ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 8
October 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2022; 22(8): 21201-21222 https://doi.org/10.18697/ajfand.113.22235

SODIUM IN PROCESSED MEATS PRODUCED BY LOCAL BUTCHERIES IN TSHWANE, SOUTH AFRICA

Mkhwebane EJ[1]*, Bekker JL[1] and NS Mokgalaka-Fleischmann[2,3]

Elphus J. Mkhwebane

*Correspondence author email: elphus@vgldimensions.co.za

[1]Department of Environmental Health, Tshwane University of Technology, Private Bag X680, Pretoria 0001, Republic of South Africa

[2]Department of Chemistry, Tshwane University of Technology, Private Bag X680, Pretoria 0001, Republic of South Africa

[3]Mamelodi Campus, University of Pretoria, Private Bag X20, Hatfield, Pretoria, 0028, Republic of South Africa

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 8
October 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

ABSTRACT

The common use of sodium in different compositions, is as a preservative, for colouring, curing, flavouring and as a binding agent in processed meats, it is also used for improved shelf life and distinct palatability. Even with modern food processing methods, sodium is still essential in manufacturing of meat derivatives. Continuous consumption of high sodium diets is associated with adverse chronic health effects, such as cardiovascular diseases, hypertension, stroke, cancers, among others, which have been on the rise. As a result, there has been a global drive by organisations such as the World Health Organization (WHO) to advise member states to reduce dietary sodium levels in various foods, including processed meats. Consequently, South Africa promulgated the first sodium reduction regulations in Africa by 2013, intended to reduce sodium in certain foodstuffs, including processed meat products. The objectives of this study were to determine (1) the level of sodium in processed meats produced by local butcheries in the City of Tshwane (CoT), Gauteng, South Africa and (2) to compare the amount of sodium in processed meats, determined using the two South African legislated methods, namely Flame Atomic Absorption Spectroscopy (FAAS) and Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES). A cross-sectional approach with qualitative and experimental dimensions approach was followed. Processed meat production records obtained from randomly selected butcheries in CoT (122) revealed that the top six commonly produced processed meats were boerewors (90.2 %), braaiwors (87.7 %), biltong (86.9 %), drywors (62.3 %), viennas (45.9 %) and burger patties (43.5 %). Subsequently, sampling (n=396) of the top six products from 66 randomly selected butcheries was done. The findings of the study revealed that processed meats analysed using ICP-AES and FAAS contained mean sodium levels of 1449 mg/100 g and 649 mg/100 g, respectively ($p<0.0001$), which were higher than the South African legal sodium limits. The concentration of sodium of products determined using ICP-AES (64.7 - 9201 mg/100 g) was significantly ($p<0.0001$) higher than in the same products analysed using FAAS (35.4 - 2351 mg/100 g). From the findings of this study, sodium reduction requires a concerted effort in enforcing the South African mandatory sodium limits in local butcheries in processed meats. The results of legislated sodium test methods must be comparable to ensure equal level of compliance.

Key words: meat products, sodium reduction, processed food, processed meat, sodium limits

https://doi.org/10.18697/ajfand.113.22235

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 8 October 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

INTRODUCTION

Sodium (Na) is used as a food preservative and has changed the nature of food processing due to its influence on palatability of food [1]. Different households and industrial products contain Na^{+} in different compositions, such as table salt, soda ash, baking soda, caustic soda, sodium nitrate, sodium nitrite, di- and tri-sodium phosphates, sodium thiosulphate and borax [2].

As in other parts of the world, urbanised South African consumers are influenced by westernised diets, which results in a high intake of energy-dense foods, such as processed meats, refined grains, added sugar and saturated fats [3,4]. Globally, the perception is that the consumption of processed meats is the second major contributor to increased dietary sodium intake after cereal products [5,6]. The most common source of sodium in processed foods is sodium chloride (table salt) [7]. The average sodium intake in South Africa is approximately 9-12 g/day/person [8], while Asian countries averaged 12 g/day/person [9]. An average of 30 % of South Africans have a mean sodium consumption of 6-11 g/day/person [10]. There is an association between excess consumption of sodium and negative health effects [4,11] which include cardiovascular diseases such as hypertension and increased risk of stroke [12], gastric cancer [13], various other human cancers [14] and the occurrence of kidney stones, kidney disease and kidney failure [15]. Most of these diseases are the leading causes of death and disability in the modern era [16].

Combatting lifestyle diseases by reduction of dietary sodium intake has been a longstanding strategy. As a result CODEX established supplementary guidelines for sodium, which was adopted together with the WHO's and the Heart and Stroke Foundation of South Africa's recommendations of daily sodium consumption reduction to less than 5 g/day/person [17]. In order to cut down the consumption of sodium in the population's daily diets to this concentration, it is necessary to consider formulation specifications by manufacturers, strict regulations and monitoring strategies by health authorities and consumer awareness [18]. By 2013, South Africa was the first country in Africa [19] to promulgate legal sodium limits in certain foods, including processed meat products [20]. Among other non-meat products, processed meats (cured and uncured) and raw processed meat sausages (all types) were specifically categorised as food categories seven, eight and nine, respectively, with maximum total sodium limits (TSL) [21]. Table 1 summarises the categories of processed meats and South Africa's mandatory limits. Although the International Organisation for Standardization (ISO) has developed several procedures, South Africa has two legally prescribed methods, namely FAAS and ICP-AES [19]. As in other parts of South Africa, local butcheries

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 8
October 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

of the CoT are increasingly involved with the production of various types of processed meat. For the purpose of this study, a local butchery is defined as premises located in shopping malls and residential suburbs, not supermarket butcheries. The objectives of the study were: (1) to determine the level of compliance to legal TSLs by local butcheries that produce processed meat in the CoT, and (2) to compare the South African legally prescribed sodium testing methods.

MATERIALS AND METHODS

Study area

The CoT is a metropolitan municipality in the north of Gauteng Province, South Africa (latitudes 25^{0}6'34.60" S to 26^{0}4'41.12" S and longitudes 27^{0}53'24.26" E to 29^{0}5'54.31" E). Figure 1 shows a map of the location of the CoT and its seven respective regions.

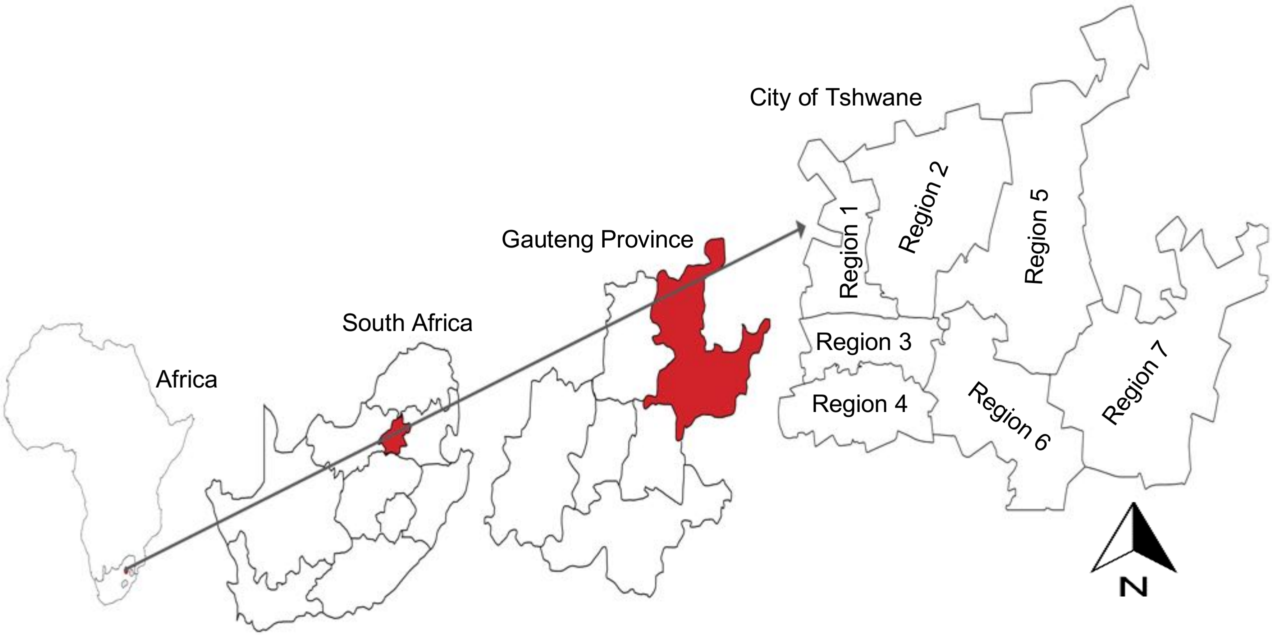

Figure 1: Map of the location of CoT in South Africa [22]

A two-pronged cross-sectional approach with qualitative and experimental dimensions was followed for this study [10]..

Processed meat products produced in local butcheries

A survey of local butcheries across the seven regions was conducted to determine the processed meat types and the volumes produced by each butchery. The number of butcheries in the respective regions came from an electronic database of the CoT. Table 2 shows the number of butcheries proportionately selected per

https://doi.org/10.18697/ajfand.113.22235

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 8
October 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

region, as determined by a statistician. Assessment of the 122 butcheries' production records was with regard to the processed meats produced (as listed in SANS 885:2011) [23]. In addition, scrutinising the labels of prepacked spices used in the manufacturing of processed meat determined the different types of sodium-based ingredients.

Sampling of processed meats from the butcheries

To determine the TSLs, the six most produced processed meat products were sampled (N=396) from 66/122 (54.1 %) local butcheries (Region one = nine, Region two = nine, Region three = 14, Region four = 13, Region five = three, Region six = 15 and Region seven = three).

Collection of samples of top six produced processed meats

Approximately 150 to 200 g of each of the products were purchased, placed in clean zip-lock plastic bags, labelled with the product name, date of sampling and region, and sent (<10 ^{0}C) to the laboratory where it was frozen (-18 ^{0}C) until analysis.

Calibration of analytical instruments and validation of FAAS and ICP-AES

To calibrate the FAAS and the ICP-AES, a series of Na standards (0 to 5 mg/L for FAAS and 0 to 500 mg/L) were prepared from a stock solution. A canned meat (T01120QC; FAPAS QC Fera Science Ltd, Sand Hutton, York, UK, valid until 2028) Certified Reference Material (CMR) was used to validate the FAAS and ICP-AES methods. Linear regression was used to determine the relationship between the instrument response and the known concentration of the standards, as indicated in Figure 2. Both regression curves were linear (R^2 = 0.9969 for FAAS and R^2 = 0.9981 for ICP-AES) and the differences between the measured and predicted values were nearly 100 % fit to the regression model. There were no outliers, and the prediction of the dependent variable could be with limited error from the independent variable.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 22 No. 8 October 2022 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

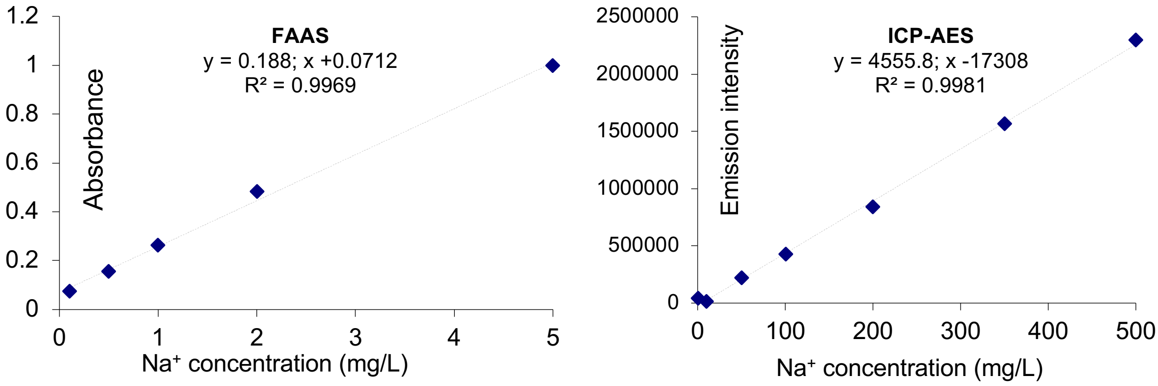

Figure 2: Calibration curves of Na using FAAS and ICP-AES

The canned meat CRM was used to validate the FAAS and ICP-AES. The mean sodium concentration acquired was 547 ± 15.3 mg/100 g obtained by FAAS and 582 ± 12.3 mg/100 g obtained by ICP-AES, results were within the certified sodium levels (548 – 653 mg/100 g) of the CRM.

Sample preparation and analysis

Defrosting of the processed meat samples took place in a defrosting booth at ambient temperature. The samples and certified reference material (CRM) were prepared and acid digested using the official AOAC Method 2011.14 [24]. A Shimadzu FAAS model A-6701F (Shimadzu, Kyoto, Japan). For ICP-AES, a Spectro ARCOS® ICP-AES (METEK, New Jersey, USA) was used.

Statistical analysis

Analysis of variance (ANOVA), using the software XLSTAT 2015.04.36025, determined any significant differences in the sodium concentrations and in butcheries. For evaluation of differences in proportions Chi-square (χ^2) test was used. Where probability values of $p<0.05$ (CL 95 %) were considered as significantly different. The results were presented in graphs and tables.

RESULTS AND DISCUSSION

In total, there were 122 butcheries, proportionally across the seven regions of the CoT, interviewed and 396 processed meat samples were taken from the top six products sampled from 66 (54 %) butcheries and analysed for sodium levels. Table 3 provides proportional butchery distribution across the seven regions of the CoT and the distribution of the samples across the regions.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 22 No. 8 October 2022 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Providing for the size of butcheries (N=122), a distinction can be made between the following categories, based on the number of pay points per butchery: one pay-point (39.3 %), two to five pay points (50.0 %), and > five pay points (10.7 %). Figure 3 indicates the data analysis and top six processed meats amongst other products.

Processed meat production by butcheries in CoT

The top six processed meats produced by butcheries were boerewors (90.2 % of the butcheries), braaiwors (87.7 % of the butcheries), biltong (86.9 % of the butcheries), drywors (62.3 % of the butcheries), viennas (45.9 % of the butcheries) and burger patties (43.4 % of butcheries). Braaiwors had the highest production capacity (27.2 %), followed by boerewors (20.6 %), biltong (15.1 %), burgers (8.9 %); drywors (8.5 %) and viennas (5.1 %). The sodium compounds, identified from commercial spice pack labels, of the top six processed meat products included sodium chloride and sodium sulphide (used in boerewors, braaiwors and burger patties), nitrates and nitrites (used in viennas), as well as a potassium (used in biltong and drywors).

Sodium content in processed meat samples

Table 4 indicates sodium levels of processed meats tested using ICP-AES and FAAS. Figure 4 (a, b, c) provides a summary of sodium concentration of processed meat products.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 8
October 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

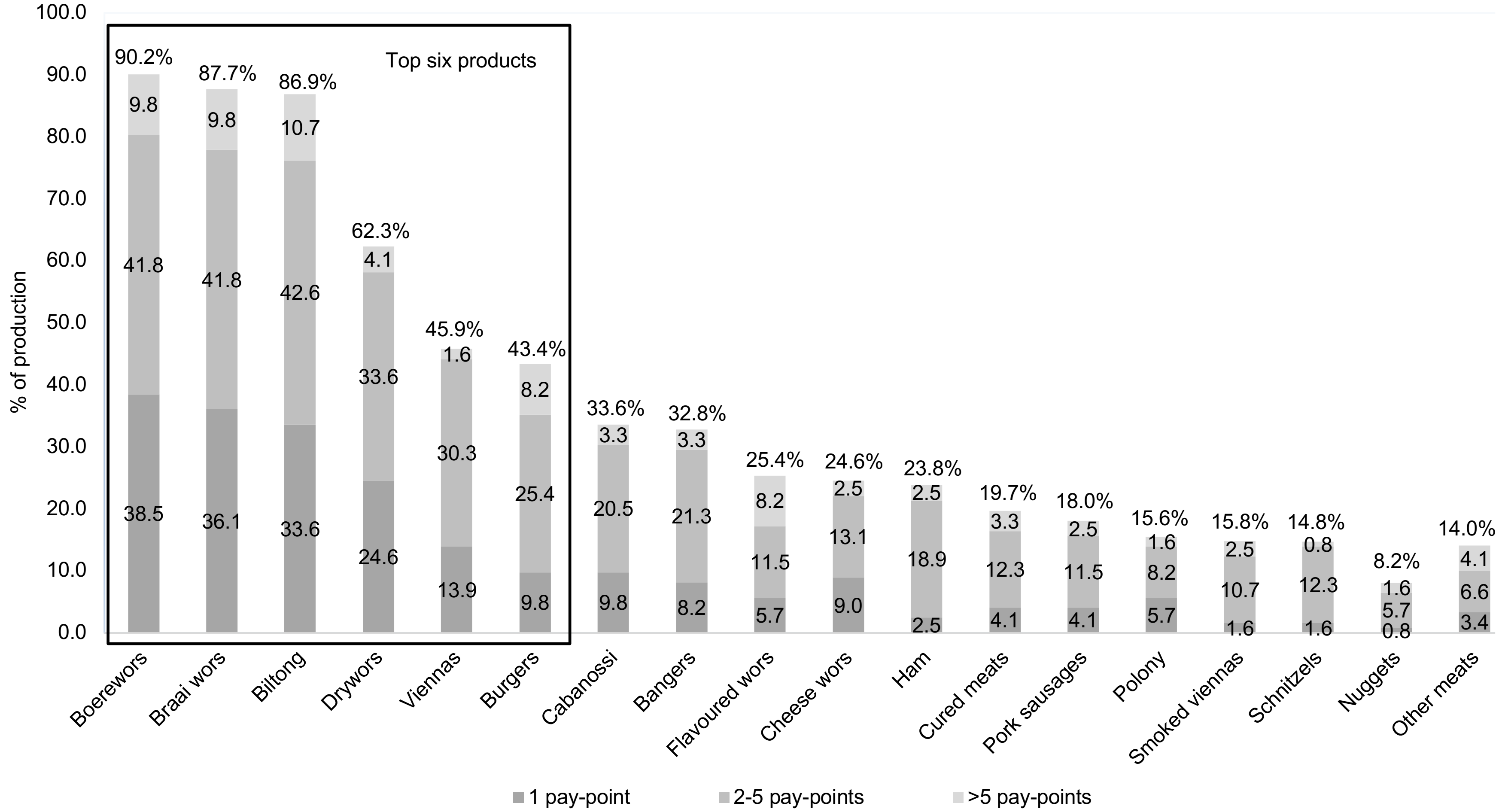

Figure 3: Processed meats produced by butchery size (number of pay-points)

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 8
October 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

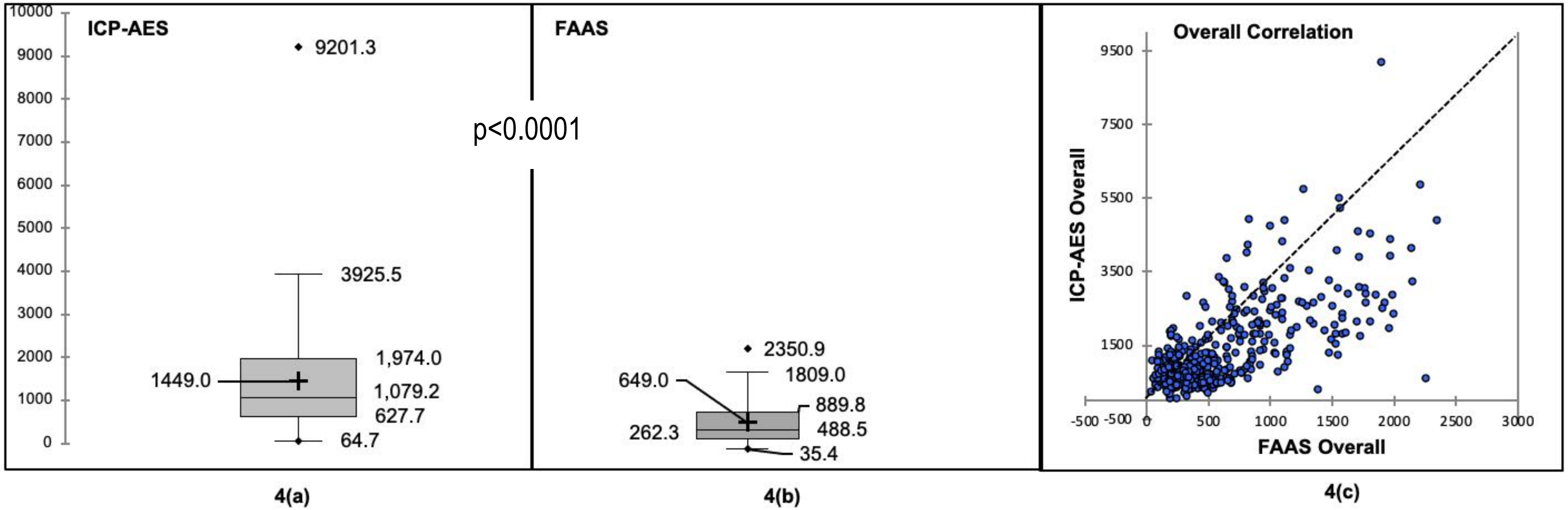

Figure 4: Comparison and correlation of sodium concentration 4(a) correlation of the mean Na^+ concentrations using ICP-AES, 4(b) correlation of the mean Na concentrations using FAAS and 4(c) overall relation of Na concentrations between ICP-AES and FAAS

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 8
October 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

From Figure 4, biltong had the highest mean concentration of total sodium (3040 mg/100 g by ICP-AES and 1293 mg/100 g by FAAS), followed by drywors (2207 mg/100 g by ICP-AES and 1004 mg/100 g by FAAS). When analysed with ICP-AES, 31.1 % (82/264) of samples did not comply with the 2019 target, and 46.6 % (123/264) did not comply with the 2020 legal limits. In contrast, when using FAAS for the same samples, 2.3 % (6/264) and 4.9 % (13/264) did not comply to the same sodium legal limits, respectively. It was evident the sodium levels were unlikely to be compliant when determined with ICP-AES than with FAAS because of the superior sensitivity of the ICP-AES compared to FAAS. In comparing, the sodium concentrations for the different products (Table 4), the mean results using ICP-AES (64.7 - 9201.3 mg/100 g) were significantly ($p<0.0001$) higher than those obtained with FAAS (35.4 - 2350.9 mg/100 g). In Figure 4, Figures 4(a) and 4(b) were significantly different ($p<0.0001$), while Figure 4(c) demonstrated there was a weak correlation between the two legally prescribed sodium testing methods.

The 2013 South African sodium reduction regulations became the first in. In 2016, 2017 and 2019 there was an amendment of the inception sodium limits, and in each of the amendments, there was a reduction or increase of sodium levels for selected processed meats. Enforcement of regulations is merely left to the under-resourced health authorities and consequently, relevant authorities lack enforcement engagements to monitor the regulations and also to create awareness [25]. There was sodium contained in various compositions used in processed meats during formulation for purposes such as preservation of flavour and colour, inhibiting microbial growth and maintaining quality.

Processed meat production

The findings of this study were similar to a study in butcheries in Ireland, where processed meat products, such as cured meats, dried and raw sausages and fermented sausages, were commonly produced [26]. Davids *et al.* [27] indicated that butcheries manufactured similar processed meats meat products across different outlets in urban cities.

Processed meat products analysis

To alleviate the health effects of high sodium intake, South Africa promulgated sodium reduction regulations in certain foodstuffs, including processed meats. A study by Peters and Dunford [28] reported that 90 % of uncured processed meats met the 2019 TSL, while just over 40 % of raw processed sausages met the 2019 TSL. Similarly, van der Veer discovered that processed meats that are dry salted showed the highest sodium content; biltong and drywors also had the highest total sodium concentrations [29]. Biltong and other processed meats (polony and ham) are often used as fillings for sandwiches in school lunchboxes [30]; it is, therefore, important to regulate the reduction of sodium in biltong and drywors as well. Apart from setting legal requirements, other methods globally promoted to reduce sodium intake include product formulation, environmental changes and increasing consumer awareness regarding the health impacts thereof [31]. Other considerations that may influence these measures appear below.

Compliance to regulatory requirements: in this regard, it is worrying that the top six products were mostly non-compliant with regulatory requirements. This could be due to the fact they used pre-packed spice mixes containing sodium. Typically, butcheries used the step-by-step spice labelling instructions and therefore trusted the products would comply with the legal sodium levels. In terms of the South African Foodstuffs, Cosmetics and Disinfectants Act 54 of 1972, the responsibility however, still lies with the person in charge of a premises to ensure that “foodstuff manufactured, kept or sold from the premises complies in all respects to the provisions of the Act and the regulations promulgated thereunder, including the labelling thereof.” That implies that measurement, as an act of determining total sodium levels in processed meat products must be carried out.

Risk identification and assessment: the assessment of risk could be the best tool of identification, evaluation and control of the use of sodium and sodium containing spice mixes during production of processed meats. For example, Food Safety Management Systems, such as ISO 22000 [32], require food processors to maintain information of raw materials to the extent needed to conduct a hazard analysis, including chemical characteristics (for example sodium content); as well as the identification of legislation related to the composition of end products. In addition, processed meats manufacturing organisations must identify the risk associated with food safety hazards that can reasonably be expected to occur due to raw materials and product ingredients. This would include high-levels of sodium in prepacked and processed meat as it has the potential to cause chronic adverse health effects for the consumer.

Sodium test method(s): the fact that the sodium results of the two sodium testing methods, legislated by the South African sodium reduction regulations significantly differ, could create misleading and/or inaccurate sense of compliance. It was for this reason that the ICP-AES replaced the use of FAAS in determining certain food trace elements due to longer linear ranges, higher sensitivity and speed of this method compared to others [33]. With the outcome of this study, the South African law makers and legislators should consider further investigation to determine an

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 8
October 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

alternative sodium testing method to be legislated whose sodium results can be comparable to the ICP-AES.

Declaration of sodium level in prepacked spices: declaration of ingredients has been part of labelling requirements in South Africa in all foodstuffs. In this instance, it is essential there is quantifying and labelling of the sodium content of the prepacked spices for use in processed meat formulation, for guidance.

Cost of testing sodium: in 2018, Taylor and colleagues listed costs as one of the challenges the food industry faces in reducing sodium [34]. In the case of local butcheries, routine analysis may not be cost effective when using the two legally prescribed methods, namely the FAAS and ICP-AES. It is therefore urgent to find an affordable and easy-to-use alternative test method for total sodium that butcheries can use on-site on a routine basis.

Bacterial growth: as a matter of consideration, reduction of sodium may have an impact on processed meats bacterial growth. Spoilage microorganisms will typically affect the palatability of biltong and its shelf life. In addition, moulds may produce mycotoxins that may have an influence on the health of consumers when consumed in the product [35].

Training of manufacturing and reformulating operators: training of manufacturers is essential in the control of sodium content in processed meat. In this regard, the South African legislation clearly specifies that a person in charge of food premises must ensure that he or she, and any other person working as a food handler in their food premises, is suitably qualified or otherwise adequately trained in the principles and practices of food safety and hygiene, as appropriate, and that there are routine assessments conducted to determine the impact of the training [36].

CONCLUSION

Globally the consumption of sodium dense processed food (including meats) has increased. For this reason, the global trend is to create awareness in populations and propose sodium reduction strategies to reduce sodium consumption and increase consumer awareness. In relation to the South African strategy, the study revealed areas of constraint, in particular local butcheries that manufacture their own products with ready-to-use spices. The study demonstrated that sodium content in processed meats produced by local butcheries in the CoT was higher than the legislated benchmarks for the analysed products. It was also clear that the targeted timeframes to reduce the total sodium content in these products would not be met. Even though the sodium reduction regulations exist and are current, there is a lack of enforcement by the authorities to control sodium levels in processed meats produced by local butcheries, and to create feasible sodium reduction strategies at that level. Legislators should consider regulating biltong and drywors sodium limits as processed meat products, due to the probable high levels of total sodium content in these products and the fact they are a popular snack in South Africa. Furthermore, because of the significant differences in the sodium concentration results obtained between FAAS and ICP-AES, it is advisable to revisit these in an attempt to find testing methods whose sodium concentration results could be comparable with ICP-AES or replace the FAAS as it is less sensitive and there could be misleading complying results obtained. Health authorities must put more effort into informing local butchery owners in different media of the sodium reduction strategies, and encourage them to become "agents of change" who can promote the national sodium reduction philosophy amongst their customers.

Ethics Statement

The Tshwane University of Technology (TUT), Faculty of Science Committee for Research Ethics granted ethical approval (Reference number FCRE2016/07/005(2)(SCI).

ACKNOWLEDGEMENTS

The authors wish to express sincere gratitude and appreciation to AgriSETA for funding, the City of Tshwane and the Agricultural Research Council. The authors are also grateful to the following persons of the Tshwane University of Technology: Mr. D.V. Nkosi of the Department of Environmental Health for technical support; and Ms. M. Malindi, Mr. P. Lepule, Dr. K. Phala and Ms. K. Mathibela from the Department of Chemistry's research laboratory.

Authors' contributions

EJM was responsible for the study preparation, design, coordinating, data collection and analysis and drafted the manuscript. JLB and NSM were responsible for conceptualising the study, technical advice, guidance and editing of the manuscript. All authors have read and approved the manuscript.

Funding

The Agriculture Sector Education Training Authority (AgriSETA) of South Africa funded the study, grant number BC19FS15. The opinions, suppositions, recommendations, conclusions articulated are exclusively those of the authors.

Availability of data and materials
The data sets analysed during the current study are available from the corresponding author on reasonable request.

Competing interests
The authors declare they have no competing interests.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 8
October 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1: Summary of meat related categories as per sodium reduction regulation [20,37]

Category description	Class description	Description and examples	South African TSL
Category 7: Processed meat products in class 5 relates to cured	Class 1: Comminuted, cured, heat treated products	Emulsion products (polonies, viennas)	1300 mg
	Class 4: Reformed, cured, heat treated	Reformed hams, chicken, turkey rolls	1150 mg
	Class 5: Unspecified		
Category 8: Processed meats in class 5 relates to uncured	Class 2: Comminuted, uncured, heat-treated products	Blanched pork sausages, uncured chicken viennas, polonies, fully cooked burgers	850 mg
	Class 3: Reformed, uncured, no partial heat-treated products	Reformed nuggets, schnitzels	650 mg
	Class 5: Unspecified		
Category 9: Raw - processed meat sausages (all types) and similar products	Class 5: Unspecified	Braaiwors (standard grade sausage), boerewors (quality sausage)	800 mg 600 mg

mg = milligram
TSL = Total Sodium Limits

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 8
October 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 2: Proportional selection of local butcheries in the seven regions of the CoT

Sample size	Regions							Total
	1	2	3	4	5	6	7	
Butcheries on CoT database (N)	41	46	71	68	12	79	8	325
Sample size statistically determined	20	20	35	35	5	40	5	160
Actual sample size (n)	16	18	27	23	5	30	3	122
Actual sample size (%)	39	39	38	34	42	38	38	38

Note: The deviation from the statistically determined sample size was influenced by the fact that the butchery database was outdated and some butcheries preferred not to partake in the study

CoT = City of Tshwane

Table 3: Butchery distribution across the regions where there were samples taken

Sample size determination	Regions							
	1	2	3	4	5	6	7	Total
Butcheries per region	9	9	14	13	3	15	3	66
Number of meat samples (Six samples / butchery)	54	54	84	78	18	90	18	396
Samples per region (%)	13.6	13.6	21.2	19.7	4.5	22.7	4.5	100

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 8
October 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 4: Sodium levels of processed meats tested using ICP-AES and FAAS

Top six sampled Products	No. of samples per product	ICP-AES (mg/100 g)						FAAS (mg/100 g)						Comparison between means of ICP-AES and FAAS (ANOVA)	
		Min	Max	SD	Mean	% Compliance to legal limits		Min	Max	SD	Mean	% Compliance to legal limits			
						2019	2020					2019	2020	df	p_{value}
Boerewors	66	74.3	2038	327	688	62.1	40.9	65.5	916	164	317	97.1	95.5	1	<0.0001
Burger patties	66	64.7	4912	617	700	59.1	42.4	35.4	1169	237	349	97.0	93.9	1	<0.0001
Braaiwors	66	195	2973	432	814	57.6	37.9	55.0	2258	291	394	95.5	90.1	1	<0.0001
Vienna	66	471	2859	410	1245	93.9	92.4	40.3	1491	310	537	100	98.5	1	<0.0001
Drywors	66	319	3869	648	2207	NA	NA	237	1986	400	1004	N/A	N/A	1	<0.0001
Biltong	66	614	9201	1466	3040	NA	NA	192	2351	508	1293	N/A	N/A	1	<0.0001

Notes: NA = Not applicable. The inclusions of dried products in the 2013 regulations and later the excluded in the 2017 amendment to the regulations

ICP-AES = Inductively Coupled Plasma Atomic Emission Spectrometry
FAAS = Flame Atomic Absorption Spectroscopy
ANOVA = A one-way analysis of variance
df = degrees of freedom
SD = Standard deviation

REFERENCES

1. **Bierenstiel M and K Snow** Periodic universe: A teaching model for understanding the periodic table of the elements. *J. Chem. Educ.* 2019;**96(7):**1367-1376. https://doi.org/10.1021/acs.jchemed.8b00740

2. **Busch JL, Yong FY and SM Goh** Sodium reduction: Optimizing product composition and structure towards increasing saltiness perception. *Trends* Food Sci Technol. 2013;**29(1):** 21-34. https://doi.org/10.1016/j.tifs.2012.08.005

3. **Spires M, Delobelle P, Sanders D, Puoane T, Hoelzel P and R Swart** Diet-related non-communicable diseases in South Africa: determinants and policy responses. *S. Afr. Health Rev.* 2016;**4(1):** 35-42. https://hdl.handle.net/10520/EJC189320 *Accessed 23 July 2019.*

4. **Jacobs I, Taljaard-Krugell C, Ricci C, Vorster H, Rinaldi S, Cubasch H, Laubscher R, Joffe M, van Zyl T and SA Norris** Dietary intake and breast cancer risk in black South African women: the South African Breast Cancer study. *Br. J. Nutr.* 2019;**121(5):** 591-600. https://doi.org/10.1017/S0007114518003744

5. **Dekkers BL, Boom RM and AJ van der Goot** Structuring processes for meat analogues. *Trends in Food Science & Technology*. 2018;**81:** 25-36. https://doi.org/10.1016/j.tifs.2018.08.011

6. **Pretorius B, and HC Schönfeldt** The contribution of processed pork meat products to total salt intake in the diet. **Food Chem**. 2018;**238:** 139-145. https://doi.org/10.1016/j.foodchem.2016.11.078

7. **Zhou G, Zhang W and X Xu** China's meat industry revolution: Challenges and opportunities for the future. *Meat Sci.* 2012;**92(3):** 188-196. https://doi.org/10.1016/j.meatsci.2012.04.016

8. **Webster J, Trieu K, Dunford E and C Hawkes** Target salt 2025: a global overview of national programs to encourage the food industry to reduce salt in foods. *Nutrients*. 2014;**6(8):** 3274-3287. https://doi.org/10.3390/nu6083274

9. **Eksteen G and V Mungal-Singh Salt** intake in South Africa: A current perspective. *JEMDSA*. 2015;**20(1):** 9-14.

10. **Wentzel-Viljoen E, Steyn K, Lombard C, De Villiers A, Charlton K, Frielinghaus S, Crickmore C and V Mungal-Singh** Evaluation of a mass-media campaign to increase the awareness of the need to reduce discretionary salt use in the South African population. *Nutrients*. 2017;**9(11):** 1238. https://doi.org/10.3390/nu9111238

11. **Patel D, Cogswell ME, John K, Creel S and C Ayala** Knowledge, attitudes, and behaviors related to sodium intake and reduction among adult consumers in the United States. *Am J Health Promot.* 2017;**31(1):** 68-75. https://doi.org/10.4278/ajhp.150102-QUAN-650

12. **Mente A, O'Donnell M, Rangarajan S, McQueen M, Dagenais G, Wielgosz A, Lear S, Ah STL, Wei L and R Diaz** Urinary sodium excretion, blood pressure, cardiovascular disease, and mortality: a community-level prospective epidemiological cohort study. *Lancet*. 2018;**392(10146):** 496-506. https://doi.org/10.1016/S0140-6736(18)31376-X

13. **Lin SH, Li YH, Leung K, Huang CY and XR Wang** Salt processed food and gastric cancer in a Chinese population. *APJCP*. 2014;**15(13):** 5293-5298. https://doi.org/10.7314/APJCP.2014.15.13.5293

14. **Daniyal M, Ahmad S, Ahmad M, Asif HM, Akram M, Rehman SU and S Sultana** Risk factors and epidemiology of gastric cancer in Pakistan. *APJCP*. 2015;*16(12):* 4821-4824. https://doi.org/10.7314/APJCP.2015.16.12.4821

15. **He F, Brinsden H and G MacGregor** Salt reduction in the United Kingdom: a successful experiment in public health. *J. Hum. Hypertens.* 2014;**28(6):** 345-352. https://doi.org/10.1038/jhh.2013.105

16. **Inguglia ES, Zhang Z, Tiwari BK, Kerry JP and CM Burgess** Salt reduction strategies in processed meat products–A review. *Trends Food Sci Technol*. 2017;**59:** 70-78. https://doi.org/10.1016/j.tifs.2016.10.016

17. **Campbell NR, Johnson JA and TS Campbell** Sodium consumption: An individual's choice? *Int. J. Hypertens*. 2012. https://doi.org/10.1155/2012/860954

18. **Singh M and S Chandorkar** Is sodium and potassium content of commonly consumed processed packaged foods a cause of concern? *Food Chem.* 2018;**238:** 117-124. https://doi.org/10.1016/j.foodchem.2016.11.108

19. **Charlton K, Webster J and P Kowal** To legislate or not to legislate? A comparison of the UK and South African approaches to the development and implementation of salt reduction programs. *Nutrients*. 2014;**6(9):** 3672-3695. https://doi.org/10.3390/nu6093672

20. **National Department of Health.** Foodstuffs, Cosmetics and Disinfectants Act 54 (Act 54 of 1972). The regulations relating to the reduction of sodium in certain foodstuffs and related matters. Government Notice 42496. No. 812. Pretoria, South Africa; 2019 [*accessed 11/05/2019*; cited 114/112020]. Available from: https://www.gov.za/sites/default/files/gcis_document/201905/42496gon812

21. **Charlton K, Ware LJ, Menyanu E, Biritwum RB, Naidoo N, Pieterse C, Madurai SL, Baumgartner J, Asare GA and E Thiele** Leveraging ongoing research to evaluate the health impacts of South Africa's salt reduction strategy: a prospective nested cohort within the WHO-SAGE multicountry, longitudinal study. *BMJ open.* 2016;**6(11):** 116-143. https://doi.org/10.1136/bmjopen-2016-013316

22. **National Department of Health**. Foodstuffs, Cosmetics and Disinfectants Act 54 (Act 54 of 1972. The regulations relating to the reduction of sodium in certain foodstuffs and related matters. Government Notice 36274. No. 214. Pretoria, South Africa, 2013. [*accessed: 12/03/2021*; cited 12/03/2021]. Available from: http://www.gpwonline.co.za/

23. **SANS 885**. South African National Standard. South African National Standard for processed meat products. Pretoria: SANS p.11-31. 2011. [*accessed: 0604/2021*; cited 12/08/2021]. Available from: http://www.sabs.co.za

24. **Poitevin E** Determination of calcium, copper, iron, magnesium, manganese, potassium, phosphorus, sodium, and zinc in fortified food products by microwave digestion and inductively coupled plasma-optical emission spectrometry: Single-laboratory validation and ring trial. *J. AOAC Int.* 2012;**95(1):** 177-185. https://doi.org/10.5740/jaoacint.CS2011_14

25. **Boatemaa S, Barney M, Drimie S, Harper J, Korsten L and L Pereira** Awakening from the listeriosis crisis: Food safety challenges, practices and governance in the food retail sector in South Africa. *Food Control.* 2019;**104:** 333-342. https://doi.org/10.1016/j.foodcont.2019.05.009

26. **Cashman KD and A Hayes** Red meat's role in addressing 'nutrients of public health concern'. Meat Science. 2017;**132:** 196-203. https://doi.org/10.1016/j.meatsci.2017.04.011

27. **Davids MP, Jooste A and F Meyer** Evaluating the South African pork value chain. University of Pretoria, Pretoria. 2014;1-8. https://www.researchgate.net/profile/Tracy-Davids/publication/314082560 *Accessed 27 May 2019.*

28. **Peters SA, Dunford E, Ware LJ, Harris T, Walker A, Wicks M, Van Zyl T, Swanepoel B, Charlton KE and M Woodward** The sodium content of processed foods in South Africa during the introduction of mandatory sodium limits. Nutrients. 2017;**9(4):** 404. https://doi.org/10.3390/nu9040404

29. **Capuano E, van der Veer G, Verheijen PJ, Heenan SP, van de Laak LF, Koopmans HB, and SM van Ruth** Comparison of a sodium-based and a chloride-based approach for the determination of sodium chloride content of processed foods in the Netherlands. *J. Food Compos. Anal.* 2013;**31(1):** 129-136. https://isisn.org/BR17(4)2020/2529-2535-17(4)2020BR20-260.pdf *Accessed 12 April 2019.*

30. **Bekker F, Marais M and N Koen** The provision of healthy food in a school tuck shop: does it influence primary-school students' perceptions, attitudes and behaviours towards healthy eating? *Public Health Nutr.* 2017;**20(7):** 1257-1266. https://doi.org/10.1017/S1368980016003487

31. **Muthuri SK, Oti SO, Lilford RJ and O Oyebode** Salt reduction interventions in sub-Saharan Africa: A systematic review. **PloS one**. 2016;**11(3):** 149-680. https://doi.org/10.1371/journal.pone.0149680

32. **Chen H, Liu S, Chen Y, Chen C, Yang H and Y Chen** Food safety management systems based on ISO 22000: 2018 methodology of hazard analysis compared to ISO 22000: 2005. *Accreditation Qual. Assur.* 2020;**25(1):** 23-37. https://doi.org/10.1007/s00769-019-01409-4

33. Ozbek N and S Akman Determination of boron in Turkish wines by microwave plasma atomic emission spectrometry. *LWT-Food Sci. Technol.* 2015;**61(2):** 532-535. https://doi.org/10.1016/j.lwt.2014.11.047

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 8
October 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

34. **Taylor C, Doyle M and D Webb** "The safety of sodium reduction in the food supply: A cross-discipline balancing act" Workshop proceedings. Crit Rev Food Sci Nutr. 2018;**58(10):** 1650-1659. https://doi.org/10.1080/10408398.2016.1276431

35. **Matsheka MI, Mpuchane S, Gashe BA, Allotey J, Khonga EB, Coetzee SH and G Murindamombe** Microbial quality assessment and predominant microorganism of biltong produced in butcheries in Gaborone, Botswana. *Food Sci. Nutr.* 2014;**17(5):** 1669-1676. https://doi.org/10.4236/fns.2014.517180

36. N**ational Department of Health**. Foodstuffs, Cosmetics and Disinfectants Act 54 (Act 54 of 1972). Regulations governing general hygiene requirements for food premises, the transport of food and related matters. Government Notice 41730. No. 638. Pretoria, South Africa, 2018. [*accessed: 06/10/2021*; cited: 08/10/2021]. Available from: http://www.gpwonline.co.za/

37. **National Department of Health**. Foodstuffs, Cosmetics and Disinfectants Act 54 (Act 54 of 1972). The regulations relating to the reduction of sodium in certain foodstuffs and related matters. Government Notice 41164. No. 1071; 2017 [*accessed 07/08/2018*; cited 17/05/2019]. Available from: http://www.gpwonline.co.za/