EFFECT OF TEXTURE MODIFICATION ON WARMED OVER FLAVOUR DEVELOPMENT IN BEEF MEAT

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Abstract - The aim of this study was to evaluate the effect of thickeners for pureed beef meat used in the dysphasia diet on the WOF development from steaming and *sous-vide* and different chilled storage days (at 4°C for 0, 1, 3, 5 days). A Quantitative Descriptive Analysis (QDA®) and headspace solid micro-extraction (HS-SPME) combined with gas chromatography mass spectrometry (GS-MS) methods were used to assess the Warmed Over Flavour (WOF) and relate them to the secondary lipid oxidation products. Sensory evaluation and identified volatile compounds indicated a significant increase of lipid oxidation in cooked pureed meat after chilled storage. Moreover, the results suggest a positive effect of the inclusion of thickeners for avoiding WOF development in pureed beef products. In addition, steam oven showed better in the prevention of WOF development than *sous- vide* method.

Key words - Pureed beef meat, Lipid oxidation, WOF, Sensory analysis, GC-MS

I. INTRODUCTION

Texture modified foods mainly involves in mincing or pureeing in order to reduce a particle size of the food, in some case, the pureed is added extra fluids then mix with thickening agents to prevent aspiration upon ingestion [1]. However, the result of food product is unattractive, nutritional value loss and reduces the release of natural food flavour[2].

It is a generally well-documented fact the addition of hydrocolloids to meat products induces a significant decrease in flavour release[3]. This fact may be the result of lowering of the diffusion rate in the media due to the increased solution viscosity and molecular binding interactions between the flavour compounds and the hydrocolloid matrix constituents [3].

Furthermore, the combination of cooking and chill storage of textured modified food can lead to an increase in the development of storage flavours, which is referred to as warmed over flavour (WOF), particularly in meat products due to the lipid oxidation [4]. WOF development in texture modified meat is greater because of increasing the rate of lipid oxidation by oxygen introduced into mincing/pureeing and increased surface area of minced/pureed pieces [5].

Numerous studies have been extensively reviewed on how various cooking methods[6] and the final internal temperature [7] on WOF development in cooked beef during chill storage. However, there are very few reports investigating how WOF development in cooked texture modified beef during chilled storage as well as the effect of thickening agents on warmed over flavour development. The aim of this study was to evaluate the effect of the adding thickening agents in pureed beef meat on the WOF development from two cooking methods and different chilled storage days (at 4°C for 0, 1, 3, 5 days).

II. MATERIALS AND METHODS

Pureed meat preparation, cooking and storage. Pureed meat samples were prepared by containing 68% raw meat, 2% waxy starch (Collelldevall), and 30% of mixture of water (95.5%), xanthan (3.8%) (Satiaxane CX-91 de Cargill), and waxy starch (0.7%) (Collelldevall). The Vedella Bencriada beef meats (female) were trimmed of visible fat prior to cutting the muscles into cubes and were then grinded in a rotary screw mincer (Castellball, S.A) through a 4.5-mm plate. The minced samples were again blended with waxy starch to a smooth paste (1mm or less in size) for 15 seconds using blender (model cri 35, Castellvall, S.A.). The mixture of water, xanthan and waxy starch were added to the meat paste during blending for further 15 seconds. The pureed samples were shaped into 100g balls (approximately 1 cm thick). One-fourth of the pureed ball samples were vacuumed-packed and frozen to use them as the freshly samples. Three-fourths of the pureed ball samples were cooked by a steam oven (combi oven) at oven temperature of

100°C until the core temperature was 70°C and *sous-vide* (water bath) at temperature of 70°C for 5 hours. After cooling, all the pureed samples were independently packaged into the plastic bags and chill-stored at 4 ºC for up to 5 days to investigate WOF development. All cooked-stored pureed samples were reheated in a steam oven at 100°C for 10 min.

Sensory Evaluation. A Quantitative Descriptive Analysis was conducted by a six-member trained panel. Prior to sensory evaluation, the generation and selection of the descriptors was carried out by open discussion in two sessions. The pureed meat products were evaluated for odour (overall intensity, fatty odour, beef odour, liver/metallic, WOF) and flavour (general intensity, beef, sweet, liver, metallic, bitter, fat, WOF).The intensity of each descriptor was scored on an unstructured 10-point scoring scale, where 0 means absence or very low intensity of the descriptor and 10 means very high intensity of the descriptor. Evaluation was carried out in 6 sessions per system of cooking.

Volatile compounds analysis. The volatile compounds of each sample were extracted using a SPME fibre coated with 75µm carboxen/polydimethylsiloxane (CAR/PDMS) (Supleco Co. Spain) and analysed using a GC-MS (Agilent 6850). Pureed sample (1.0g) was weighed and placed in a 10mL vial (Supleco Co. Spain). 5 µL of internal standard (IS) 2-methyl-1-pentanol (100mg/L in Milli-Q water) was then added to each sample. The vial was equilibrated in 10 min at 60°C and the extraction of volatile compounds was performed in 30 mins. The fiber was then immediately thermal desorbed at 240 °C in the injector port in the split mode (split ratio 15:1) for 1.5 min. A Capillary GC column DB- 5ms (30m × 0.25 mm, 1.0 µm, Agilent, Spain) was used to separate the volatile compounds. The GC oven temperature was held at 40°C for 3 min, ramped to 200 °C at the rate of 5 °C min^{-1} and maintained at 200°C for 10 min. Helium was used as carrier gas with a flow rate of 0.8 ml min^{-1}. The mass spectrometer operated in electron impact ionisation mode with an emission current of 10 µA and a multiplier voltage of 2000 V. The mass spectrometer scanned masses from *m*/*z* 30 to 300 at a rate of 1.0 scan s^{-1}

Data analysis. Statistical analysis was carried out with the SAS statistical package. A General Linear Model (GLM) was used to analyse the effect of the treatment and storage time on the aroma compounds. The ANOVA test for sensory analysis data was performed on the mean score (6 panellists) for each sample. The model included treatment, storage time and session as fixed effects. Differences among means were tested with the Tukey test ($P < 0.05$).

III. RESULTS AND DISSCUSION

Sensory Evaluation. The significant levels for each sensory attributes ad by a steam oven and *sous-vide* method are shown in Table 1. The data showed significant differences between freshly cooked and chill-stored pureed meat regarding WOF odour and flavour attributes in both cooking methods. Panellists noted a significant increase of WOF intensity and significant decrease in beef flavour when increasing chilled storage time. Furthermore, WOF intensity decreased when thickeners were added to pureed samples. These samples containing thickeners had significantly lower intensity of WOF, were sweeter and fattier than the samples without thickeners. Bitter taste was found only in *sous-vide* cooked samples. According to Pearson & Gray [8], the sensory perception of WOF in cooked chill-stored meats is the primary results of the autoxidation of unsaturated fatty acids. However, there are reports that reactions involving the degradation of proteins and some other components, e.g. the Maillard-derived aroma volatiles associated with the aroma of freshly cooked meat, leading to a decrease in meatiness, may also be implicated of WOF development [9]. Furthermore, addition of starch and xanthan may induce a significant decrease in flavour release may be the result of lowering of the diffusion rate in the media due to the increased solution viscosity [3]. The sensory results obtained are in agreement with a number of studies showing that freshly cooked meats initially have a high proportion of desirable meaty aromas and tastes that quickly fade and are replaced by rancid following a short period of chilled storage [10].

Volatile Compounds Analysis. The volatile compounds of pureed beef meat from two cooking methods extracted by SPME combined with GC-MS analysis are presented in Table 2. In this study, 16 major volatile compounds were indentified in the headspace of cooked pureed beef by both cooking methods. Most of these compounds represented well known products of lipid oxidation which could be associated with the WOF perception in meat since previous studies have found similar results in cook-chill stored meat [11]. The volatiles indentified significantly increase when increasing the chill storage time. Especially a larger increase was observed regarding hexanal, pentanal, and 1-octen-3-ol, which already showed marked increase in day 1. Moreover, the intensity of these volatiles was significantly reduced when thickeners were added to pureed meat samples. Both cooking methods showed similar; however, several differences were detected during chill storage. *Sous-vide* cooked samples achieved the highest values of hexanal and 2-heptanone which associated to WOF after 1 day storage while no significant differences were observed in steamed samples. Other studies showed that hexanal was the predominant aldehyde in cooked beef, which is a primary contributor in the WOF development and its concentration increased at the most rapid rate during chill storage, when compared with other aldehydes [12]. Furthermore, there were no significant differences for lipid derived volatiles between day 3 and day 5 chill stored samples for both cooking methods.

IV. CONCLUSIONS

Chill storage had a significant effect on the lipid oxidation and subsequent development of WOF in pureed meat. Steam oven is better than *sous vide* cooking method to minimize WOF development. The addition of thickeners agents in pureed beef meat resulted in a significant decrease in WOF flavour release and a significant increase of sweet taste when compared to pureed meat itself. The relationship between volatile compounds, sensory attributes and processing conditions (thickener added, cooking methods, chill storage) will be deeply investigated.

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Table 1 Significant level and Root Standard Error (RSME) for the sensory attributes of pureed beef samples cooked by steam oven and *sous-vide* method

Atributes[4]	**Steam Oven**			***Sous-vide***		
	Significant level[1]		RSME	Significant level[1]		RSME
	Treatment[2]	Storage[3]		Treatment[2]	Storage[3]	
Overall intensity-O	NS	NS	0.2458	NS	*	0.1669
Fatty-O	NS	NS	0.3169	NS	NS	0.2547
Beef-O	NS	*	0.3982	NS	**	0.4757
Liver/Metallic-O	NS	**	0.1435	NS	*	0.2817
WOF-O	**	***	0.2332	*	**	0.4038
Overall intensity-F	NS	NS	0.5359	*	NS	0.3445
Beef-F	NS	*	0.5752	NS	**	0.4638
Sweet-F	*	NS	0.2369	**	NS	0.1914
Liver-F	*	NS	0.3862	NS	**	0.2180
Metallic-F	NS	NS	0.3298	NS	NS	0.2348
Bitter-F	NS	NS	0.4064	**	NS	0.1777
Fat-F	*	NS	0.3021	**	*	0.1221
WOF-F	**	**	0.4337	**	***	0.3015

[a] Different letters in a row indicate significance at $p<0.05$
Significance level[1]: NS (no significant); *: $p<0.05$; **: $0.001<p<0.01$; ***: $p<0.001$
Treatment[2]: control, ST+XT (starch + xanthenes)
Storage time[2]: 0 (fresh), 1 (1 day-storage), 3 (3 days-storage)
[4]Suffix to sensory attribute indicates O:Odour and F:Flavour

Table 2 Significant level and Root Standard Error (RSME) for Volatile compounds of pureed beef samples cooked by steam oven and *sous-vide* method.

Volatile compounds	**Steam Oven**			***Sous-vide***		
	Significant level[1]		RSME	Significant level[1]		RSME
	Treatment[2]	Storage[3]		Treatment[2]	Storage[3]	
1-Penten-3-ol	**	**	25.6	*	**	35.0
Pentanal	**	***	361.8	*	***	122.4
2-Butanone,3-hydroxy	NS	NS	41.8	NS	**	8.3
1-Pentanol	**	**	158.6	NS	**	155.2
Hexanal	**	***	4382.9	*	***	2680.3
1-Hexanol	**	***	20.6	NS	**	25.6
2-Heptanone	**	***	17.6	NS	**	216.6
Heptanal	*	**	395.1	*	**	144.7
2-Heptenal, (E)	*	***	10.7	*	*	10.3
Benzaldehyde	NS	**	41.8	NS	**	36.2
1-Octen-3-ol	**	***	190.0	**	**	288.5
2,3-Octanedione	*	**	190.4	**	**	207.3
Furan, 2-pentyl	**	**	63.5	**	*	67.4
Octanal	*	**	209.4	NS	**	83.1
2-Octenal,(E)-	**	**	12.8	*	*	16.3
Nonanal	*	**	136.1	*	**	88.2

[a] Different letters in a row indicate significance at $p<0.05$
Significance level[1]: NS (no significant); *: $p<0.05$; **: $0.001<p<0.01$; ***: $p<0.001$
Treatment[3]: control, ST+XT (starch + xanthenes)
Storage time[3]: 0 (fresh), 1 (1 day-storage), 3 (3 days-storage), 5(5 days-storage)