic acid bacteria (LAB), respectively.

Statistical analysis

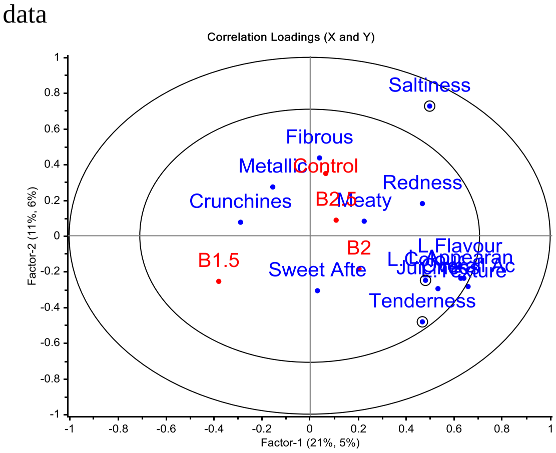
Discriminant Partial Least Squares Regression (DPLSR) was used to find the sensory attributes describing the variation among the four formulations. ANOVA Partial Least Squares Regression (APLSR) was used to study the correlation between the attributes and formulations. Both PLSR analyses were performed using Unscrambler (CAMO Software). For evaluating the physicochemical data one-way ANOVA for each of the attributes was carried out using R Studio [6].

III. RESULTS AND DISCUSSION

Sensory evaluation

DPLSR shows which attributes are responsible for sensory differences. The first three principal components accounted for 46 % of the total variance. Three attributes varied significantly between formulations: saltiness, tenderness and liking of colour. Variation between formulations caused by the hedonic properties and juiciness were explained by the first principal component (PC) (Fig 1). Formulations B2.5 and B2 were given the highest scores for likeness. The second PC was mainly explained by saltiness, fibrous and tenderness. Both saltiness and fibrous were positively loaded on PC2 and tenderness negatively. Formulation B2 was scored as the tenderest while the Control was scored as the least tender. The salt concentration was also detected in the sensory analysis by the panellists, with the control being the most salty and B1.5 the least salty. The Control, B2.5 and B2 were situated on the positive side of the PC1 while B1.5 was on the negative side of both PCs. Most of the attributes were on the positive side of PC1, only crunchiness and metallic appeared on the left side. Thus, panellists negatively associated the sensory attributes of the bacon with lower salt content (B1.5).

Figure 1. Correlation loading plot of DPLSR on sensory data



Sensory data was further analysed with APLSR in order to determine the differences between the formulations. Table 1, presents the corresponding ANOVA with weighted coefficients and significance. Negative correlations are presented with a negative algebraic sign before the value. With regard to the hedonic characteristics, formulation B1.5 was negatively and significantly correlated with likeness of appearance, texture, flavour and overall acceptability, in agreement with the DPLSR. Visual perception was different among the formulations. The Control formulation was negatively correlated with likeness of appearance and colour. However, B2 correlated positively and significantly with these two parameters. Therefore, salt content in back bacon rashers can be reduced to 2 % without affecting sensory perception. In terms of the intensity of parameters, saltiness significantly correlated with the Control and B2.5 and negatively with B1.5, in accordance with the salt levels in the formulations. These results are in agreement with those presented by Tobin *et al.*[3] in low-fat frankfurters, the higher the salt level the higher the perceived saltiness. The other flavour attributes only showed a significant and negative correlation with B2. No trend in relation with the different formulations was found for tenderness and juiciness; only B2 had a positive and significant correlation with these parameters. However, fibrous perception was correlated with salt content. The correlation was positive for the Control and B2.5 and negative for B2 and B1.5, but not always significant. Redness was positively correlated with B2 and negatively with B1.5.

Table 1. ANOVA values of regression coefficients from APLSR for the different sensory terms of the bacon samples

Sensory terms	Samples			
	Control	B2.5	B2	B1.5
Hedonic				
Appearance	-0.296*	0.007	0.726***	-0.438**
Colour	-0.266**	-0.044	0.475**	-0.165
Texture	0.027	0.094	0.265*	-0.386**
Flavour	0.121	0.115	0.114	-0.351*
Acceptability	0.061	0.093	0.178	-0.332*
Intensity				
Redness	0.131	0.164	0.261*	-0.557***
Tenderness	-0.225	-0.032	0.421***	-0.163
Juiciness	-0.019	0.065	0.270*	-0.316*
Fibrous	0.267*	0.110	-0.250*	-0.126
Crunchiness	0.053	-0.016	-0.180	0.143
Saltiness	0.579*	0.369*	-0.086	-0.862***
Meaty	0.147	0.024	-0.264*	0.092
Metallic	0.137	0.016	-0.268**	0.116
Sweet Aftertaste	-0.086	-0.064	-0.022	0.172

$^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

Characterization and stability

Salt content of back bacon rashers significantly differed (Table 2); values were in agreement with those planned for the formulations. As expected, no significant differences were found in moisture, fat or protein. The variation in ash content reflected the differences in salt levels. Cooking yield was not significantly affected by the salt content of the samples. This finding is in agreement with Fellendorf *et al.*[7], where the authors did not find differences in terms of cooking loss with varying salt levels in white puddings.

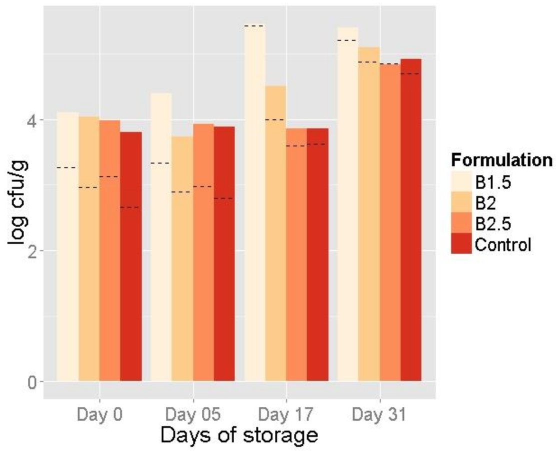
Table 2. Physicochemical characteristics of back bacon rashers

Attributes	Samples				SEM
	Control	B2.5	B2	B1.5	
Cooking Yield (%)	67.49^{a}	70.04^{a}	73.05^{a}	72.98^{a}	1.25
Texture					
Shear Force (N/g)	76.32^{c}	49.26^{a}	51.49^{a}	62.21^{b}	2.96
Composition (%)					
Moisture	65.01^{a}	67.18^{a}	69.54^{a}	67.34^{a}	0.75
Fat	18.11^{a}	14.96^{a}	12.94^{a}	16.35^{a}	0.99
Protein	14.93^{a}	15.71^{a}	15.93^{a}	15.49^{a}	0.25
Ash	3.81^{c}	3.33^{bc}	2.76^{b}	2.00^{a}	0.19
Salt	2.93^{d}	2.47^{c}	1.95^{b}	1.24^{a}	0.17
Colour					
L*	50.70^{a}	50.93^{a}	52.94^{a}	53.54^{a}	0.64
a*	9.43^{a}	9.43^{a}	8.09^{a}	8.49^{a}	0.34
b*	10.36^{a}	10.79^{a}	11.08^{a}	11.20^{a}	0.15
C*	14.02^{a}	14.39^{a}	13.74^{a}	14.09^{a}	0.24
h	47.82^{a}	49.13^{a}	53.91^{a}	53.04^{a}	1.16

SEM: Standard error of the mean.
Different superscript letters in the same row denotes statistical difference ($p<0.05$)

Control samples had significantly higher shear force, followed by B1.5 and B2.5 with similar values and B2. Shear force has been negatively correlated with the tenderness of meat [8]. This correlation is also observed in our study for most of the samples; the ones with higher shear force values were scored as less tender in the sensory analysis (Tables 1, 2). More added salt in meat products has also been related with firmer and less tender products [4, 9]. No significant differences were observed in the colour of the four different bacon formulations. Although non-significant, redness (a*) and Chroma were lowest for B2 (Tables 2). Chroma (saturation index) was highly correlated with colour likeness (r^2=-0.856). In terms of colour, this shows a preference for less saturated samples, in particular B2 (Table 1).

Figure 2. Total Viable Counts (bars) and Lactic Acid Bacteria (dashed lines) of back bacon rashers during storage



Total viable counts and the growth of lactic acid bacteria were slightly affected by salt reduction (Fig 2.), and just after processing all samples had TVC values bellow the standard target of pre-packed bacon (<5 log cfu/g) [10]. Bacteria grew faster in sample B1.5, reaching their maximum number at day 17, while the rest of the samples the TVC continued to increase up to day 31. This growth was fundamentally LAB, accounting for almost all the TVC at days 17 and 31. An increase in TVC in reduced-salt bacon was also observed by Aaslyng *et al.* [5]

IV. CONCLUSION

The salt content of back bacon rashers can be reduced to 2 % without impairing their physicochemical, sensory and microbiological characteristics.

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