

## Analysis of Nitrosamines in Processed Meat Products in Medan City by Liquid Chromatography-Mass Spectrometry

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#### Abstract

BACKGROUND: Nitrosamine is a carcinogen and the maximum level in processed meat products set by WHO.

**AIM:** The purpose of this study was to determine nitrosamine levels in meat products in Medan City and compared nitrosamine levels with standards set by WHO.

**METHODS:** The samples analysed were obtained from Berastagi Supermarket, sausages, burgers, corned beef and smoked beef. Nitrosamine levels were determined by reverse phase liquid chromatography-mass spectrometry.

**RESULTS:** The results showed that only 5 out of 20 samples of N-nitroso-thiazolidine-4-carboxylic acid (NTCA) nitrosamine ranged from 501.290 to 4227.492 µg/kg. The highest level of NTCA was found in smoked beef (Chiefs), which is 4227.492 µg/kg. N-nitroso-2-methyl-thiazolidine-4-carboxylic acid (NMTCA) was contained in all the samples analysed which ranged from 20.50 to 989.175 µg/kg. The highest NMTCA nitrosamine content was found in smoked beef (Chiefs), which is 989.175 µg/kg.

CONCLUSION: From this study reveal that nitrosamines in meat products exceed the maximum standards set by WHO (10  $\mu$ g/kg).

## Introduction

Nitrite and nitrate are generally found widely in soil, water, and food (especially in vegetables) [1]. Also, nitrite and nitrate are also intentionally added to some foods such as processed meats as preservatives and colouring agents [2]. The use of nitrite in processed meat products may react with alkyl amines to form carcinogen nitrosamines. The maximum level in processed meat set by WHO WHO is 10  $\mu$ g/kg [3], [4], [5], [6]. There are several factors affecting the formation of nitrosamines, namely the concentration of nitrite, acidity, temperature, storage condition, the alkalinity of amines, and the presence of catalysts or inhibitors. So it is very necessary to analyse the content of nitrosamines in food, especially in meat products [7], [8], [9], [10], [11]. Nitrosamine analysis in food can be done by highperformance liquid chromatography and gas chromatography with a detector system. The method of high-performance liquid chromatography using mass spectroscopy is very selective and sensitive and can be used as an alternative method compared to other chromatographic methods [12], [13], [14], [15], [16].

The purpose of this study was to determine nitrosamine levels in meat products in Medan City and compared nitrosamine levels in meat products with standards set by WHO.

#### **Material and Method**

#### Materials

The materials used in this study were acetonitrile, formic acid (98%), methanol. Nitrosamines standard are *N*-*Nitrosodietylamine* (NDEA), *N-nitroso-2-methyl-thiazolidine 4-carboxylic acid* (NMTCA) and *N-nitroso-thiazolidine-4-carboxylic acid* (NTCA).

#### Samples Preparation

The samples used in this study were meat products (sausages, corned beef, burgers, and smoked beef) were obtained from Berastagi Supermarket in Medan city. Samples that have been taken and then placed in a *cooling bag* containing ice, then stored in the Laboratory in the freezer (temperature -20°C) before testing.

# Format Acid Solution 0.1% in Purified Double Distillation Water

Transferred 0.5 mL formic acid (E.Merck) in a 1000 mL beaker glass, then added distilled water up to 500 mL. The mixture was stirred and filtered with 0.2  $\mu$ m of cellulose nitrate filter membrane. The results obtained was 0.1% formic acid solution in distilled water.

#### Format Acid Solution 0.1% in Acetonitrile

Transferred 0.5 ml of formic acid (E. Merck) in a 1000 ml beaker glass, then added acetonitrile to 500 ml. The mixture was stirred and filtered with a 0.5  $\mu$ m polymeretraflouroethylene (PTFE) filter membrane. The results obtained was 0.1% formic acid solution in acetonitrile.

#### Preparation of NDEA Standard Solution

Weighed 100 mg NDEA standard, transferred into a 10 ml volumetric flask, dissolved with acetonitrile to the marked line and shaken. Then, it was stirred for 5 minutes until it dissolved to obtain NDEA 10000  $\mu$ g/ml solutions.

#### Preparation NMTCA Standard Solution

Weighed 10 mg of NMTCA standard, transferred into a 10 ml volumetric flask, dissolved with acetonitrile to the mark and shaken. Then, it was stirred for 5 minutes until it dissolved to obtain NMTCA 1000  $\mu$ g/ml solutions.

## Preparation of NTCA Standard Solution

Weighed 10 mg of NTCA standard, transferred into a 10 ml volumetric flask, dissolved with acetonitrile to the mark and shaken. Then, it was stirred for 5 minutes until it dissolved to obtain NDEA 1000  $\mu$ g/ml solutions.

## Chromatographic Condition

The nitrogen generator was turned on until it is ready to produce nitrogen gas used for mass spectrometry detectors. Then high performance liquid chromatography (Agilent 1290 HPLC) mass spectrometry (ABSciex API 4000 Q TRAP type) was turned on, by: turning on the mass spectrometry detector, setting positive detection, leaving it for a while until the mass spectrometry conditions become vacuum, run the pump on the type mixture of mobile phase, comparison of ratio mobile phase and predetermined mobile phase flow rate, as well as column oven temperature set at predetermined conditions, then the mobile phase was flowed until a stable pressure was obtained, which indicates that the high-performance liquid chromatography system of mass spectrometry has been stable and ready used for analysis [14].

#### Mobile Phase

The mobile phase used was a mixture of 0.1% formic acid solution in water and 0.1% formic acid solution in acetonitrile. The ratio of the mobile phase in the mixture were 10:90, 30:70, 50:50, 70:30 and 90: 10. Each of this mobile phase was used to separate the standard solution to determine optimum mobile phase composition [3], [12].

#### Nitrosamine Extraction

Five (5) g of mashed meat samples were weighed and transferred into 25 ml volumetric flask. Acetonitrile added was until 25 ml and then homogenised. Then, it was transferred into a tube and then centrifuged for 10 minutes at 8000 rpm. Five (5) ml of supernatant was filtered through a 0.2 µm filter membrane; then the solution was transferred into a vial. Ten (10) µL of solution was iniected high-performance into а liauid chromatography system through an automatic injector [3], [12].

#### **Calibration Curves**

From the standard solution (NDEA, NMTCA, NTCA) with concentration of and а 1.25 mg/ml, pipetted 0.4 ml; 1 ml; 2 ml; 4 ml, and 10 ml, respectively. Each solution was transferred into volumetric flask 25 ml, then added acetonitrile to the marked line. The concentration of nitrosamine solutions (NDEA, NMTCA, and NTCA)

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is 20: 50: 100: 200: and 500 ng/ml). Each solution was filtered through a membrane filter politetraflouroetilen (PTFE) of 0.2 µm. Then, the filtered solutions were transferred into a vial. Ten (10) µL of solution was high-performance iniected into а liauid through chromatography system an automatic injector. The peak chromatogram area of was obtained. Then a calibration curve is made by plotting peak area versus concentration. Then, the regression line equation (Y = aX + b) determined.

#### Analysis of Nitrosamines in Processed Meat Products

Five (5) g of mashed meat samples were weighed and transferred into 25 ml volumetric flask. Acetonitrile was added until 25 ml and then homogenised. Then, it was transferred into a tube and then centrifuged for 10 minutes at 8000 rpm. Five (5) ml of supernatant was filtered through a 0.2 µm filter membrane; then the solution was transferred into a vial. Ten (10) µL of solution was high-performance iniected into liquid а chromatography system through an automatic injector. MS/MS detection was done by Multiple Reaction Monitoring (MRM). The mass spectrometer is operationalised using electrospray ionisation (ESI) and atmospheric pressure chemical ionisation (APCI) technique. The ion monitored in mass spectrometry is a positive ion that has a mass of 103 for NDEA, and negative ions that have a mass of 175 for NMTCA. and 161 for NTCA. Chromatogram and peak area were obtained, and then the concentration was calculated by substituting the peak area into the regression equation (y = ax + b) obtained from the calibration curve on linearity testing [3], [12]. Nitrosamine levels in solution can be calculated by the regression equation Y = a X + b.

Nitrosamine concentration was calculated using this equation:

$$C = \frac{X \times V \times Fp}{sample \ weigt \ (5 \ g)}$$

Notes: Y = Peak Area

C = Nitrosamine concentration in the sample (µg/kg); X = Nitrosamine levels in sample solution (ng/ml); V = Volume of sample solution before dilution (25 ml); Fp = Dilution Factors (1).

## Results

Determination of Mobile Phase Composition

Determination of the mobile phase composition was done to get the best separation method. NDEA, NMTCA, and NTCA standard

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solutions in water and acetonitrile (ratio 10:90, 30:70, 50:50. 70:30) were injected into LCMS- MS/MS system through an automatic injector. The ideal chromatogram shown peak was bv asymmetric a Gaussian form with value (tailing factor) which of 1. Tailing factor data with a different ratio of mobile phase for the analysis of NDEA, NMTCA, and NTCA can be seen in Table 1.

Table 1: Tailing Factor with different ratio of mobile phase for analysis of NDEA, NMTCA, and NTCA

Motion Phase	Tailing Factor		
	NDEA	NMTCA	NTCA
0.1% Formic acid in water: 0.1%	NA	NA	1,2
Formic acid acetonitrile (10:90)			
0.1% Formic acid in water: 0.1%	0.95	NA	0.93
Formic acid acetonitrile (30:70)			
0.1% Formic acid in water: 0.1%	NA	NA	1.5
Formic acid acetonitrile (50:50)			
0.1% Formic acid in water: 0.1%	1.08	1	1
Formic acid acetonitrile (70:30)			
Water: Acetonitrile (Format acid	NA	NA	1.07
0.1%) 0.1% format) 90:10			

(Description: NA = Not applied)

In Table 1 it is shown that the best chromatogram mobile phase ratio is 70:30 (water: acetonitrile) because a symmetrical and sharp peak was produced and meets the requirements for tailing factor of 1.08 for the NDEA, 1 for NMTCA and NTCA. The best mobile phase with a ratio of 70:30 was then used for analysis of mixed solutions of NDEA, NMTCA, and NTCA. Chromatogram of NTCA, NMTCA, and NDEA using optimum mobile phase detected by Multiple Reaction Monitoring (MRM) Mass Spectrometry can be seen in Figure 1.

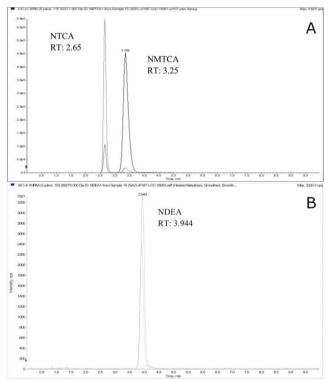


Figure 1: Chromatogram of NTCA, NMTCA, and NDEA using optimum mobile phase detected by Multiple Reaction Monitoring (MRM) Mass Spectrometry (A); N-nitroso-thiazolidine-4-carboxylic acid (NTCA) and N-nitroso-2-methyl-thiazolidine 4-carboxylic acid (NMTCA) detected with ESI ionisation and (B); N-Nitrosodietylamine (NDEA) with APCI ionisation

As seen Figure 1, it is shown that the optimum mobile phase for the analysis of both volatile and non-volatile nitrosamines is 0.1 % formic acid in water: 0.1% formic acid in acetonitrile (70:30) with flow rate 1 ml/minute. The standard mixture of NDEA, NMTCA, and NTCA eluted the optimum mobile phase shows a symmetrical and sharp peak. NDEA is analysed better using APCI compared to ESI. This is indicated by the high signal response obtained when NDEA standard solutions were analysed using APCI compared to ESI. APCI is usually used for the analysis of volatile nitrosamine compounds. On the other hand, NMTCA and NTCA are analysed better using ESI because higher signal responses were obtained [3], [12].

#### **Calibration Curve**

The concentration used for calibration curve preparation are: 20 ng/ml; 50 ng/ml; 100 ng/ml; 200 ng/ml; and 500 ng/ml for NDEA, NMTCA, and NTCA. Calibration curve of NDEA can be seen in Figure 2.

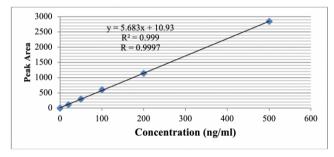


Figure 2: Calibration Curve of NDEA

In Figure 2 it can be seen that the calibration curve obtained has a linear relationship between peak area and concentration. The regression line equation obtained is y = 5.683 x + 10.93 with a correlation coefficient (r) of 0.9997. This shows a linear correlation between the area of the chromatogram and the concentration of NDEA [5], [6]. The calibration curve of NMTCA can be seen in Figure 3.

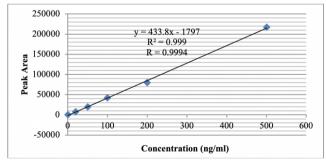


Figure 3: Calibration Curve of NMTCA

In Figure 3 it can be seen that the calibration curve obtained has a linear relationship between peak area and concentration. The regression line equation obtained is  $y = 433.8 \times 1797$  with a correlation

coefficient (r) of 0.9994. This shows a linear correlation between the area of the chromatogram and the concentration of N MTCA [5], [6]. The calibration curve of NTCA can be seen in Figure 4.

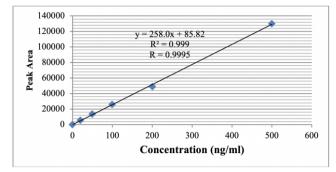


Figure 4: Calibration Curve of NTCA

In Figure 4 it can be seen that the calibration curve obtained has a linear relationship between peak and concentration. The regression line equation obtained is y = 258 x + 85.82 with a correlation coefficient (r) of 0.9995. This shows a linear correlation between the area of the chromatogram and the concentration of NTCA [5], [6].

## Nitrosamine Levels in Various Types of Processed Meat Products

Determination of nitrosamines levels was carried out using reverse-phase highperformance liquid chromatography method which is then characterised by a mass spectrometer. Nitrosamine levels in various types of processed meat products can be seen in Table 2.

## Discussion

Based on Table 3, it can be seen that there are differences in nitrosamine levels (NDEA, NMTCA, NTCA) in various types of processed meat products. There are 20 samples consisting of 5 types of sausage brands, 5 types of corned beef brands, 5 types of burger brands, and 5 types of smoked beef brands.

Of all samples analysed, NDEA (a volatile nitrosamine) was not detected. There are 2 possibilities, either NDEA is not present in the samples, or it is present in the sample, but below the limit of detection. On the other hand, non-volatile nitrosamine compounds such as NMTCA and NTCA are found in the samples and vary greatly. There are also some samples where these compounds are not detected. The highest nitrosamine level is NTCA (4227.492 µg/kg) which is found in smoked beef (Chiefs).

No.         Ntrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Flesta         -           Velicious         -         -         -           Kenfood         -         -         -           2         NMTCA         Flesta         36.91 ± 6.2210           2         NMTCA         Flesta         36.91 ± 6.2210           2         NMTCA         Flesta         36.64 ± 6.2340           3         NTCA         Flesta         56.54 ± 6.2347           2         So good         108.14 ± 6.5348         -           3         NTCA         Flesta         585.45 ± 23.847           Delicious         -         -         -           Kornetku         20.565.44 ± 60.8385         -         -           8         CORNED         -         -         -           1         NDEA         Kornetku         20.54 ± 0.2861         -           2         NMTCA         Flesta         20.54 ± 0.2861         -           46.04 ± 37.3362         Bernardi         -         -           1         NDEA         Kornetku         20.54 ± 0.2861           2         NMTCA	No			
1         NDEA         Fiesta		Nitrosamine	Brand	Nitrosamine ± SD (µg/kg)
2         NMTCA         Fiesta         36.91 ± 6.2210           3         NTCA         Fiesta         50.900           3         NTCA         Fiesta         58.45 ± 23.447           Delicious         58.45 ± 23.447         Delicious         -           No.         Nitrosamine ± 50 (µg/kg)         -         Kenfood         -           No.         Nitrosamine ± 50 (µg/kg)         -         -         Hiti           2         NMTCA         Fiesta         20.54 ± 0.2951         -           4         Pronsis         -         -         -           4         Pronsis         -         -         -           4         Pronsis         -         -         -           1         NDEA         Kornetku         20.52 ± 0.2651         -           4         Pronsis         -         -         -           4         Bernardi         -         -         -           1         NDEA         Kimbo				- (10 5)
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Delicious         No.         Nutrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Kornetku         -           Pronas         -         -           Milli         -         -           2         NMTCA         Kornetku         20.54 ± 0.2051           2         NMTCA         Kornetku         20.54 ± 0.2051           2         NMTCA         Kornetku         20.50 ± 0.2604           Milli         48.05 ± 2.8778         Libbys         46.84 ± 37.362           1         MDEA         Kornetku         -         Pronas           3         NTCA         Kornetku         -         -           Pronas         -         -         Milli         -           1         NDEA         Kornetku         -         -           Pronas         -         -         -         -           1         NDEA         Kornetku         -         -           Pronas         -         -         -         -           1         NDEA         Bernardi         -         -           2         NMTCA         Kimbo         20.703 ± 0.0073         -				
Kenfood     -       So good     2565.44 ± 60.8385       B. CORNED     Brand     Nitrosamine ± SD (µg/kg)       1     NDEA     Kornetku     -       Pronas     -     -       Mili     -     -       Libbys     -     -       2     NMTCA     Kornetku     20.54 ± 0.2951       Pronas     -     -       Mili     48.05 ± 2.8778       Libbys     48.05 ± 2.8778       Bernardi     90.52 ± 84.3006       3     NTCA     Kornetku       Pronas     -       Milli     -       Libbys     -       Bernardi     90.52 ± 84.3006       3     NTCA     Kornetku       Pronas     -       Milli     -       Libbys     -       Bernardi     -       1     NDEA       Kimbo     -       2     NMTCA       Bernardi     -       -     -       Vitalia     -       Hemato     -       -     Abbys       2     NMTCA       Bernardi     -       Vitalia     -       Abbys     -       2     NMTCA	3	NTCA	Fiesta	585.45 ± 23.8477
Kimbo         -           So good         2565.44 ± 60.8385           B. CORNED         Nitrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Kornetku         -           Pronas         -         -         -           2         NMTCA         Kornetku         20.54 ± 0.2951           2         NMTCA         Kornetku         20.54 ± 0.2951           2         NMTCA         Kornetku         20.50 ± 0.2604           Milli         48.64 ± 37.3622         Bernardi           3         NTCA         Kornetku         -           Pronas         -         -           Bernardi         -         -           Ubbys         46.84 ± 37.3622         Bernardi           Bernardi         -         -           Pronas         -         -           Milli         46.84 ± 37.3622         Bernardi           -         Bernardi         -         -           Vitalia         -         -         -           NDCA         Kimbo         20.705 ± 0.0077         -           2         NMTCA         Kimbo         20.705 ± 0.0062           Abbys <td></td> <td></td> <td>Delicious</td> <td>-</td>			Delicious	-
So good         2565.44 ± 60.8385           B. CORNED         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Kornetku         -           Pronas         -         -           Milli         -         -           Libbys         -         -           2         NMTCA         Kornetku         20.54 ± 0.2951           2         NMTCA         Kornetku         20.50 ± 0.2061           Pronas         20.50 ± 0.2951         Pronas           3         NTCA         Kornetku         -           Pronas         20.50 ± 0.2951         Pronas           Jibbys         46.84 ± 37.3362         Bernardi           90.52 ± 84.3906         -         -           Milli         -         -           Libbys         -         -           Bernardi         -         -           Mo.         Nitrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Kimbo         -           Abbys         -         -         -           2         NMTCA         Kimbo         20.705 ± 0.0077           Bernardi         20.705 ± 0.0077 <t< td=""><td></td><td></td><td>Kenfood</td><td>-</td></t<>			Kenfood	-
B. CORNED         No.         Nitrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Kornetku         -           Pronas         -         Milli         -           Libbys         -         -           Bernardi         -         -           2         NMTCA         Kornetku         20.54 ± 0.2951           Pronas         20.50 ± 0.2604         Milli           Hilli         48.05 ± 2.8778         Libbys           Libbys         46.84 ± 37.3802         Bernardi           90.52 ± 84.3906         -         -           Attribuss         -         -           Milli         -         -           Libbys         -         -           Bernardi         -         -           No.         Nitrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Kimbo         -           Abbys         20.705 ± 0.0077         -           Bernardi         -         -           Vitalia         35.79 ± 2.7469           Hemato         -         -           Abbys         -         -           D.SM			Kimbo	
B. CORNED         No.         Nitrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Kornetku         -           Pronas         -         Milli         -           Libbys         -         -           Bernardi         -         -           2         NMTCA         Kornetku         20.54 ± 0.2951           Pronas         20.50 ± 0.2604         Milli           Hilli         48.05 ± 2.8778         Libbys           Libbys         46.84 ± 37.3802         Bernardi           90.52 ± 84.3906         -         -           Attribuss         -         -           Milli         -         -           Libbys         -         -           Bernardi         -         -           No.         Nitrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Kimbo         -           Abbys         20.705 ± 0.0077         -           Bernardi         -         -           Vitalia         35.79 ± 2.7469           Hemato         -         -           Abbys         -         -           D.SM			So good	2565.44 ± 60.8385
No.         Nitrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Kornetku         -           Pronas         -         Milli         -           Milli         Libbys         -         -           2         NMTCA         Kornetku         20.54 ± 0.2951           Pronas         20.50 ± 0.2604         Milli           Milli         48.64 ± 37.3362         Bernardi           90.52 ± 84.3906         -         -           Milli         48.64 ± 37.3362         Bernardi           90.52 ± 84.3906         -         -           Milli         -         -           Libbys         -         -           Bernardi         -         -           Milli         -         -           NDEA         Kimbo         -           2	B. CORNE	D	0	
1         NDEA         Korretku         -           Pronas         -           Milli         -           Libbys         -           Bernardi         -           Pronas         20.50 ± 0.2604           Milli         48.05 ± 0.2778           Libbys         46.84 ± 37.3362           Bernardi         90.52 ± 84.3906           3         NTCA         Kornetku           Pronas         -           Milli         46.84 ± 37.3362           Bernardi         90.52 ± 84.3906           3         NTCA         Kornetku           Pronas         -           Milli         -           Libbys         1           NDEA         Kornetku           Pronas         -           Milli         -           Libbys         -           Bernardi         -           Vitalia         -           NDEA         Kimbo           2         NMTCA         Kimbo           2         NMTCA         Kimbo           3         NTCA         Kimbo           4         Hemato         -           Abbys			Brand	Nitrosamine + SD (µg/kg)
Pronas     -       Milli     -       Libbys     -       2     NMTCA     Kornetku     20.54 ± 0.2951       Pronas     20.50 ± 0.2604       Milli     48.65 ± 2.8778       Libbys     46.84 ± 37.3362       Bernardi     90.52 ± 84.3906       3     NTCA     Kornetku       Pronas     -       Libbys     -       Libbys     -       Bernardi     90.52 ± 84.3906       3     NTCA     Kornetku       Pronas     -       Milli     -       Libbys     -       Libbys     -       Libbys     -       Milli     -       Milli     -       Milli     -       Milli     -       Milli     -       No.     Nitrosamine       Bernardi     -       Vitalia     -       Hermato     -       Abbys     -       2     NMTCA     Kimbo       20.705 ± 0.0075 ± 0.0075 ± 0.0075 ± 0.0062       Abbys     -       Abbys     -       2     NMTCA     Kimbo       3     NTCA     Fiesta       Yona     -				- (µgritg)
Mili Ibbys     -       2     NMTCA     Kornetku     20.54 ± 0.2951       Pronas     20.50 ± 0.2604       Mili     48.05 ± 2.8778       Libbys     48.04 ± 37.3362       Bernardi     90.52 ± 84.3906       3     NTCA     Kornetku       Pronas     -       Mili     1       Libbys     48.08 ± 37.3362       Bernardi     90.52 ± 84.3906       3     NTCA     Kornetku       Pronas     -       Mili     -       Libbys     1       NCA     Kornetku       Pronas     -       Mili     -       Libbys     1508 ± 2975.7       C. BURGER     -       No.     Nitrosamine       Bernardi     -       Vitalia     -       Abbys     -       2     NMTCA       Kimbo     20.705 ± 0.0077       Bernardi     -       Vitalia     35.79 ± 2.7409       Hemato     -       Abbys     20.705 ± 0.0062       Abbys     20.705 ± 0.0071       Bernardi     -       Abbys     -       D.SMOKED BEEF     -       No     Ntrosamine ± SD (µg/kg)		NULA		
Libbys         -           Bernardi         -           2         NMTCA         Kornetku         20.50 ± 0.2604           Pronas         20.50 ± 0.2604           Milli         48.05 ± 2.8778           Libbys         46.84 ± 37.362           Bernardi         90.52 ± 28.3906           3         NTCA         Kornetku           Pronas         -           Mili         -           Libbys         -           Bernardi         90.52 ± 8.3906           3         NTCA         Kornetku           Pronas         -           Mili         -           Libbys         -           Bernardi         -           Vitalia         -           Hemato         -           Abbys         -           Abbys         20.700 ± 0.0077           Bernardi         -           Vitalia         35.79 ± 2.7469           Hemato         -           Abbys         20.700 ± 0.0013           Vitalia         -           Bernardi         -           Vitalia         -           Abbys         -           D.SMOK				-
Bernardi         -           2         NMTCA         Korretku         20.54 ± 0.2951           Pronas         20.50 ± 0.20604           Milli         48.05 ± 2.8778           Libbys         46.85 ± 2.8778           Libbys         46.85 ± 2.8778           Libbys         46.85 ± 2.8778           Bernardi         90.52 ± 64.3906           3         NTCA         Kornetku           Pronas         -           Milli         -           Libbys         -           Bernardi         1508 ± 2975.7           C. BURGER         Bernardi         -           No.         Nitrosamine         Brand           NDEA         Kimbo         -           J         NDA         Kimbo           2         NMTCA         Kimbo         -           2         NMTCA         Kimbo         20.705 ± 0.0077           Bernardi         20.705 ± 0.0075         -           4bbys         -         -           2         NMTCA         Kimbo         -           3         NTCA         Kimbo         -           4bbys         -         -         -				-
2         NMTCA         Kornetku         20.54 ± 0.2961 Pronas         20.50 ± 0.2604 Milli         48.05 ± 2.8778 46.84 ± 37.3662           3         NTCA         Bernardi         90.52 ± 0.2786 Bernardi         91.52 ± 0.2064           3         NTCA         Kornetku         -           Pronas         -         -           Milli         -         -           Libbys         -         -           Bernardi         1008 ± 2975.7         -           C. BURGER         -         -           No.         Nitrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Kimbo         -           Abbys         -         -         -           2         NMTCA         Kimbo         20.705 ± 0.0077           Bernardi         -         -         -           Abbys         20.705 ± 0.0062         -         -           3         NTCA         Kimbo         -         -           Bernardi         -         -         -         -           1         NDEA         Bernardi         -         -           2         NMTCA         Kimbo         -         -				-
Pronas         20.50 ± 0.2004           Milli         48.65 ± 2.8778           Libbys         46.84 ± 37.3362           Bernardi         90.52 ± 84.3906           3         NTCA         Kornetku           Pronas         -           Milli         Libbys           Libbys         -           Pronas         -           Milli         -           Libbys         -           Bernardi         1508 ± 2975.7           C. BURGER         Bernardi           No.         Nitrosamine           Bernardi         -           Vitalia         -           Hernato         -           Abbys         -           2         NMTCA         Kimbo           2         NMTCA         Kimbo           2         NMTCA         Kimbo           3         NTCA         Kimbo           3         NTCA         Kimbo           -         -         -           Abbys         20.700 ± 0.0071           Bernardi         -           20.700 ± 0.0062         Abbys           3         NTCA         Kimbo				-
Mili         48.05 ± 2.87.78           Libbys         46.84 ± 37.3362           Bernardi         90.52 ± 84.3906           3         NTCA         Kornetku           Pronas         -           Mili         -           Libbys         -           Pronas         -           Mili         -           Libbys         -           Bernardi         1508 ± 2975.7           C. BURGER         Bernardi           No.         Nitrosamine         Brand           Nitrosamine         Brand         -           Hernato         -           Abbys         -           2         NMTCA         Kimbo           2         NMTCA         Kimbo         20.703 ± 0.0043           Vitalia         35.79 ± 2.7469         -           Hernato         20.705 ± 0.0062         Abbys           3         NTCA         Kimbo         -           Bernardi         -         -           Vitalia         35.79 ± 2.7469         -           Hernato         -         -           Abbys         20.700 ± 0.0118         -           Vitalia         -	2	NMTCA		
Libbys         46.84 ± 37.3862           Bernardi         90.52 ± 84.3906           3         NTCA         Kornetku         -           Pronas         -         -           Milli         -         -           Libbys         -         -           Bernardi         1508 ± 2975.7         -           C. BURGER         Bernardi         -           No.         Nitrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Kimbo         -           Abbys         -         -         -           2         NMTCA         Kimbo         -           2         NMTCA         Kimbo         20.705 ± 0.0077           Bernardi         20.705 ± 0.0075 ± 0.0062         -           Abbys         20.700 ± 0.0013         -           2         NMTCA         Kimbo         -           3         NTCA         Kimbo         -           3         NTCA         Fiesta         -           4         Kimbo         -         -           5         D.SMOKED BEEF         -         -           NO         Nitrosamine         Bernardi				
3     NTCA     Bernardi     90.52 ± 84.3906       3     NTCA     Kornetku     -       Pronas     -     -       Libbys     1     1508 ± 2975.7       C. BURGER     Bernardi     1508 ± 2975.7       No.     Nitrosamine     Brand       NDEA     Kimbo     -       Bernardi     -     -       Vitalia     -     -       Vitalia     -     -       Abbys     -     -       2     NMTCA     Kimbo     -       3     NTCA     Kimbo     -       4     Bernardi     20.705 ± 0.0077       Bernardi     20.705 ± 0.0043       Vitalia     35.79 ± 2.7469       Hemato     20.705 ± 0.0043       Vitalia     35.79 ± 2.7469       Hemato     20.705 ± 0.0043       Vitalia     -       Bernardi     -       Abbys     20.700 ± 0.00118       Sonos     -       NTCA     Kimbo       5     -       6     Bernardi       6     -       7     Abbys       7     -       8     -       9     -       9     -       1 </td <td></td> <td></td> <td></td> <td></td>				
3     NTCA     Kornetku     -       Pronas     -       Milli     -       Libbys     -       Bernardi     1508 ± 2975.7       C. BURGER     Brand     Nitrosamine ± SD (µg/kg)       1     NDEA     Kimbo       Bernardi     -       Vitalia     -       Hemato     -       Abbys     20.705 ± 0.0077       Bernardi     20.705 ± 0.0074       Bernardi     20.705 ± 0.0074       Bernardi     20.705 ± 0.0074       Bernardi     20.705 ± 0.0074       Bernardi     20.705 ± 0.0062       Abbys     20.700 ± 0.0118       3     NTCA     Kimbo       D.SMOKED BEEF     -       No.     Nitrosamine     Brand       NITCA     Fiesta     -       Yona     -       2     NMTCA     Fiesta       Yona     -       2     NMTCA     Fiesta       2     NMTCA     Fiesta       4     Yona     -       2     NMTCA     Fiesta       2     NMTCA     Fiesta       2     NMTCA     Fiesta       2     NMTCA     Fiesta       20.702 ± 0.0113     - <tr< td=""><td></td><td></td><td></td><td></td></tr<>				
Pronas     -       Milli     -       Libbys     Bernardi       No.     Nitrosamine       Bernardi     -       Vitalia     -       Vitalia     -       Abbys     -       2     NMTCA       Kimbo     -       2     NMTCA       Bernardi     20.705 ± 0.0077       Bernardi     20.705 ± 0.0043       Vitalia     35.79 ± 2.7469       Hemato     20.705 ± 0.0062       Abbys     20.700 ± 0.0118       Kimbo     -       Bernardi     -       Vitalia     -       MBCA     Fiesta       Vona     -       Chiefs     20.703 ± 0.0113       Yona     -       Chiefs     969.175 ± 116.403       Bernardi     20.702 ± 0.0113       Yona     20.702 ± 0.0107       Chiefs     4227.492 ± 605.5445			Bernardi	90.52 ± 84.3906
Mili Libbys         -           Bernardi         1508 ± 2975.7           C. BURGER         -           No.         Nitrosamine         Brand           NITCA         Kimbo         -           Bernardi         -         -           Vitalia         -         -           Abbys         -         -           2         NMTCA         Kimbo         20.705 ± 0.0077           Bernardi         20.703 ± 0.0043         Vitalia         35.79 ± 2.7469           Hemato         -         -         -           Abbys         20.700 ± 0.0043         Vitalia         35.79 ± 2.7469           Hemato         20.700 ± 0.0018         -         -           3         NTCA         Kimbo         20.700 ± 0.0018           3         NTCA         Kimbo         -           Bernardi         -         -           Vitalia         -         -           Abbys         -         -           D.SMOKED BEEF         -         -           No.         Fiesta         20.703 ± 0.0113           Yona         -         -           2         NMTCA         Fiesta         20.	3	NTCA	Kornetku	-
Mili Libbys         -           Bernardi         1508 ± 2975.7           C. BURGER         -           No.         Nitrosamine         Brand           NITCA         Kimbo         -           Bernardi         -         -           Vitalia         -         -           Abbys         -         -           2         NMTCA         Kimbo         20.705 ± 0.0077           Bernardi         20.703 ± 0.0043         Vitalia         35.79 ± 2.7469           Hemato         -         -         -           Abbys         20.700 ± 0.0043         Vitalia         35.79 ± 2.7469           Hemato         20.700 ± 0.0018         -         -           3         NTCA         Kimbo         20.700 ± 0.0018           3         NTCA         Kimbo         -           Bernardi         -         -           Vitalia         -         -           Abbys         -         -           D.SMOKED BEEF         -         -           No.         Fiesta         20.703 ± 0.0113           Yona         -         -           2         NMTCA         Fiesta         20.			Pronas	-
Bernardi         1508 ± 2975.7           C. BURGER         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Kimbo         -           Bernardi         -         -           Vitalia         -         -           Vitalia         -         -           Abbys         -         -           2         NMTCA         Kimbo         20.703 ± 0.0077           Bernardi         20.703 ± 0.0043         Vitalia         35.79 ± 2.769           2         NMTCA         Kimbo         20.703 ± 0.0062           Abbys         20.700 ± 0.00118         -           3         NTCA         Kimbo         -           Bernardi         -         -           Vitalia         35.79 ± 2.769         -           Bernardi         -         -           Bernardi         -         -           4bbys         20.700 ± 0.0018         -           Mono         Nitrosamine ± SD (µg/kg)         -           D. SMOKED BEEF         -         -           No.         Nitrosamine ± SD (µg/kg)         -           2         NMTCA         Fiesta         20.703 ± 0.0113				-
Bernardi         1508 ± 2975.7           C. BURGER         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Kimbo         -           Bernardi         -         -           Vitalia         -         -           Vitalia         -         -           Abbys         -         -           2         NMTCA         Kimbo         20.703 ± 0.0077           Bernardi         20.703 ± 0.0043         Vitalia         35.79 ± 2.769           2         NMTCA         Kimbo         20.703 ± 0.0062           Abbys         20.700 ± 0.00118         -           3         NTCA         Kimbo         -           Bernardi         -         -           Vitalia         35.79 ± 2.769         -           Bernardi         -         -           Bernardi         -         -           4bbys         20.700 ± 0.0018         -           Mono         Nitrosamine ± SD (µg/kg)         -           D. SMOKED BEEF         -         -           No.         Nitrosamine ± SD (µg/kg)         -           2         NMTCA         Fiesta         20.703 ± 0.0113				-
C. BURGER           No.         Nitrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Kimbo         -           Vitalia         -         -         -           Hemato         -         -         -           Abbys         -         -         -           2         NMTCA         Kimbo         20.705 ± 0.0077           Bernardi         20.705 ± 0.0073 ± 0.0043         Vitalia         35.79 ± 2.7469           Hemato         20.705 ± 0.0062         Abbys         -           3         NTCA         Kimbo         -           Abbys         20.700 ± 0.0018         -         -           3         NTCA         Kimbo         -           Bernardi         -         -         -           Vitalia         -         -         -           Bernardi         -         -         -           Vitalia         -         -         -           D. SMOKED BEEF         -         -         -           No         Nitrosamine         Bernardi         -           Yona         -         -         -           2				1508 + 2975 7
No.         Nitrosamine         Brand         Nitrosamine ± SD (μg/kg)           1         NDEA         Kimbo         -           Bernardi         -         -           Vitalia         -         -           Hemato         -         -           Abbys         -         -           2         NMTCA         Kimbo         20.705 ± 0.0077           Bernardi         20.705 ± 0.0043         Vitalia         35.79 ± 2.7469           Vitalia         35.79 ± 2.7469         -         -           Hemato         20.705 ± 0.0043         Vitalia         35.79 ± 2.7469           Abbys         20.700 ± 0.0043         Vitalia         35.79 ± 2.7469           Hemato         20.705 ± 0.0062         Abbys         20.700 ± 0.0013           3         NTCA         Kimbo         -           Bernardi         -         -         -           Vitalia         -         -         -           No.         Nitrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Fiesta         -           Yona         20.703 ± 0.0113         -           Chiefs         989.175 ± 116,403         Bem		D	Domaidi	1000 2 201011
1         NDEA         Kimbo         -         -           Bernardi         -         -         -         -           Vitalia         -         -         -         -           Hemato         -         -         -         -           Abbys         2         NMTCA         Kimbo         20.705 ± 0.0077           Bernardi         20.703 ± 0.0043         Vitalia         35.79 ± 2.7469           Hemato         20.705 ± 0.0062         Abbys         20.700 ± 0.0118           3         NTCA         Kimbo         -           Witalia         -         -           Vitalia         35.79 ± 2.7469         -           Hemato         20.700 ± 0.0118         -           Vitalia         -         -         -           Vitalia         -         -         -           Vitalia         -         -         -           Abbys         -         -         -           D.SMOKED BEEF         -         -         -           NDEA         Fiesta         -         -           Yona         -         -         -           2         NMTCA         Fiesta </th <th></th> <th></th> <th>Brand</th> <th>Nitrosamine + SD (ug/kg)</th>			Brand	Nitrosamine + SD (ug/kg)
Bernardi         -           Vitalia         -           Hemato         -           Abbys         -           2         NMTCA         Kimbo         20.705 ± 0.0077           Bernardi         20.705 ± 0.0043         Vitalia         35.79 ± 2.7469           Hemato         20.705 ± 0.0062         Abbys         20.705 ± 0.0062           Abbys         20.700 ± 0.0118         Bernardi         -           3         NTCA         Kimbo         -           Bernardi         -         -         Vitalia           3         NTCA         Kimbo         -           D.SMOKED BEEF         -         -         -           NDEA         Fiesta         -         -           Yona         -         -         -           Chiefs         -         -         -           2         NMTCA         Fiesta         -         -           2         NMTCA         Fiesta         20.703 ± 0.0113         -           2         NMTCA         Fiesta         20.703 ± 0.0113         -           2         NMTCA         Fiesta         20.703 ± 0.0107         -           2				Hitesamme ± eb (µg/kg)
Vitalia         -           Hernato         -           Abbys         -           Abbys         -           Abbys         -           Abbys         -           Abbys         -           Bernardi         20.703 ± 0.0043           Vitalia         35.79 ± 2.7469           Hernato         20.700 ± 0.0062           Abbys         20.700 ± 0.0118           3         NTCA         Kimbo           Bernardi         -           Vitalia         -           Hernato         -           Vitalia         -           Bernardi         -           Hernato         -           D.SMOKED BEEF         -           No.         Nitrosamine         Brand           Yona         20.703 ± 0.0113           Yona         20.703 ± 0.0113           Yona         20.703 ± 0.0113           Yona         20.703 ± 0.0017           Chiefs         989.175 ± 116.403           Bernardi         20.708 ± 0.0078           Farmhouse         -           Sampuse         20.697 ± 0.0224           3         NTCA         Fiesta      <		NDEA		-
Hemato         -           Abbys         -           2         NMTCA         Kimbo         20.705 ± 0.0077           Bernardi         20.703 ± 0.0043         Vitalia         35.79 ± 2.7469           Hemato         20.705 ± 0.0062         Abbys         20.705 ± 0.0062           Abbys         20.700 ± 0.0018         3         S.79 ± 2.7469           Hemato         20.700 ± 0.0018         3         Abbys         20.700 ± 0.0018           3         NTCA         Kimbo         -         -           Bernardi         -         -         -           Vitalia         -         -         -           D.SMOKED BEEF         -         -         -           NDEA         Fiesta         -         -           Yona         -         -         -           2         NMTCA         Fiesta         20.703 ± 0.0113           Yona         20.702 ± 0.0107         -         -           Chiefs         989.175 ± 116.403         -           Bernardi         20.708 ± 0.0078         -           2         NMTCA         Fiesta         -           Yona         20.697 ± 0.0224         -				-
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3         NTCA         Kimbo         -           Bernardi         -         -           Vitalia         -         -           Hemato         -         -           Abbys         -         -           D. SMOKED BEEF         Fiesta         -           No.         Nitrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Fiesta         -           Yona         -         -         -           2         NMTCA         Fiesta         20.703 ± 0.0113           Yona         20.703 ± 0.0107         -           Chiefs         989.175 ± 116.403           Bernardi         20.708 ± 0.0078           Bernardi         20.708 ± 0.0078           Farmhouse         -           Samardi         20.708 ± 0.0078           Farmhouse         20.697 ± 0.0224           Farmhouse         20.697 ± 0.0224           3         NTCA         Fiesta         -           Yona         -         -           Chiefs         4227.492 ± 605.5445	2	NMTCA	Abbys Kimbo Bernardi Vitalia	20.703 ± 0.0043 35.79 ± 2.7469
3         NTCA         Kimbo         -           Bernardi         -         -           Vitalia         -         -           Hemato         -         -           Abbys         -         -           D. SMOKED BEEF         Fiesta         -           No.         Nitrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Fiesta         -           Yona         -         -         -           2         NMTCA         Fiesta         20.703 ± 0.0113           Yona         20.703 ± 0.0107         -           Chiefs         989.175 ± 116.403           Bernardi         20.708 ± 0.0078           Bernardi         20.708 ± 0.0078           Farmhouse         -           Chiefs         989.175 ± 116.403           Bernardi         20.708 ± 0.0078           Farmhouse         20.697 ± 0.0224           3         NTCA         Fiesta           Yona         -           Chiefs         4227.492 ± 605.5445	2	NMTCA	Abbys Kimbo Bernardi Vitalia	20.703 ± 0.0043 35.79 ± 2.7469
Bernardi         -           Vitalia         -           Hemato         -           D. SMOKED BEEF         -           No.         Nitrosamine         Brand           NItrosamine         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Fiesta           Chiefs         -           Bernardi         -           Parmhouse         -           2         NMTCA         Fiesta           Yona         20.703 ± 0.0113           Yona         20.703 ± 0.0107           Chiefs         989.175 ± 116.403           Bernardi         20.708 ± 0.0078           Farmhouse         -           Chiefs         20.697 ± 0.0224           3         NTCA         Fiesta           Yona         20.697 ± 0.0224           Ghiefs         4227.492 ± 605.5445	2	NMTCA	Abbys Kimbo Bernardi Vitalia Hemato	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062
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Hemato         -           Abbys         -           D. SMOKED BEEF         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Fiesta           Yona         -         -           Bernardi         -         -           2         NMTCA         Fiesta         20.703 ± 0.0113           Yona         20.702 ± 0.0107         -           Chiefs         989.175 ± 116.403         Bernardi           20.708 ± 0.0078         Fiesta         20.708 ± 0.0078           3         NTCA         Fiesta         -           Yona         20.697 ± 0.0224         -           3         NTCA         Fiesta         -           Yona         20.697 ± 0.0224         -           Chiefs         4227.492 ± 605.5445         -			Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062
Abbys     -       D. SMOKED BEEF     Nitrosamine     Brand     Nitrosamine ± SD (µg/kg)       1     NDEA     Fiesta     -       1     NDEA     Fiesta     -       Chiefs     -     -       Bernardi     -       2     NMTCA     Fiesta     20.703 ± 0.0113       Yona     20.703 ± 0.0107     Chiefs     989.175 ± 116.403       Bernardi     20.708 ± 0.0078     Bernardi     20.697 ± 0.0224       3     NTCA     Fiesta     -       Yona     -     -     -       Chiefs     4227.492 ± 605.5445     -			Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062
D. SMOKED BEEF         Brand         Nitrosamine ± SD (µg/kg)           1         NDEA         Fiesta         -           Yona         -         -         -           Chiefs         -         -         -           Bernardi         -         -         -           2         NMTCA         Fiesta         20.703 ± 0.0113           Yona         20.702 ± 0.0107         -           Chiefs         989.175 ± 116.403           Bernardi         20.708 ± 0.0078           Farmhouse         -           Samardi         20.707 ± 0.0078           Farmhouse         -           Yona         20.697 ± 0.0224           3         NTCA         Fiesta         -           Yona         -         -           Chiefs         4227.492 ± 605.5445         -			Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062
No.         Nitrosamine         Brand         Nitrosamine ± SD (μg/kg)           1         NDEA         Fiesta         -           Yona         -         -           Chiefs         -         -           Bernardi         -         -           2         NMTCA         Fiesta         20.703 ± 0.0113           Yona         20.702 ± 0.0107         Chiefs         989.175 ± 116.403           Bernardi         20.708 ± 0.0078         Fiesta         -           3         NTCA         Fiesta         -         -           Yona         20.697 ± 0.0224         -         -           3         NTCA         Fiesta         -         -           Yona         -         -         -         -           Chiefs         4227.492 ± 605.5445         -         -			Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062
1         NDEA         Fiesta         -           Yona         -         -           Chiefs         -         -           Bernardi         -         -           Farmhouse         -         -           2         NMTCA         Fiesta         20.703 ± 0.0113           Yona         20.702 ± 0.0107         -         -           Chiefs         989.175 ± 116.403         -           Bernardi         20.708 ± 0.0078         -           Farmhouse         20.697 ± 0.0224         -           3         NTCA         Fiesta         -           Yona         -         -         -           Chiefs         4227.492 ± 605.5445         -	3	NTCA	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062
Yona         -           Chiefs         -           Bernardi         -           Farmhouse         -           2         NMTCA         Fiesta           20.703 ± 0.0113         Yona           Yona         20.702 ± 0.0107           Chiefs         989.175 ± 116.403           Bernardi         20.708 ± 0.0078           Farmhouse         20.697 ± 0.0224           3         NTCA         Fiesta           Yona         -           Chiefs         4227.492 ± 605.5445	3 D. SMOKE	NTCA D BEEF	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062 20.700 ± 0.0118 - -
Chiefs	3 D. SMOKE No.	NTCA D BEEF Nitrosamine	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys Brand	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062 20.700 ± 0.0118 - -
Bernardi         -           Farmhouse         -           2         NMTCA         Fiesta         20.703 ± 0.0113           Yona         20.702 ± 0.0107         -           Chiefs         989.175 ± 116.403           Bernardi         20.708 ± 0.0078           Farmhouse         20.697 ± 0.0224           3         NTCA         Fiesta           Yona         -           Chiefs         4227.492 ± 605.5445	3 D. SMOKE No.	NTCA D BEEF Nitrosamine	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys Brand Fiesta	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062 20.700 ± 0.0118 - -
Farmhouse         -           2         NMTCA         Fiesta         20.702 ± 0.0113           Yona         20.702 ± 0.0107         Chiefs         989.175 ± 116.403           Bernardi         20.708 ± 0.0078         Farmhouse           3         NTCA         Fiesta         -           Yona         -         -         -           Chiefs         4227.492 ± 605.5445         -	3 D. SMOKE No.	NTCA D BEEF Nitrosamine	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys Brand Fiesta Yona	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062 20.700 ± 0.0118 - -
2         NMTCA         Fiesta         20.703 ± 0.0113           Yona         20.702 ± 0.0107           Chiefs         989.175 ± 116,403           Bernardi         20.708 ± 0.0078           Farmhouse         20.697 ± 0.0224           3         NTCA         Fiesta           Yona         -           Chiefs         4227.492 ± 605.5445	3 D. SMOKE No.	NTCA D BEEF Nitrosamine	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys Brand Fiesta Yona Chiefs	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062 20.700 ± 0.0118 - -
Yona         20.702 ± 0.0107           Chiefs         989.175 ± 116.403           Bernardi         20.708 ± 0.0078           Farmhouse         20.697 ± 0.0224           3         NTCA         Fiesta           Yona         -           Chiefs         4227.492 ± 605.5445	3 D. SMOKE No.	NTCA D BEEF Nitrosamine	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys Bernand Fiesta Yona Chiefs Bernardi	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062 20.700 ± 0.0118 - -
Chiefs 989.175 ± 116,403 Bernardi 20.708 ± 0.0078 Farmhouse 20.697 ± 0.0224 3 NTCA Fiesta - Yona - Chiefs 4227.492 ± 605.5445	3 D. SMOKE No. 1	NTCA D BEEF Nitrosamine NDEA	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys Bernard Fiesta Yona Chiefs Bernardi Farmhouse	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062 20.700 ± 0.0118 - - - - - - - - - - - - - - - - - -
Chiefs 989.175 ± 116.403 Bernardi 20.708 ± 0.0078 Farmhouse 20.697 ± 0.0224 3 NTCA Fiesta - Yona - Chiefs 4227.492 ± 605.5445	3 D. SMOKE No. 1	NTCA D BEEF Nitrosamine NDEA	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys Bernard Fiesta Yona Chiefs Bernardi Farmhouse	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062 20.700 ± 0.0118 - - - - - - - - - - - - - - - - - -
Bernardi 20.708 ± 0.0078 Farmhouse 20.697 ± 0.0224 3 NTCA Fiesta - Yona - Chiefs 4227.492 ± 605.5445	3 D. SMOKE No. 1	NTCA D BEEF Nitrosamine NDEA	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys Bernardi Fiesta Serand Chiefs Bernardi Farmhouse Fiesta	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062 20.700 ± 0.0118 - - - - - - - - - - - - - - - - - -
Farmhouse         20.697 ± 0.0224           3         NTCA         Fiesta         -           Yona         -         -           Chiefs         4227.492 ± 605.5445         -	3 D. SMOKE No. 1	NTCA D BEEF Nitrosamine NDEA	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys Bernardi Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Yona	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062 20.700 ± 0.0118 - - - Nitrosamine ± SD (µg/kg) - - 20.703 ± 0.0113 20.702 ± 0.0107
3 NTCA Fiesta - Yona - Chiefs 4227.492 ± 605.5445	3 D. SMOKE No. 1	NTCA D BEEF Nitrosamine NDEA	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys Bernardi Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Yona Chiefs	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062 20.700 ± 0.0118 - - - - Nitrosamine ± SD (µg/kg) - - 20.703 ± 0.0113 20.702 ± 0.0113 20.702 ± 0.0107 988.175 ± 116.403
Yona - Chiefs 4227.492 ± 605.5445	3 D. SMOKE No. 1	NTCA D BEEF Nitrosamine NDEA	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys Brand Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Yona	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0662 20.700 ± 0.0118 - - - Nitrosamine ± SD (µg/kg) - - - - - - - - - - - - -
Chiefs 4227.492 ± 605.5445	3 D. SMOKE No. 1	NTCA D BEEF Nitrosamine NDEA NMTCA	Abbys Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys Bernardi Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Yona Chiefs Bernardi Farmhouse	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0662 20.700 ± 0.0118 - - - Nitrosamine ± SD (µg/kg) - - - - - - - - - - - - -
	3 D. SMOKE No. 1	NTCA D BEEF Nitrosamine NDEA NMTCA	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys Bernardi Fiesta Yona Chiefs Bernardi Famhouse Fiesta Yona Chiefs Bernardi Famhouse Fiesta Bernardi Famhouse Fiesta	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0662 20.700 ± 0.0118 - - - Nitrosamine ± SD (µg/kg) - - - - - - - - - - - - -
	3 D. SMOKE No. 1	NTCA D BEEF Nitrosamine NDEA NMTCA	Abbys Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Vitalia Hemato Abbys Brand Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Yona Chiefs Pona Chiefs P	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062 20.700 ± 0.0118   Nitrosamine ± SD (µg/kg)  20.703 ± 0.0113 20.702 ± 0.0107 989.175 ± 116.403 20.708 ± 0.0078 20.708 ± 0.0078 20.697 ± 0.0224 
	3 D. SMOKE No. 1	NTCA D BEEF Nitrosamine NDEA NMTCA	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Hemato Abbys Bernardi Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Senardi Farmhouse Fiesta Senardi Farmhouse Fiesta Senardi Farmhouse Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Yona Chiefs	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0662 20.700 ± 0.0118 - - - - Nitrosamine ± SD (µg/kg) - - 20.703 ± 0.0113 20.702 ± 0.0113 20.705 ± 0.0113 20.705 ± 0.0113 20.705 ± 0.0113 20.705 ± 0.0107 989.175 ± 116,403 20.697 ± 0.0224 - - - 4227.492 ± 605.5445
Farmhouse - Note: ((-): Not Detected, the data is an average of three Repeat times)	3 D. SMOKE No. 1	NTCA D BEEF Nitrosamine NDEA NMTCA	Abbys Kimbo Bernardi Vitalia Hemato Abbys Kimbo Bernardi Hemato Abbys Brand Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Yona Chiefs Bernardi Farmhouse Fiesta Yona Chiefs Bernardi	20.703 ± 0.0043 35.79 ± 2.7469 20.705 ± 0.0062 20.700 ± 0.0118   Nitrosamine ± SD (µg/kg)  20.703 ± 0.0113 20.702 ± 0.0107 989.175 ± 116.403 20.708 ± 0.0078 20.708 ± 0.0078 20.697 ± 0.0224 

Table 2: Nitrosamine Levels (NDEA, NMTCA, and NTCA) in Various Types of Processed Meat Products

Note: ((-): Not Detected, the data is an average of three Repeat times

The level of NMTCA in all samples analysed varies greatly, ranging from 20.50 to 989.175  $\mu$ g/kg. Whereas NTCA was only found in 5 of the 20 samples tested, ranging from 501.290-4227.492  $\mu$ g/kg.

In this study, it is found that the levels of NMTCA in all samples exceed the limit set by the WHO, which is 10 µg/kg body weight. In sausage samples, NMTCA levels detected are 36.91 µg/kg (Fiesta), 39.41 µg/kg (Delicious), 35.64 µg/kg (Kenfood), 41.99 µg/kg (Kimbo) and 108.31 µg/kg (So Good). In corned beef samples, NMTCA levels detected are 20.54 µg/kg (Korenetku), 20.50 µg/kg (Pronas), 48.05 µg/kg (Mili), 46.84 µg/kg (libbys), and 90.52 µg/kg (Bernardi). In the burger samples. NMTCA levels detected are 20.705 µg/kg (Kimbo), 20.703 µg/kg (Bernanrdi), 35.79 µg/kg (Vitalia), 20.705 (Hemato), and 20.70 µg/kg (Abbys). In smoked beef samples, NMTCA levels detected are µg/kg (Fiesta), 20.702 µg/kg (Yona), 20.703 989.175 µg/kg (Chiefs), 20.708 µg/kg (Bernardi), and

Besides that, it is also found that NTCA in some samples exceeds the limit allowed by the WHO. Those samples are Fiesta sausage (585.45  $\mu$ g/kg) and So Good (2565.44  $\mu$ g/kg), corned beef Bernardi (1508.00  $\mu$ g/kg), smoked beef Chiefs (4229.492  $\mu$ g/kg) and smoked beef Bernardi (501.29  $\mu$ g/kg).

Based on previous research conducted by Herrmann (2014), nitrosamines levels obtained were also varied. The highest nitrosamine content found is NTCA which is 4030 µg/kg. The results of this study are the same as previous studies, where NDEA levels are not detected in all analysed samples. But in this study nitrosamine levels are higher than previous studies. The highest nitrosamine level is NTCA which is 4227.492 µg/kg (smoked beef Chiefs). The highest NMTCA and NTCA levels are found in smoked beef products. This is also corresponding to the previous study conducted by Herrmann (2014) where the levels of nitrosamines reach the maximum level of 2034-4030 µg/kg. The formation of these two nitrosamines is high in smoked beef samples because the high temperature applied during the smoking process triggers NMTCA and NTCA formation. It is also likely to occur due to several factors such as the concentration of nitrite. temperature, storage condition, the presence of catalysts or inhibitors. The higher the concentration of nitrite and amine compounds, the easier the formation of nitrosamines will be. However, the toxicological properties of both NMTCA and NTCA (nonvolatile nitrosamine) compounds have not been detected. Nonvolatile nitrosamines are weak carcinogens, but not enough data to determine the toxicological properties of these compounds. However, NMTCA and NTCA two nitrosamine levels in processed meat products need to be considered to prevent cancer prevalence [3], [9], [11], [12], [16], [17], [18], [19], [20].

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