LWT - Food Science and Technology 74 (2016) 92–98

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Physico-chemical properties of reduced-fat beef species sausage with pork back fat replaced by pineapple dietary fibres and water

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A R T I C L E I N F O

Article history:
Received 3 December 2015
Received in revised form
31 May 2016
Accepted 3 July 2016
Available online 4 July 2016

Keywords:
Dietary fibre
Ground meat
Species sausage
Physico-chemical characteristics

A B S T R A C T

The effects of pineapple dietary fibres (PDF) on physical, chemical and textural attributes of species sausage were investigated. Samples containing 1% of three different PDF (NSP60, NSP100, NSP200) and water (replacing pork back fat) were compared to the control. The control species sausages differed in moisture, protein, total fat, ash and total fibre from those containing fibre. Fibre containing sausages were similar in terms of proximate composition. The ground meat mixture stability was based on total expressible fluid (TEF), cooking loss and purge. The NSP200 samples had cooking loss and TEF similar to the control. NSP100 samples had the lowest cooking loss though similar to both the control and NSP200 sausages. NSP60 samples had higher cooking loss and TEF values than all sausage samples. Addition of fibre and water caused increases in purge, lightness, hue and chroma while reducing pH and textural properties. Fibre NSP100 was the most suitable for use in species sausage.

1. Introduction

The association of fat with a variety of pathologies has resulted in the food industry investing in research into new products. Consumer demands for healthier meat products as well as the ferocious competition within the food industry are the major drivers of such research (Jimenez-Colmenero, 2000). Fat, however, is an important source of energy and essential fatty acids as well as carrier of fat soluble vitamins in meat products (Choi et al., 2009; Vural, Javidipour, & Ozbus, 2004). Additionally, fat plays an important role in stabilisation of meat emulsions, reduction of cooking losses, improving texture, tenderness, juiciness and mouth feel (Kim et al., 2010). The success of any food product, however, is dependent on its organoleptic, textural and nutritional qualities. Stability in storage, cooking yield and cost of production are also important in this regard (Heinz & Hautzinger, 2007; Mapanda, Hoffman, Mellett, & Muller, 2015). Low-fat meat products that are not acceptable in such terms will not sell regardless of the health characteristics attributed to them (Jimenez-Colmenero, 2000).

Various procedures have been followed to reduce fat content in meat products, either on their own or in combination with other ingredients, and are based on selecting suitable meat ingredients in terms of composition and functionality, using non-meat ingredients that lend desirable characteristics (especially those enhancing water holding) and adopting appropriate manufacturing practices that induce functionality or vary final product composition (Jimenez-Colmenero, 1996). The practices are meant to offset the undesired effects of formula changes and thus maintaining the product characteristics to compete with non-substituted original products (Giese, 1992). Inulin, cereal and fruit fibres and water have been used for such purposes in the meat industry (Fernandez-Lopez et al., 2008). These practices should pay attention to the nutritional factors, the safety of the products, technological and/or processibility factors, general consumer appreciation, legal regulations as well as the costs of the products (Jimenez-Colmenero, 2000). The dietary fibres provide technological functions such as water holding and retention thereby reducing shrinkage, cooking loss, drip loss during storage, minimising production costs without affecting sensory properties (Besbes, Attia, Deroanne, Makni, & Blecker, 2008; Biswas, Kumar, Bhosle, Sahoo, & Chatli, 2011).

Most ingredients are functional, as they have the ability to introduce or improve certain textural and organoleptic quality characteristics, whilst improving water binding, counteracting fat separation and preservation (Heinz & Hautzinger, 2007). Functionality is also attributed to an ingredient's ability to provide additional physiological and health benefits beyond their basic

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http://dx.doi.org/10.1016/j.lwt.2016.07.007
0023-6438/

nutrition value (Thomas & Earl, 1994; International Life Sciences Institute, 1999; American Dietetic Association, 2004; Health Canada, 2004; International Food Information Council, 2006). Addition of functional ingredients in meat products is also an attempt to change the meat products' image in these health conscious days (Fernandez-Gines, Fernandez-Lopez, Sayas-Barber, Sendra, & Perez-AAlvarez, 2004).

Dietary fibres from various sources have been used as fat replacers and as means to introduce functionality in meat products (Eim, Simal, Rossello, & Femenia, 2008; Fernandez-Lopez, Sendra, Sayas-Barbera, Navarro, & Perez-Alvarez, 2008; Garcia, Caceres, & Selgas, 2007; Keeton, 1994; Mansour & Khalil, 1997; Grigelmo-Miguel, Gorinstein, & MartoAn-Belloso, 1999). Dietary fibre has a protective effect against weight gain and obesity, cardiovascular disease (CVD), infectious and respiratory diseases (WHO, 2003). Fillers are low protein plant abstracts such as cereals, roots, tubers and vegetables or starches and flours. These components are added to "fill up" product volumes or add new components that are not usually inherent in meat such as carbohydrates or fibre (Heinz & Hautzinger, 2007).

The objective of this study was to evaluate the effects of three commercial pineapple dietary fibres [(PDF), (NSP60, NSP100 and NSP200)] in combination with water, on the physico-chemical, shelf-life stability, and textural characteristics of reduced fat beef species sausage. The fibres were incorporated at a level of 1% and water was added in accordance to the water holding capacity of the specific fibre (as per supplier recommendations, Summerpride Pty Ltd, S.A.).

2. Materials and methods

2.1. Raw materials

Vacuum packed lean beef meat, (90% lean meat and 10% fat), was obtained from a reputable meat distributor (Roelcor Meats, Kraaifontein, Cape Town) and stored at −20 °C until used. Pork back fat was obtained from PK Vleis (Stikland, Cape Town) and stored at −20 °C. Vinegar (3% in sausage formulation) and a spice mix (2% in sausage formulation); which consisted of salt (80% of the spice mix), thyme (10%), coriander (7.5%) and white pepper (2.5%), were purchased at a local supermarket (Pick 'n Pay, Bellville). Sheep casings were purchased from Crown National (Montague Gardens, Cape Town). Three commercial (Fibiz™) pineapple dietary fibres (NSP60, NSP100 and NSP200) of neutral taste and aroma were provided by Summerpride Foods (PTY) Ltd. (East London, South Africa). The properties of the fibres are outlined in Table 1.

Table 1
Specific characteristics of the three Fibiz™ pineapple dietary fibres (NSP60, NSP100, and NSP200) as supplied by product specification sheets.

Characteristic	Fibre type		
	NSP60	NSP100	NSP200
WBC[a] (g/g fibre)	8	7.4	7.8
OBC[b] (g/g fibre)	6	4.2	5.0
Particle size (μm)	<63	63˃<100	100˃<400
Colour	7.06	4.44	5.54
L/a ratio			
a/b ratio	−0.009	0.10	−2.88
pH	4.45	4.37	4.53
Instrumental Lightness[c]	85.36	80.91	80.25

[a] WBC = Water binding capacity.
[b] OBC = Oil binding capacity.
[c] Parameters determined in laboratory.

2.2. Manufacture of species sausage

All sausages were manufactured as beef species sausage according to SANS 885:2011. The adjusted formulations used in the manufacture of the control, the different species sausage batches containing the three different PDF at 1.0% level are shown in Table 2. Note that for the formulations containing fibre, fat was replaced by an equal weight of the added fibre as well as the water to be bound by that fibre in accordance to Fibiz™ water binding specifications (Table 1). All formulations (control, NSP60, NSP100, and NSP200) were manufactured in six replicate batches. The meat and fat were thawed overnight at 4 °C and separately minced through a 6 mm dice. The minced meat and fat, vinegar, fibre and spice mix were mixed with gradual addition of crushed ice-water using a hand mixer, ensuring the temperature did not exceed 10 °C.

Six samples of approximately 25 g each were drawn from each ground batch for each formulation for the analysis of "emulsion" stability, making a total of 36 samples. The rest of the ground samples were used to manufacture sausages per batch per formulation for shelf-life and proximate composition analysis.

The sausages were manufactured by stuffing the ground mixtures into 20 mm sheep casings, packaged into punnets containing absorbent paper, and covered in low-density polyethylene wrap (LDPE) (moisture vapour transfer rate of 585 g/m^2/24 h/1 atm, O_2 permeability of 25 000 cm^3/m^2/24 h/1 atm, and a CO_2 permeability of 180 000 cm^3/m^2/24 h/1 atm) as normally done in South African supermarkets, weighed and stored at 4 °C. For the shelf-life stability analysis, four packages of sausages were randomly selected from each of the 6 batches per formulation, making 24 samples of sausages per formulation, for analysis of pH, colour, purge, cooking-loss, and texture profile over a period of 7 days. Of the four samples drawn, random computer generated numbers were allocated as a means to reduce bias in the order of analysis for days 0, 2, 4 and 7. Colour and pH analysis were performed from day 0–7 on all the samples, whilst purge started at day 2, cooking loss and texture profile analysis (TPA) were performed only on day-7 samples. The remaining sausages from each batch were vacuum packaged and stored at −60 °C for proximate analysis.

2.3. "Emulsion" stability

"Emulsion" stability was determined by a modified procedure described by Hughes, Confrades, and Troy (1997). Although it is recognised that these samples were not in fact emulsions, this procedure is ideal for the determination of water binding ability/capacity in meat mixtures such as found in ground meat products and/or emulsions (Yang, Choi, Jeon, Park, & Joo, 2007; Zhigang & Zhongyue, 2011). Six replicate samples 25 g from each batch were weighed into 50 ml centrifuge tubes and centrifuged at 3000 rpm

Table 2
Formulation of species sausage per 500 g batch for the four different formulations (control, and the three batches; NSP60, NSP100, and NSP200, containing 1% of the specific fibre).

Ingredient	Control (%)	Control (g)	NSP60 (g)	NSP100 (g)	NSP200 (g)
Lean beef	57	285	285	285	285
Pork back fat	26	130	85	88	86
Water	12	60	100	97	99
Vinegar	3	15	15	15	15
Spices	2	10	10	10	10
Fibre	0	0	5	5	5
Total	100	500	500	500	500
TME[a]	83	83	74	74.6	74.2

[a] Calculated Total Meat equivalent (TME) = % Lean Meat + % Total Fat where % Lean Meat = % N in the sample × 30 (Anonymous, 2011).