# SENSORY ANALYSIS OF COOKED FRESH MEAT SAUSAGES CONTAINING BEEF OFFAL

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**OPSOMMING**

Voldoende toegang tot goeie kwaliteit vleisproteïen is belangrik vir die ontwikkelende gemeenskappe in Suid-Afrika, alhoewel vleisproteïen baie duur is. Vleisprodukte is tog uitstekende bronne van hoë gehalte of kwaliteit proteïen en is baie duur. Die doel van hierdie studie was om aanvaarbare, voedsame en bekostigbare worsprodukte wat beesafval bevat te maak. Tydens 'n voorlopige ondersoek is 'n verskeidenheid van 25 formulasies voorberei en geëvalueer vir eienskappe soos aroma, smaak, tekstuur en kleur met behulp van 'n tuisverbruikerstoets.

Die vyf mees aanvaarbare worsprodukte wat deur die verbruikerspaneel aangewys is, is gekies vir verdere evaluasie. Weens godsdienstige redes is een van die vyf finale formulerings weggelaat omdat dit varkvleis bevat het. Die finale vier formulerings is derhalwe saam met die kontrole gekies vir verdere evaluasie. Die proef het vervolgens bestaan uit 'n kontrole formulering en nog vier ander formulerings wat beesafval bevat. Formulerings 1 en 2 het beesvleis, hart, ingewande en milt bevat en formulerings 3 en 4 het beeslewer, maag (blaarpens) en longe bevat. Die kontrole formulering het slegs beesvleis, krummels en speserye bevat. 'n Verbruikerspaneel en 'n opgeleide sintuiglike paneel (12 lede) het die sintuiglike eienskappe van die gaar wors geëvalueer.

'n Opgeleide swart proe-paneel (12 lede) is gebruik om die wors te evalueer. Dit is gedoen aan die hand van 'n agt-punt evalueringskaal (1 – mees smaaklose, 8 – die mees intense smaak). Die proe-paneel was saamgestel uit ervare proe-paneellede wat almal afval eet.

Die verbruikerspaneel het die aroma, smaak en tekstuur geëvalueer met behulp van 'n vyf-punt evalueringskaal (1 – hou absoluut niks daarvan nie, 5 – hou baie daarvan). Die verbruikerspaneel was saamgestel uit universiteitstudente van die Universiteit van Suid-Afrika (UNISA) en die Tshwane Universiteit van Tegnologie (TUT). Beide universiteite is in Pretoria, in die Gauteng Provinsie van Suid-Afrika geleë. Vyf van die 63 paneellede was blanke Suid-Afrikaners en die res was swart Suid-Afrikaners en almal eet afval. Die produkte is een vir een bedien en gekodeer met ewekansige nommers. Die paneellede het nie die produkte in dieselfde volgorde ontvang nie, sodat elke worsproduk 'n gelyke kans gehad het om eerste bedien te word.

Die bedieningstemperatuur vir al die proefmonsters was gekontroleer deur die proefmonsters warm te hou in 'n oond teen 'n temperatuur van 80°C. Die paneellede is ook versoek om aan te dui of hulle die worsprodukte sou koop al dan nie. Variansie analise is gebruik om te bepaal of daar betekenisvolle verskille tussen die vyf formulerings was ten opsigte van die sintuiglike eienskappe. 'n Hoofkomponentanalise is gedoen op die opgeleide paneel se resultate om die sintuiglike eienskappe wat diskrimineer tussen die verskillende formulerings uit te wys of te

onderskei.

Volgens die verbruikerspaneel was die kontrole formulering en formulering 2 die mees aanvaarbare in terme van die eienskappe soos aroma, smaak en tekstuur, en volgens die opgeleide paneel was dit die aroma intensiteit en voorkoms van sappigheid die mees aanvaarbare eienskappe. Vir beide die verbruikers – en die opgeleide paneel, was die aroma intensiteit en voorkoms van sappigheid van formulering 2 aanvaarbaar. Die vebruikerspaneel het aangedui dat hul bereid sou wees om die worsproduk van die kontrole formulering en formulering 2 te koop. Vleisworsprodukte wat beesafval bevat, soos formulering 2, is aanvaarbaar en bekostigbaar en sal die minder gegoede sektore in die Suid-Afrikaanse gemeenskap kan bevoordeel indien hulle dit sou koop en eet, aangesien afval 'n algemene en gewilde produk is onder die plaaslike swart bevolking van Suid-Afrika.

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## INTRODUCTION

Meat sausages are more economical than whole meat cuts since they are usually manufactured from the trimmings of primal cuts such as pork loins, hams, shoulders and by-products (Pearson & Tauber, 1984:188-190). Apart from being more economical, sausage products are also found to be of good nutritional value in that they contain significant amounts of high quality proteins and are good sources of various essential minerals and vitamins such as iron, zinc, folic acid and vitamin $B_6$ and $B_{12}$. Sausage products are also quick to prepare and cook (Pearson & Tauber, 1984:188).

In South Africa, sausages are categorised as raw species sausage, raw mixed-species sausage and raw boerewors sausage (Department of National Health & Population Development, 1990:2-3). Raw species sausage is sausage that is manufactured predominantly from the meat of a specific species of animal or bird and should contain a minimum of 75% of the predominant species. A maximum of 25% of the product may be the meat of any one or more species, other than the predominant species and it may not contain more than 30% fat. (Department of National Health & Population Development, 1990:2-3). Raw mixed-species sausage is sausage that is manufactured from a mixture of the meat of two or more species of animal, contains a minimum of 75% total meat and does not contain more than 30% fat. (Department of National Health & Population Development, 1990:2-3). Raw boerewors sausage should be manufactured from the meat of an animal of bovine, ovine or porcine species or a mixture of the meat of two or more of these species of animal. Raw boerewors should contain a minimum of 90% total meat content and should not contain more than 30% fat (Department of National Health & Population Development, 1990:2-3).

Research has been previously conducted utilising edible meat by-products (such as tripe) during sausage making and is reported by Wilson (1960:349), Kramlich (1960:493-494), Rust (1976:85) and Pearson and Tauber (1984:109-211). The inclusion of beef and/or pork trimmings, head meat, cheek meat, spleen, lungs, intestines, liver and heart during the processing of sausages is also encouraged by Ockerman and Hansen (1988:38) and Ranken (2000:138-145). The literature, although informative, nevertheless provides limited information about the processing of fresh meat sausages using beef offal. Therefore more research is required in this area with regard to the cultural and traditional acceptability and the nutritional value of meat by -products, such as offal.

Therefore, the main aim of this study is to determine the acceptability of cooked meat sausages that contain beef offal when compared with a control sample containing beef trimmings. This study is based on the hypothesis that offal is a popular commodity in the local black communities in South Africa. Trained and consumer panels from the local black ethnic groups were consequently used to evaluate the sensory attributes of the products.

## MATERIALS AND METHODS

### Formulations of raw fresh meat sausages containing beef offal

During preliminary trials, a variety of about 25 formulations were prepared and tested for sensory attributes such as aroma, flavour, texture and colour. Out of the 25 formulations, five were selected as the best formulations or recipes, as judged by the consumer panel. One of the five best formulations contained pork trimmings and therefore was excluded from this study, because of religious factors. Thus, the final four formulations were evaluated for sensory and chemical analysis. See examples of the top four formulations of fresh meat sausages containing beef offal and the control formulation in Table 1.

Five replications of 10kg batch-sizes of the control and of each of the selected formulations of raw fresh meat sausages containing beef offal was prepared and a standard mixture of spices (Crown National's Eezy Braaiwors® spice) was added to each formulation. The control formulation only contained beef trimmings, rusk and the standard mixture of spices. Formulations 1 and 2 contained beef trimmings (B) and red and rough beef offal such as: spleen (S), heart (H), and intestines (IN), with rusk or Multibase™ (MB); whereas formulations 3 and 4 contained beef trimmings (B) and red and rough beef offal such as: liver (Li), lungs (Lu) and stomachs (ST) with rusk or Multibase™.

Rusk is a specially prepared commercial material for the meat industry made from wheat flour and yeast (Ranken, 2000:137). Rusk is normally used during the manufacturing of fresh meat sausages to retain moisture, thus improving texture (Ranken, 2000:137) MultiBase™ is manufactured by the Specialized Protein Products Company (SPP™) and is a soy protein product that can be used during the making of processed meat products, such as fresh and emulsion type meat products (Hill, 2007).

The five 10kg batches of each of the formulations which were prepared, were packaged on polystyrene trays with blotting sheets to absorb the exudate from the sausage and wrapped with polyvinyl chloride (PVC) film. The packages were then frozen at -20°C and later they were sequentially thawed at 4°C and cooked.

### Cooking procedure for the control formulation and the raw fresh meat sausage formulations containing beef offal

One replication per day of the five batches of fresh meat sausages containing beef offal and

**TABLE 1: CONTROL AND FOUR SELECTED FORMULATIONS OF RAW FRESH MEAT SAUSAGES CONTAINING BEEF OFFAL**

| Ingredients (in descending order of mass) | C (B, R) | 1 (B, IN, S, H & R) | 2 (B, IN, S, H & MB) | 3 (B, Lu, ST, Li, & R) | 4 (B, Lu, ST, Li & MB) |
|---|---|---|---|---|---|
| | % | % | % | % | % |
| Beef trimmings (70:30) | 60 | 26 | 26 | 26 | 26 |
| Beef heart | | **15** | **15** | | |
| Beef liver | | | | **15** | **15** |
| Beef intestines | | **10** | **10** | | |
| Beef stomachs | | | | **10** | **10** |
| Beef lungs | | | | **9** | **9** |
| Beef spleen | | **9** | **9** | | |
| Ice | 28 | 28 | 28 | 28 | 28 |
| Eezy Braaiwors® spice mix [a] | 9 | 9 | 9 | 9 | 9 |
| Multibase™ [b] | | | 2 | | 2 |
| Rusk | 2 | 2 | | 2 | |
| Vinegar | 1 | 1 | 1 | 1 | 1 |
| Total formulation | 100 | 100 | 100 | 100 | 100 |

[a] Contains: Vegetable protein, cereal, salt, spices and spice extracts, phosphates, anti-oxidant, food colour erythrosine (C145430), flavourant, Preservative: sodium metabisulphite (Yields 450 ppm $SO_2$ in finished product). Source: Crown National Eezy Braaiwors® Spice pack formulation

[b] Specialized Protein Product with 40-45 % protein concentrate, C= Control, B=Beef trimmings, IN=Intestines, S= Spleen, H= Heart, R= Rusk, Li= Liver, ST = Stomachs, Lu = Lung and MB = Multibase™ [b]

**Highlighted** values **(in bold)** in the table show the amounts of red and rough offal parts (beef hearts, livers, lungs, spleens, intestines and stomachs) added in formulations 1, 2, 3 & 4

the control were thawed for 24 hours in a 4°C cold room prior to being cooked. Thawing loss data was determined on the day of cooking by the following:

(a) the mass (in grams) of the thawed packaged sausage product (this included the sausage, blotting sheet, exudate, polystyrene tray and PVC film),

(b) the mass (in grams) of the sausage, weighed separately,

(c) the mass (in grams) of the PVC film, exudate, tray and blotting sheet, and finally,

(d) the mass (in grams) of the PVC film and polystyrene tray without the blotting sheet. These measurements were calculated as the final thawing loss data and were recorded on the cooking form for calculation purposes.

The sausages were then cooked the morning after thawing, in a well-equipped, temperature-controlled sensory laboratory (Sensory Evaluation Laboratory, ARC-Irene). Five Pineware™ Electric non-stick frying pans (model number FPC81 230V, 1200W) supplied by the Makro® retail outlet, were used for cooking the sausages. The mass of the cold electric frying pan (without the electric cord) with and without the raw sausage mass was recorded before the sausages were cooked. The sausages were cooked at 135°C (setting number 4) for ten minutes, after which the temperature was reduced to 105°C (setting number 2) for 20 to 25 minutes.

The sausages were cooked for five minutes before being turned and before the water was added, as required, to prevent the sausage from sticking to the pan. This turning procedure was repeated every five minutes, with a constant loosening of the sausage from the pan with a plastic spatula to prevent sticking of the sausage and bursting of the sausage casing. The total cooking time, amount of water used during cooking and the internal sausage temperature

was recorded at the end of each cooking period.

The mass (in grams) of the cooked sausage in the pan together with the drip loss was recorded immediately after cooking. The small amount of drip loss from each sausage sample was poured into coded plates and the mass of the residual drip loss in the pan together with the mass of the pan were also recorded. The total cooking loss was calculated in the following manner:

$$\text{Total cooking loss \%} = \frac{\text{Calculated mass of raw sausage} - \text{mass of cooked sausage}}{\text{Calculated mass of raw sausage}} \times 100\%$$

After all the cooking masses were recorded, the sausages were cut into small pieces of 5cm long using an electric knife, to ensure uniform sausage piece lengths and cut surfaces for the sensory evaluation. The pieces of sausage were then placed into heated 100ml glass beakers with a cut surface facing downwards and each beaker was covered with a coded 90mm by 90mm aluminium foil square to prevent evaporation and to concentrate the odours and flavours.

The foil was pre-coded with a randomly-assigned three digit code which was also recorded earlier on the evaluation forms. The covered beakers were then placed in an oven set at 80° C for a maximum of five minutes to keep all the samples uniformly warm before serving them to the sensory taste panel. The sausage samples from each formulation were then taken out of the

**TABLE 2: LEXICON FOR THE DESCRIPTIVE SENSORY EVALUATION OF THE CONTROL AND OTHER FOUR FORMULATIONS OF RAW FRESH MEAT SAUSAGES CONTAINING BEEF OFFAL**

| ATTRIBUTES | Description |
|---|---|
| **AROMA** | Instructions |
| Overall sausage aroma | Aroma associated with a typical sausage aroma that is pleasant, beefy, spicy and meaty. |
| Liver | Aromatics associated with cooked beef liver, could be present but not overpowering (not too intense). |
| Offal | Aromatics associated with cooked offal such as a mixture of beef trimmings including lungs, stomach, intestines and spleen. Could be present but not too overpowering or intense. |
| **APPEARANCE** | Remove the sausage by inserting the fork into it and look at the bottom of the cut surface of the sausage first. |
| Initial impression of juiciness | The appearance of juiciness in the product which is a combination of oil or fat and water. The appearance is judged by first looking at the bottom cut surface and then when pressing the sausage lightly between the fingers. |
| **TEXTURE** | This is evaluated by biting into the cut surface of the sausage and chewing lightly on the filling. |
| Consistency of filling in the mouth | The consistency refers to the cohesiveness of the filling. How much does the filling hold together or stay together or break up when beginning to chew.<br>Pasty – smooth but sticking to top of mouth.<br>Compact – firm or solid, sticks together. |
| Chewiness | The amount and nature of chewing required.<br>(If it is soft and mushy, it is easy to swallow. If it is chewy and tough it requires a lot of energy to chew it.) |
| **FLAVOUR** | Judged or evaluated while eating the sausage. |
| Overall sausage taste | Typical sausage flavour and taste should be easily detectable in a sausage (and therefore easy to identify). |
| Overall liver taste | A liver taste that is readily detectable part of the overall taste of the sausage. |
| Overall offal taste | An offal taste that is part of the overall taste of the sausage. |
| Mouth-coating | Measured as the oiliness or coating of fat left on the palate and sides of the mouth immediately after swallowing the sample. |

oven, placed on a pre-heated sand bath (100° C) in the correct, randomly-allocated serving order, which was recorded earlier on the evaluation forms. The samples were then served to the trained panel in individual sensory booths under white light. Each sample had an equal chance of being served first to the trained panel.

**Sensory evaluation**

**Trained panel** A black ethnic twelve-member trained panel was used to evaluate the sensory characteristics of the cooked, offal-containing sausages. The twelve-member panel consisted of four Food Technology Master's degree students (who were familiar with sensory analysis procedures), five meat-processing learners and three matriculated black students who were offal eaters from the local township, Tembisa.

The panellists were trained for four consecutive days in order to develop the lexicon (shown in Table 2) and also to become familiar with the descriptive analysis attributes. After the training, the panel evaluated the sausage samples on five consecutive days for a period of two consecutive hours per day while seated in individual sensory booths. Distilled water and peeled carrot rings were served to the panel as palate cleansers before and in-between tasting the respective samples. A score sheet with an eight-point category scale where 1 represented an extremely bland or weak flavour and 8 represented an extremely intense or strong flavour was provided to the trained panel to evaluate sausage samples.

The following sensory quality attributes were evaluated: aroma intensity (overall sausage aroma, liver aroma and offal aroma), appearance (initial impression of juiciness), texture (consistency of the filling in the mouth and the chewiness of the particles in the mouth), flavour (overall sausage flavour, overall liver flavour, and the overall offal flavour) and mouth-coating (measured by the presence of oiliness or coating of fat left on the palate and inside of the mouth immediately after swallowing the sample).

**Consumer panel** An untrained consumer panel that consisted of a total of 63 members compared the four cooked meat sausage formulations containing beef offal with the control for overall acceptability (aroma, flavour and texture) on a five-point hedonic scale (1 represented disliked extremely and 5 represented liked extremely). The panel members were university students selected from two institutions, namely: the University of South Africa (UNISA) (30 students were selected) and the Tshwane University of Technology (TUT) (33 students were selected). Both institutions are located in Pretoria, in the Gauteng Province of South Africa.

Five members of the panel were Caucasian South Africans and the rest were black South Africans. The panel members were all offal eaters and were divided roughly into two groups. The two groups tasted samples in two different venues respectively, namely: TUT's Arcadia Campus and the Agricultural Research Council's (ARC) Meat Industry Centre (MIC) on the Irene Campus. The UNISA students were attending a meat processing course at the Meat Industry Centre (MIC) when they were requested to be part of the consumer panel.

The consumer panel members were seated in individual sensory booths under white light. They were provided with distilled water and unsalted crackers to cleanse their palates before and in-between tasting the respective cooked sausage samples. A score sheet with a five-point category scale was provided to each member of the consumer panel to evaluate the sausage samples. Sausage samples were evaluated one at a time. Each sample had an equal chance of being served first to the consumer panel.

The serving temperature for all samples was

maintained by keeping the samples in ovens set to 80°C before each serving. The panellists were requested to indicate if they would buy the sausages or not after evaluating the aroma, taste and texture of the individual products. Cooked fresh meat sausages containing beef offal were prepared and served as for the trained panel. Cooking losses were not determined in this part of the experiment because of time constraints as it was more important to serve the samples when they were still hot.

**Statistical analyses**

The data obtained from cooking and the descriptive sensory data from the five replications of cooked sausages were statistically analysed using a randomised complete block design, to determine if there were any statistical differences between the control and the four raw fresh meat sausage formulations containing beef offal. Data were analysed by the ARC Biometry Unit, using the statistical program GenStat® (Payne, 2003).

Factorial ANOVA was used to test for the panel-by-product interaction (MacFie, 2006). Means per row were separated using Fisher's protected t-test. The least significant difference was based on a 5% level ($p \leq 0,05$). Principal component analysis (PCA) was done to determine (and identify) the smallest number of the latent variables, called principal components. This process was carried out to identify factors that differentiated the sausage samples.

Correlation coefficients (r) were also determined and they summarised the strength of the relationship between the attributes and their values lying between two random variates ($-1 < r < +1$). According to Draper and Smith (1981:709), this only shows the extent to which two variates are linearly related and does not imply any causal relationship between them. A negative value (-1) indicates a perfect inverse linear relationship between the variables, where it can be seen that as the one variable decreased, the other variable increased (Draper & Smith 1981:709).

Generally, a correlation coefficient of ±0,7 or more is regarded as an indication of a fairly strong correlation and a correlation coefficient in

**TABLE 3: MEANS FOR THE THAWING AND COOKING-RELATED DATA OF THE CONTROL AND OTHER FOUR FORMULATIONS OF COOKED FRESH MEAT SAUSAGES CONTAINING BEEF OFFAL**

| Cooking data | SEM | F. prob. (p) | LSD (5%) | CV% | C (B,R) | 1 (B, IN, S, H & R) | 2 (B, IN, S, H & MB | 3 (B, Lu, ST, Li, & R) | 4 (B, Lu, ST, Li & MB) |
|---|---|---|---|---|---|---|---|---|---|
| **Thawing loss (%)** | 0,24 | 0,022 | 0,71 | 24,9 | 1,32[b] | 2,15[a] | 2,45[a] | 2,45[a] | 2,23[a] |
| **Total cooking loss (%)** | 1,55 | 0,093 | NS | 19,3 | 18,60 | 18,72 | 20,69 | 17,41 | 14,19 |
| **Drip loss (%)** | 0,75 | 0,442 | NS | 65,6 | 3,09 | 2,97 | 3,19 | 1,65 | 1,82 |
| **Evaporation loss (%)** | 1,82 | 0,415 | NS | 26,5 | 15,52 | 15,76 | 17,50 | 15,75 | 12,37 |
| **Volume of water (ml)** | 30,0 | 0,713 | NS | 20,7 | 303,0 | 352,4 | 340,4 | 305,0 | 318,0 |
| **Cooking time (min)** | 1,01 | 0,211 | NS | 8,1 | 25,85 | 28,59 | 28,04 | 29,21 | 27,38 |

Means per row with a different superscript letter were significantly different at the 5 % level
C = Control; B=Beef trimmings, IN=Intestines, S= Spleen, H= Heart, R= Rusk, Li= Liver, ST= Stomachs, Lu= Lung and MB= Multibase™
SEM = the standard error of the means
LSD = the t-test least significant difference
CV% = the percentage coefficient of variation
NS = No significant difference

contributed to the high thawing loss percentages in formulations 1, 2, 3 and 4.

No significant differences were found between the total cooking loss (p = 0,093), drip loss (p = 0,442), evaporation loss (p=0,415), volume of water used during (p=0,713) cooking and the cooking time (p = 0,211) for the sausages.

**Descriptive sensory attributes**

Table 4 shows the statistical results in terms of the significant differences seen in the sensory attributes measured for each sausage formulation tested by the trained panel. The data were subjected to a factorial analysis of variance (ANOVA).

**Aroma attributes** The three characteristic aroma attributes that were identified by the trained panellists whilst drawing up the lexicon (Table 2) were aroma intensity, liver aroma and offal aroma.

***Aroma intensity*** According to the lexicon (Table 2), aroma intensity is associated with a typical fresh sausage aroma that is beefy, spicy and meaty and is found to be pleasant and desirable. The control formulation made from beef trimmings and rusk was found to have the most intense aroma intensity (5,34) and was significantly higher (p = 0,015) than formulations 3 (4,59) and 4 (4,51) which contained beef liver(s), stomachs, lungs and either Multibase™ or rusk (Table 4). Formulation 2 (5,10) also had a significantly more intense aroma (p = 0,015) than formulation 4, with an aroma intensity of 4,51 (formulation 4) (Table 4). No significant difference was found between the control formulation and formulations 1 and 2 in terms of aroma intensity.

***Liver aroma*** Liver aroma has been defined as the aroma associated with cooked liver (Table 2). Formulation 3 (4,10) (Table 4) was found to have the most intense liver aroma and differed significantly (p < 0,001) from the control formulation (2,58) and formulation 2 (3,39). The control formulation had the least intense liver aroma and differed significantly from formulations 1, 2, 3 and 4. This significant difference between the control formulation and the other formulations was expected because the control formulation contained only beef trimmings and rusk. No significant differences were found between formulations 1 (3,64), 2 (3,39) and 4 (3,73) with regard to liver aroma. The liver aroma for formulations 3 and 4 was expected to be more intense than for formulations 1 and 2 as formulations 1 and 2 did not contain liver.

***Offal aroma*** Offal aroma is associated with the aroma of cooked offal. In Table 4, the highest offal aroma score was given, as was expected, to formulations 3 (4,17) and 4 (4,58) since these formulations contained liver, lungs and stomachs. These two formulations differed significantly (p < 0,001) from the control (2,63) and formulations 1 (3,15) and 2 (3,27) (Table 4). The control formulation was found to have the least intense (2,63) offal aroma, which was expected because it did not contain any offal parts (Table 4). Formulations 1 (3,15) and 2 (3,27) were found to be similar in their score of offal aroma intensity, which was expected since both of these formulations contained similar offal parts (intestines, spleen and heart) (shown in Table 4). Formulations 1 and 2 did not differ significantly from each other, but formulation 1 was found to be closest to the control formulation and did not differ significantly from the control.

**Appearance of juiciness** The "appearance of juiciness" in the product is the combination of the discernible oil or fat and water in the formulation (Table 2). Formulation 2 (5,66) (Table 4) had the highest appearance of juiciness value (was the most juicy-looking) and differed significantly from the control (4,76), as well as formulations 1 (5,14), 3 (4,51) and 4 (4,98). The reason for the most juicy appearance, might be because formulation 2 contained spleen and

**TABLE 4: MEANS FOR SENSORY ATTRIBUTE DATA FROM DESCRIPTIVE SENSORY ANALYSIS OF THE CONTROL AND COOKED MEAT SAUSAGES CONTAINING BEEF OFFAL**

| Sensory Attributes | SEM | F. prob.(p) | LSD (5%) | CV% | C | 1 (B, IN, S, H & R) | 2 (B, IN, S, H & MB | 3 (B, Lu, ST, Li & R) | 4 (B, Lu, ST, Li & MB) |
|---|---|---|---|---|---|---|---|---|---|
| Aroma intensity | 0,19 | 0,015 | 0,55 | 16,0 | #5,34$^{a}$ | 4,92$^{abc}$ | 5,10$^{ab}$ | 4,59$^{bc}$ | 4,51$^{c}$ |
| Liver Aroma | 0,18 | <0,001 | 0,51 | 30,6 | 2,58$^{c}$ | 3,64$^{ab}$ | 3,39$^{b}$ | 4,10$^{a}$ | 3,73$^{ab}$ |
| Offal Aroma | 0,21 | <0,001 | 0,59 | 29,7 | 2,63$^{c}$ | 3,15$^{bc}$ | 3,27$^{b}$ | 4,17$^{a}$ | 4,58$^{a}$ |
| Appearance of juiciness | 0,15 | <0,001 | 0,42 | 23,3 | 4,76$^{bc}$ | 5,14$^{b}$ | 5,66$^{a}$ | 4,51$^{c}$ | 4,98$^{b}$ |
| Texture – Consistency | 0,12 | <0,001 | 0,35 | 15,3 | 5,78$^{a}$ | 4,02$^{d}$ | 4,49$^{c}$ | 4,80$^{bc}$ | 4,90$^{b}$ |
| Texture – Chewiness | 0,09 | <0,001 | 0,27 | 13,8 | 5,51$^{a}$ | 4,20$^{d}$ | 4,53$^{c}$ | 4,81$^{b}$ | 4,80$^{b}$ |
| Sausage Flavour | 0,17 | <0,001 | 0,47 | 14,7 | 5,81$^{a}$ | 4,71$^{bc}$ | 5,15$^{b}$ | 4,56$^{c}$ | 4,51$^{c}$ |
| Liver Flavour | 0,18 | <0,001 | 0,52 | 29,2 | 2,41$^{c}$ | 4,02$^{a}$ | 3,48$^{b}$ | 4,48$^{a}$ | 4,27$^{a}$ |
| Offal Flavour | 0,19 | <0,001 | 0,55 | 27,0 | 2,19$^{c}$ | 3,19$^{b}$ | 3,07$^{b}$ | 4,12$^{a}$ | 4,44$^{a}$ |
| Mouth – coating | 0,09 | 0,554 | NS | 28,8 | 2,70 | 2,85 | 2,90 | 2,88 | 2,85 |

Means per row followed by the same superscript letter were not significantly different at the 5 % level, # (1 = extremely intense/strong, 8 = extremely bland/weak); SEM = the standard error of the means; LSD = the t-test least significant difference; CV% = the percentage coefficient of variation; NS = No significant difference; C = Control; B=Beef trimmings; IN=Intestines; S= Spleen; H= Heart; R= Rusk; Li= Liver; ST= Stomachs; Lu= Lung and MB= Multibase™

the region of ±0,9 indicates a very strong correlation (Rayner, 1969:626). A correlation coefficient in the region of ±0,5 indicates a moderate correlation and a correlation coefficient in the range of -0,3 to +0,3 is considered a weak correlation (Rayner, 1969:626).

The consumer panel data were analysed statistically by means of ANOVA and the contingency table Chi-squared test. The Chi-squared test was applied to the number of consumers that would or would not buy the five products. Data were analysed using the statistical program GenStat® (Payne, 2003).

## RESULTS AND DISCUSSION

### Cooking results

Thawing losses (%) of formulations 1 (2,15%), 2 (2,45%), 3 (2,45%) and 4 (2,23%) were found to be significantly higher than that of the control formulation which contained only beef trimmings and rusk (1,32%) (p = 0,022) (Table 3). Proximate chemical analysis results showed raw fresh meat sausage samples to contain a high moisture content when compared to the control sausage sample mainly due to the inclusion of rough offal (intestines and stomach) (Magoro, 2007:72). A high moisture content might have

Multibaseä in its formulation. Multibaseä was found to have a high fat content (23,02%) when compared to rusk, which was found to contain 0,35% fat content (Magoro, 2007:20-21). The high amount of fat in Multibaseä might have contributed to the highest "appearance of juiciness'' value found in formulation 2. Formulation 3 (4,51) was found to have a slight appearance of juiciness and differed significantly from formulation 4 (4,98). Formulation 2 was found to be more appealing and differed significantly from the control and other formulations (1, 3 and 4). The least appealing formulation was found to be formulation 3, which differed significantly from formulations 1, 2 and 4 (Table 4).

**Texture attributes** Two characteristics of texture were identified and judged, namely texture consistency and texture chewiness.

***Texture consistency*** A significant difference ($p < 0,001$) was found between the texture consistency of the fresh meat sausages containing beef offal (formulations 1, 2, 3 and 4) and the control formulation. Consistency refers to the cohesiveness of the filling, how the filling holds together or stays together versus how it breaks up when chewed (Table 2). The control formulation had the most intense (5,78) texture consistency, which was described as good or firm and differed significantly from all other samples (Table 4). The texture consistency of the control formulation was expected to differ from the other formulations, since it contained beef trimmings and rusk with no offal parts. According to Ranken (2000:137), rusk soaks up any free water in the formulation which results in the control formulation (which contained beef trimmings and rusk) having a good firm texture in comparison with formulations 1 and 3 (which contained beef offal and rusk), which had a softer texture. Formulation 1 was found to have the lowest texture consistency (4,02). Formulations 1, 2 and 4 were significantly different from each other.

**TABLE 5: CORRELATION COEFFICIENTS AMONG SENSORY ATTRIBUTES OF THE CONTROL AND COOKED MEAT SAUSAGES CONTAINING BEEF OFFAL**

| Correlation | Aroma intensity | Liver aroma | Offal aroma | Appearance of juiciness | Texture consistency | Texture-chewiness | Sausage flavour | Liver flavour | Offal flavour | Mouth - coating |
|---|---|---|---|---|---|---|---|---|---|---|
| Aroma intensity | 1 | | | | | | | | | |
| Liver aroma | -0,886 | 1 | | | | | | | | |
| Offal aroma | -0,961 | 0,792 | 1 | | | | | | | |
| Appearance of juiciness | - | - | - | 1 | | | | | | |
| Texture - consistency | - | - | - | - | 1 | | | | | |
| Texture - chewiness | - | - | - | - | 0,997 | 1 | | | | |
| Sausage flavour | 0,937 | -0,957 | -0,839 | - | - | - | 1 | | | |
| Liver flavour | -0,930 | 0,986 | 0,834 | - | - | - | -0,991 | 1 | | |
| Offal flavour | -0,988 | 0,877 | 0,985 | - | - | - | -0,920 | 0,916 | 1 | |
| Mouth -coating | - | 0,841 | - | - | -0,790 | -0,793 | -0,763 | 0,799 | - | 1 |

Correlation coefficients >0,763
Correlation coefficient must be 0,878 to be significant at 5% level ($p \leq 0,05$)

**FIGURE 1: GRAPHICAL PCA REPRESENTATION OF THE POSITIONING OF THE CONTROL FORMULATION AND FOUR FORMULATIONS OF COOKED MEAT SAUSAGES CONTAINING BEEF OFFAL IN RELATION TO THE PRINCIPAL COMPONENT (PC) SCORES OF EACH FORMULATION**

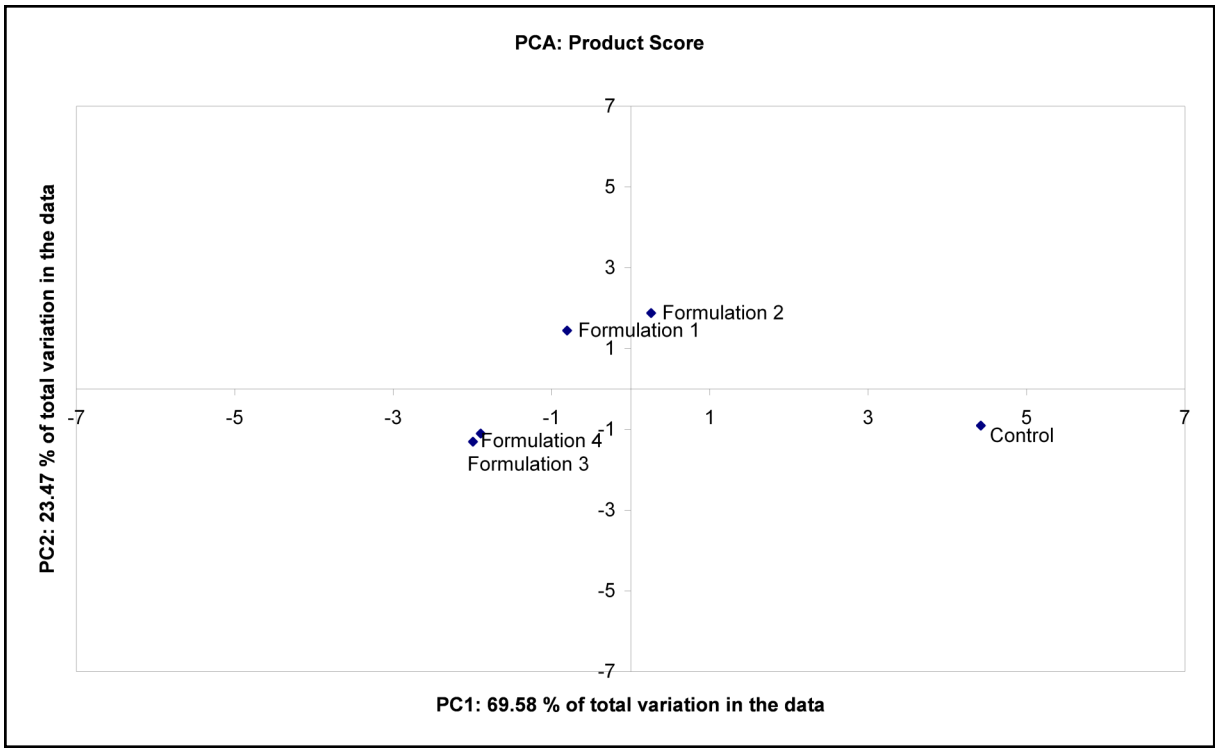
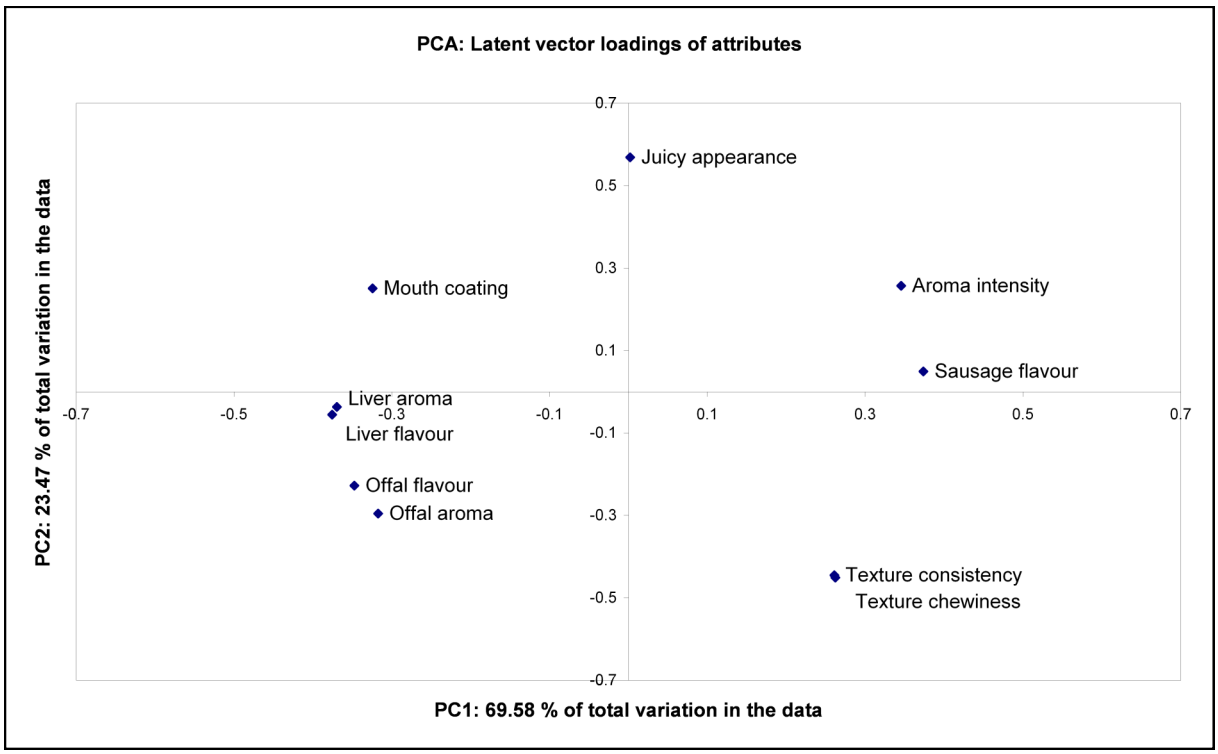



**FIGURE 2: GRAPHICAL REPRESENTATION OF THE MAIN ATTRIBUTES IDENTIFIED IN THE PRINCIPAL COMPONENT ANALYSIS (PCA) THAT DISCRIMINATED BETWEEN THE CONTROL AND COOKED MEAT SAUSAGES CONTAINING BEEF OFFAL**



***Texture chewiness*** As can be seen in Table 4, the control formulation had the highest 'chewiness' score (5,51) and differed significantly ($p < 0,001$) from formulations 1, 2, 3 and 4. No significant differences existed between the chewiness of formulations 3 (4,81) and 4 (4,80). Formulation 1 had the lowest texture chewiness (4,20) and differed significantly from formulation 2. Formulations 3 and 4 did not differ significantly from each other and had the most acceptable "texture chewiness" when compared to formulations 1 and 2 (which had the least texture chewiness).

**Flavour attributes** Three characteristics of flavour were identified and judged, namely sausage flavour, liver flavour and offal flavour.

***Sausage flavour*** Sausage flavour was described as a typical sausage flavour and taste by the trained panel (shown in Table 2). A significant difference ($p < 0,001$) existed between the sausage flavour attributes of the offal-containing sausages (Table 4). The control formulation was found to have the highest sausage flavour attribute score (5,81) and it differed significantly from formulations 1 (4,71), 2 (5,15), 3 (4,56) and 4 (4,51). The four offal-containing formulations contained only 26% beef trimmings in their formulation, compared with 60% beef trimmings found in the control formulation. Formulation 2 differed significantly from Formulations 3 and 4 (Table 4). The four formulations nevertheless had what could be regarded as 'satisfactory' sausage flavour intensity on the eight-point category scale.

***Liver flavour*** Liver flavour refers to a liver taste that is part of the overall taste of the sausage, but it should not be too intense (Table 2). A significant difference ($p < 0,001$) was found to exist between the liver flavours of the offal containing sausages (Table 4). Formulations 3 (4,48) and 4 (4,27) had the most intense liver flavours and differed significantly from formulation 2 (3,48) and the control (2,41) formulation. Formulation 1 (4,02) was also found to have a high liver flavour score, which was not expected as formulation 1 did not contain any liver. Formulation 1 differed significantly from the control formulation and formulation 2. As seen in Table 4, the control formulation was found to have the lowest liver flavour score (2,41), which was expected since this formulation did not contain any offal parts and only contained beef trimmings and rusk.

***Offal flavour*** The highest offal flavour scores (Table 4) were given to formulations 3 (4,1) and 4 (4,44). These scores differed significantly ($p < 0,001$) from the control formulation (2,19) and formulations 1 (3,19) and 2 (3,07). The control formulation was found to have the least intense offal flavour (2,19) which was expected because

**TABLE 6: MEANS FOR CONSUMER SENSORY ANALYSIS OF THE COOKED CONTROL AND MEAT SAUSAGES CONTAINING BEEF OFFAL**

| Attributes | SEM | F-prob. (p) | LSD (5%) | CV % | C | 1 (B, IN, S, H & R) | 2 (B, IN, S, H & MB) | 3 (B, Lu, ST, Li, & R) | 4 (B, Lu, ST, Li & MB) |
|---|---|---|---|---|---|---|---|---|---|
| Aroma | 0,1369 | 0,023 | 0,3810 | 32,0 | #3,603$^{a}$ | 3,540$^{a}$ | 3,540$^{a}$ | 3,254$^{ab}$ | 3,063$^{b}$ |
| Flavour | 0,1457 | 0,035 | 0,4055 | 33,1 | 3,698$^{ab}$ | 3,540$^{abc}$ | 3,730$^{a}$ | 3,317$^{bc}$ | 3,190$^{c}$ |
| Texture | 0,1418 | 0,020 | 0,3947 | 30,4 | 3,984$^{a}$ | 3,524$^{b}$ | 3,952$^{a}$ | 3,540$^{b}$ | 3,508$^{b}$ |

Means per row with a different superscript letter were significantly different at the 5 % level ($p < 0,05$)
CV% = the percentage coefficient of variation
# (1= dislike extremely and 5 = like extremely)
C = Control; B=Beef trimmings; IN=Intestines; S= Spleen; H= Heart; R= Rusk; Li= Liver; ST= Stomachs; Lu = Lung and MB= Multibase™

it contained no beef offal parts in its formulation. An offal flavour, as part of the overall taste of the sausage, was regarded as satisfying and acceptable to the trained panel when evaluated on an eight-point category scale.

**Mouth coating** Mouth coating was measured as the feeling of oiliness or coating of fat left on the palate and on the inside of the mouth immediately after swallowing the sample. No significant difference (p = 0,554) was found to exist between the control formulation and any of the other formulations (1, 2, 3 and 4) with regard to mouth coating as an attribute (Table 4).

**Correlation between attributes**

"Aroma intensity" correlated positively with sausage flavour attributes and negatively with liver and offal aroma. The control formulation scored higher values for aroma intensity and sausage flavour as seen from Table 4 (ANOVA results).

Liver aroma correlated positively with the liver flavour attribute and negatively with sausage flavour – which was expected (Table 5) – while offal aroma correlated positively with offal flavour (Table 5). With regard to the texture of the sausages, texture consistency correlated positively with "texture chewiness'' (Table 5). Texture chewiness and texture consistency were found to be most intense in the control formulation (Table 4). The liver flavour attribute was found to correlate positively with offal flavour. These two attributes were found to be the lowest in the control formulation and the most intense in formulations 3 and 4, which was expected (Table 4).

**Results of the Principal Component Analysis (PCA) of the sensory attributes**

PCA was performed to illustrate the graphical representations (Figure 1 and 2) of the relationship between the sensory attributes of the five different formulations that included a cooked control formulation (with no offal) and fresh meat sausage formulations (1, 2, 3 and 4) containing beef offal. Lawless and Heymann (1998:592) state that similar products lie close to one another on the graph and products that are different are further apart. Figure 1 is a graphical representation of the position of the different formulations of cooked meat sausages containing beef offal and the control formulation. The control formulation (seen in the right-hand bottom corner of the graph) contrasted the most with formulations 3 and 4 (seen in the left-hand bottom corner of the graph) and this indicates that the control formulation differed significantly from

**TABLE 7: CHI-SQUARED TEST DETERMINING THE PROPORTIONS OF CONSUMERS THAT WOULD OR WOULD NOT BUY THE SAUSAGES**

| Formulations | Buy | Not buy | Total |
|---|---|---|---|
| **C** (B, R) | 47 (75%) [a] | 16 (25%) | 63 |
| **1** (B, IN, S, H & R) | 36 (57%) [b] | 27 (43%) | 63 |
| **2** (B, IN, S, H & MB) | 44 (70%) [a] | 19 (30%) | 63 |
| **3** (B, Lu, ST, Li, & R) | 31 (49%) [b] | 32 (51%) | 63 |
| **4** (B, Lu, ST, Li & MB) | 33 (52%) [b] | 30 (48%) | 63 |

Formulation proportions (per column) with the same letter do not differ at a 5% significance level
C = Control; B=Beef trimmings; IN=Intestines; S= Spleen; H= Heart; R= Rusk; Li= Liver;
ST= Stomachs; Lu= Lung and MB= Multibase™

these formulations (3 and 4, both containing liver) (Figure 1). Formulations 1 and 2 are correctly grouped together in Figure 1 since they contained the same offal parts.

In Table 4, the control formulation was found to have scored the highest aroma intensity, texture consistency, texture chewiness and sausage flavour and these attributes were found to have differed significantly from formulations 1, 2, 3 and 4 in each case.

Figure 2 is a graphic representation of the PCA loadings of the attributes and is an indication of the correlation of the sensory attributes for the cooked sausages. Only the attributes with correlation coefficient (r) values r >0,8 were investigated. The PCA explained 93,05% of the total variation in the data. The first principal component PC1 (x-axis), as seen in Figure 2, accounted for 69,58% of the total variation in the data and was characterised by the following values shown in descending order, with negative or positive loadings (the correlation coefficient between the scores and the attributes are shown in brackets): liver flavour (r = ‑0,990), liver aroma (r = ‑0,975), offal flavour (r = ‑0,916), mouth coating (r = ‑0,855), offal aroma (r= ‑0,837), sausage flavour (r = +0,986) and aroma intensity (r = +0,911).

In the PC2 (y-axis), the attributes with correlation coefficient (r) values r > 0,680 were investigated. The y-axis accounted for 23,47% of the total variation of the data, was characterised by a juicy appearance (r = +0,871) and displayed a positive loading. Texture chewiness (r = ‑0,691) and texture consistency (r = ‑0,682) displayed negative loadings in a descending order. Formulations 1 and 2 contrasted with formulations 3 and 4 the most (Figure 1) with regard to these attributes, which was expected based on the formulations and the presence of offal components.

When Figures 1 and 2 are read adjacent to each other, they show that in PC1 the control formulation was mainly associated with the attributes aroma intensity, sausage flavour and textural attributes, such as texture consistency and texture chewiness (second quadrant). In PC2 (y-axis), formulations 3 and 4 were associated with liver and offal aroma attributes and also with liver and offal flavour attributes. Liver and offal aroma attributes and liver and offal flavour attributes scored lower values in the control formulation, which contained beef trimmings, rusk and other spices only, without any offal parts (Table 4). Formulation 2 was found to be associated with the appearance of juiciness attribute which corresponds to the ANOVA table and was the most intense with regard to this attribute (Table 4).

**Consumer panel evaluations**

Table 6 shows the factorial analysis of variance (ANOVA) results obtained from the consumer test and indicates the statistical significance of differences between the aroma, flavour and texture attributes measured for each sausage formulation tested by the consumer panel. No significant differences were found to exist between the control and formulations 1, 2 and 3 in terms of the aroma attribute. However, the control formulation and formulations 1 and 2 differed significantly from formulation 4. Formulation 3 did not differ significantly from formulation 4 which was expected since they both contained the same beef offal parts.

No significant differences were found to exist between the control formulation and formulations 1, 2 and 3 in terms of the flavour attribute. Formulation 4 was rated lowest in terms of the flavour attribute and differed significantly from the control formulation and formulations 1, 2 and 3. With regard to the texture attribute, the control formulation and formulation 2 were rated highest and differed significantly from formulations 1, 3 and 4 (see Table 6). Therefore it can be concluded that the control formulation and formula-

tion 2 were the formulations most preferred by the consumer panel in terms of the aroma, flavour and texture attributes.

**Willingness of the consumer panel to buy sausages**

The consumer sensory results were also statistically analysed using the contingency table method called the Chi-squared test. The Chi-squared test for the row-by-column (R x C) (5 x 2) contingency table in Table 7 was done to test whether the proportion of consumers that would or would not buy the sausages varied between the sausages. A significant Chi-squared test ($X^2$ = 12,954, $p \leq 0,012$, degrees of freedom = 4) indicated that the proportions did vary. In other words, the proportion of consumers that would buy the sausage was dependent on the formulation of the sausage. Further pair-wise comparisons between the proportions for the sausages (Table 7) were tested using a normal approximation (Z deviate) (Snedecor & Cochran, 1967:10-12). Since the Chi-squared test was significant, the control formulation (75%) and formulation 2 (70%) were significantly different from formulation 1 (57%), formulation 3 (49%) and formulation 4 (52%) in terms of the proportion of consumers that would buy the sausages.

**Cost of the control and raw meat sausages containing beef offal**

The price per kilogram (excluding labour costs) for fresh meat sausages containing beef offal was found to be ZAR14,33 for formulation 1 (~US$2,05 at a conversion rate of ~ZAR7,00 to the US Dollar); ZAR14,43 for formulation 2 (~ US$2,06); ZAR15,02 for formulation 3 (~$2,15) and ZAR15,13 for formulation 4 (~$2,16). The control formulation, which was developed using 60% beef trimmings, was the most expensive with a calculated cost of ZAR19,82 (~$2,83 using the same conversion rate). The price per kilogram of a popular, traditional South African sausage used for outdoor cooking (made from a mixture of beef and pork) is about ZAR50,00 (~$7,14) and thus, compared to the price of the popular traditional sausage, offal sausages are more affordable to a market of lower income consumers.

**CONCLUSION**

Fresh meat sausages containing beef offal could be developed using 26% beef trimmings, 34% of various beef offal parts (such as intestines, spleen and the heart) and a soya protein product, such as Multibase™ or rusk (made from wheat flour and yeast). The control formulation and formulation 2 (a red offal formulation) were the most acceptable formulations in terms of desirable sensory attributes or properties such as aroma, flavour and texture attributes, as judged by the consumer panel and the appearance of juiciness and aroma intensity, as judged by the trained panel. The consumer results corresponded with the trained panel results as the members of both panels found the overall aroma intensity of the control formulation and formulation 2 to be acceptable. Meat sausages containing beef offal (such as formulation 2) should be easily accepted by local ethnic black communities amongst whom offal is a popular food product. Meat sausages containing beef offal have a lower cost per kilogram when compared to other sausages and therefore could also benefit the lower income population groups of the South African society.

The utilisation of red and rough beef offal in sausage products offers enormous potential to add value to and enrich processed meat products. It is recommended that Non-Meat Protein (NMP) products (such as whey protein, Isolated Soya Protein (ISP) and Textured Vegetable Protein (TVP)) should be investigated in the future development of similar products. It is also recommended that after cleaning offal parts, water from the cleaned rough offal should be thor-

oughly drained in order to reduce the high moisture content in offal products. Traditional spices such as chakalaka (a reddish relish mixture of onion, green peppers, curry powder, cayenne pepper and cooking oil), curry and barbeque spices can also be added to enhance the flavour and aroma of the sausages.

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