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EXPLORING THE CONSUMPTION OF MAIZE PRODUCTS, SIDE DISHES AND SNACKS PREFERRED BY CONSUMERS AT A PUBLIC TERTIARY INSTITUTION IN SOUTH AFRICA

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ABSTRACT

Maize is a staple food for most South Africans, yet maize meal (corn flour) does not provide enough sustenance, contributing to food insecurity and malnutrition. Improving the nutrient content of maize and maize-based products could benefit communities where maize is the staple food. This study aimed to determine the relationship and frequency of consuming maize products, side dishes and snacks preferred by consumers of different provinces of origin and language speakers. One hundred respondents participated in a survey after tasting nixtamalized maize products in a sensory laboratory. The results showed that *Pap* in the forms of soft (58%), stiff (73%), *phutu* [crumbly] (68%), or porridge (55%) was regularly or frequently included in meals. Pap was eaten daily by 11.2% for breakfast, 17.2% for lunch and 23.2% of respondents for supper. Soft (36.1%), stiff (56.6%) and phutu (43.0%) were preferred for supper, while porridge (73.7%) was preferred for breakfast. Braaied meat (40.2%) and meat stew or soup (40.0%) were enjoyed as side dishes. The language that participants spoke influenced the food items or side dishes more than the province of origin. The study showed the maize consumption habits of South African consumers to inform future product development or nutrition intervention programs.

KEYWORDS

corn, Zea Mays, staple food, fortification vehicle, nixtamalization

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INTRODUCTION

Globally, maize (Zea mays L.) is one of the most important crops for human consumption (Rouf Shah, Prasad & Kumar, 2016). Maize is considered a global dietary staple (Murdia, Wadhwani, Wadhawan, Bajpai & Shekhawat, 2016) and provides as much as 30% of the total dietary energy of 4.5 billion people (Kaushal, Sharma, Vaidya, Gupta, Saini, Anand, Thakur, Verma, Thakur, Priyanka & Kc, 2023). By 2025, maize is expected to be the world's top-produced crop, with demand in the developing world doubling by 2050 (Murdia *et al.* 2016). In addition to its value as a dietary staple, maize grows in diverse agroecological zones. It can be adapted to different farming systems, contributing to its resilience in light of climate change (Grote, Fasse, Nguyen & Erenstein, 2021).

Maize provides 3502 kJ/capita/day in Southern Africa (Galani, Orfila & Gong, 2022) and is one of the most significant grains grown in South Africa (Amegbor, van Biljon, Shargie, Tarekegne & Labuschagne, 2022). The amount of maize produced in South Africa, in 2020/2021, was 15 470 million tonnes (South African Grain Laboratory, 2023), with approximately 38.0% going to human consumption (Koot, 2022). Maize is primarily produced in the Free State, North West and Mpumalanga provinces (South African Grain Laboratory, 2023).

And yet, food and nutrition security remains a primary concern in the region. The FAO (2021) determined that more than 237 million people in sub-Saharan Africa and 23% of the population are malnourished and suffering from severe food insecurity. A food crisis is looming, and the Sustainable Development Goal 2 set by the United Nations in 2015 of zero hunger by 2030 (FAO, 2016) is becoming an almost impossible challenge (Chakona & Mushangai, 2021).

Likewise, in the growing population of South Africa, tackling hunger and malnutrition is a significant challenge (Hall, Dawson, Macdiarmid, Matthews & Smith, 2017). South Africans are affected by the triple challenges of unemployment, poverty and inequality. The isolation of rural communities, gender inequality, and large households contribute to the lack of availability, affordability and access to food (Mbajiorgu & Odeku, 2022).

There is an increasing concern as maize is the primary source of food and nutrition for many South Africans, some solely relying on maize and maize products for all three daily meals (Ekpa *et al.* 2018; 2019). Maize-based products are often deficient in nutrients because the nutritious parts are removed during processing, and antinutrients like tannins and phytic acid prevent the bioavailability of minerals (Ekpa, Palacios-Rojas, Kruseman, Fogliano & Linnemann, 2019). The most consumed maize products include maize meal, maize rice and samp (Lombard, Steyn, Burger, Charlton & Senekal, 2013). Maize meal (mealie meal) is generally consumed as pap (boiled maize meal) and is also the primary use of white maize (Koot, 2022).

As food insecurity remains a challenge in South Africa, increasing the nutrient value of maize through processes like nixtamalization or fortification of staples could play a pivotal role in addressing this challenge (Ekpa, Palacios-Rojas, Kruseman, Fogliano & Linnemann, 2018; Ekpa *et al.* 2019). Robust interventions in the form of long-term and short-term strategies that promote access to food in rural and poor households could enhance the availability and access to food and improve the health and well-being of the people (Mbajiorgu & Odeku, 2022). These complex challenges must be addressed strategically and involve empowering individuals and communities (Leburu-Masigo, 2020).

In recent years, there has been an increasing interest in enhancing the nutrient content of a staple, i.e. maize meal pap, to benefit Southern African communities (Galani *et al.* 2022). Interventions to improve, add or replace nutrients in maize meal must be employed through processing, fortification or enrichment. Since October 2003, all commercial mills have fortified maize meal in South Africa due to regulations according to Foodstuffs, Cosmetic and Disinfectants Act No. 54 of 1972. Maize meal is fortified with vitamins A, B1, B2, B3, B6, folic acid, iron and zinc (Department of Health, 2016).

Recent evidence suggests that although food is fortified for nutritional reasons, acceptance and consumption of food products still depend on culture. Eating habits, preferences and consumption patterns are based on culture (Nemeth, Rudnak, Ymeri & Fogarassy, 2019). Cultural identity determines food consumption habits, patterns and processing (Govender *et al.* 2017). Culture must be considered when food products are developed because consumers must feel connected to what they eat (Beagan, Ristovski-Slijepcevic & Chapman, 2010). South Africa is an ethnically diverse and multilingual country resulting in a proverbial rainbow nation with a diversity of food traditions and preferences (Avramenko, 2020). Therefore, food products, processing methods, and forms of consumption of maize-based foods in the country vary between ethnic groups. In recognition of the diversity of culture and languages spoken across the country, the Constitution of South Africa, in Section 6(1), guarantees equal status to 12 official languages, being Sepedi, Sesotho, Setswana, siSwati, South African Sign Language, Tshivenda, Xitsonga, Afrikaans, English, isiNdebele, isiXhosa and isiZulu (Brenzinger, 2017). Each of the nine provinces has a dominating food culture that corresponds with the predominant languages spoken in these areas, especially as it pertains to the cooking and consumption of pap (Brenzinger, 2017). In this study, provinces where respondents grew up and their home language were proxy indicators for culture and associated food habits.

A major issue from a food security standpoint is the lack of nutritional value of pap. Pap usually contains three ingredients: maize meal, water, and salt. The dish's consistency depends on the ratio of water to maize meal. Pap is prepared by boiling maize meal with water (and salt) to make porridge, soft, stiff, or phuthu (crumbly) pap, and is enjoyed by almost all cultures in South Africa. Pap is rarely eaten alone and often consumed with cabbage (Molefe, 2022a), morogo (Njume, Goduka, & George, 2014), chakalaka (Westfalia Fruit, 2022), tomato salsa (Olla-Logday, 2017), fried egg and achar (Woolworths TASTE, 2022), and phuthu pap and maas (fermented milk product with a tangy flavour) (Molefe, 2022b). Any meat, such as steak, beef stew, barbecued (braaied) chicken, traditional sausages (boerewors), and lamb chops, can be eaten with pap (Erasmus & Hoffman, 2017). Steamed or baked maize bread (corn bread) with whole maize kernels is consumed with soups and stews (Ekpa *et al.* 2019). Maize meal is

fermented by mixed cultures composed of lactic acid bacteria (LAB) and yeasts (Adavachi, 2017) to form mageu and sour porridge (Simango, 2002). Fermentation creates products with enhanced nutritional value, improved digestibility, decreased undesirable substances, and inhibition of microorganisms (Chaves-López, Rossi, Maggio, Paparella & Serio, 2020). Besides improving organoleptic properties, lactic acid fermentation creates new tastes and flavours in existing foods (Sharma, Garg, Kumar, Bhatia & Kulshrestha, 2020). White maize on the cob is sold on the streets during harvest season. Boiled maize kernels are consumed and preserved to be eaten all year round (Ekpa *et al.* 2019). Maize is also processed commercially into maize chips (crisps) and other snacks (Koot, 2022). Popular South African maize-based snacks are Doritos and Fritos manufactured by Pepsico via Frito-Lay, Corn Nibs by Picola Foods, and Big Korn Bites and Cheese Curls from Willards (Rose, 2018; Kohler, 2019).

The challenge in South Africa is that food development must follow a hybrid approach, where a solution is based on the expanded problem of not only the nutritional but also the emotional needs of consumers (Alongi & Anese, 2021). Successful food products are those that consumers enjoy in their social environment. There must, therefore, be empathy in food innovation (Hermannsdóttir, Dawes, Gideonsen & De Moor, 2016) as it is necessary to bring new technologies and processes on board to move foods forward into the future, where sustainability will be critical and essential (Zurek, Hebinck & Selomane, 2021). The community must be given a seat at the table. Thus, food innovators must do social research and adapt to consumer preferences to relate food to consumers to benefit more people faster.

One of the most significant questions is whether consumers in an ethnically diverse and multilingual society with different eating habits in various regions would change their eating habits and patterns from well-known maize products and snacks to include more nutrient-dense maize products.

Research is lacking on which types of maize products South African consumers prefer and what dishes are regularly consumed with maize products, as such information could be invaluable to commercial and small-scale producers and farmers, as value-adding affects the entire food system (Khumalo, Schönfeldt & Vermeulen, 2011). Understanding maize and maize meal product consumption habits is essential when developing and introducing new or nutritionally enhanced maize products, which could be more economical, convenient, sustainable, and beneficial to health. Consumers adjust to eating different food types owing to health concerns, convenience, and affordability (Kearney, 2010). South African consumers are difficult to please or impress with new products (Madinga, Maziriri & Lose, 2016).

However, no studies are available on the eating habits, patterns and frequency of the consumption of maize products and items consumed with maize products by the complex multilingual, multicultural and ethnically diverse South African consumer. The main purpose of this study is to determine the frequency of consumption and relationships between consumers of different provinces of origin and language speakers consuming maize products, side dishes and snacks. The insight gathered in this study is relevant for food product development and for determining the ideal vehicles for interventions such as fortification or improved food processing techniques such as nixtamalization.

MATERIALS AND METHODS

An exploratory, quantitative research design was used as the goal was to determine the relationships between variables on a topic that has not yet been studied extensively (George, 2023). Data were collected at a public tertiary educational institution in South Africa. Ethical clearance was obtained on 2 August 2021 by the General/Human Research Committee. Data was collected on 16 March 2022. One hundred regular consumers of maize products were recruited for a pilot and final study, respectively, using convenience sampling (participants who were available in terms of time and place). The sample size was set at 100 participants as this was the maximum number of people the sensory lab could accommodate under COVID-19 restrictions and regulations. The number of observations for the survey was therefore limited due to resource constraints - balancing the practical aspect of exposing participants to unknown food products with the number of booths in the sensory lab under COVID-19 restriction (Lakens, 2022). The survey respondents received information about the nixtamalization of maize and tasted nixtamalized maize products before completing the questionnaire based on their experience in the same session. Experiencing the products was important because nixtamalization is mostly unknown in South Africa (Ekpa *et al.* 2018). Although there are 12 booths in the sensory lab, only six respondents could be accommodated every 30 minutes from early morning to late afternoon to ensure an open booth between respondents in adherence to social distancing requirements. The study population consisted of students and staff of the University. Participants had to be between 18 and 65 and not have any related food allergies. All participants were informed and aware that the study was voluntary and that they would remain anonymous before participation. Informed consent was obtained from each participant before their participation. Respondents took approximately 15 minutes to complete the questionnaire. No communication was allowed while completing the questionnaire. Communication was conducted in English.

The self-developed questionnaire was designed to determine the maize eating habits of respondents and was created using EvaSys© software. It consisted of two sections. Section One contained demographic questions on age, gender, language, provinces and education. Section Two first included questions about maize eating habits and second about the consumption of maize products during different times. Thirdly, the food items and side dishes commonly eaten with maize products. All questions in Section Two were scaled questions. The questionnaire was constructed to allow all respondents to understand the questions and statements, i.e., using simple wording and pictures. The response rate for the questionnaire was 98.9%.

Reliability and validity of the questionnaire

Validity was achieved by conducting a pilot study consisting of 100 consumers. The pilot study determined that *pap* had different eponyms in South Africa. Adding pictures to the questionnaire made it easier for the respondents to know what was referred to. Adding images and reducing the number of questions decreased the time spent completing the final questionnaire. To test reliability, the overall Cronbach's Alpha coefficient was 0.569, and the Cronbach's Alpha excluding the demographics was 0.630, which was below 0.8. Thus, the reliability of the questionnaire was in an acceptable range.

Data analysis

Data were analysed descriptively using SPSS (Statistical Package for the Social Sciences)

version 29. Chi-square tests were used to determine the statistical significance of associations between variables, with a significance level set at $p<0.05$. For bivariate analyses, a Spearman correlation was used to assess the strength of relationships between pairs of independent variables that displayed statistical significance (Deng, Deng & Cheong, 2021). The closer the correlation was to 1.00, the stronger the relationship was (Aggarwal & Ranganathan, 2016). Correlation coefficients above 0.50 and up to 1.00 showed a moderate to very strong relationship between the two variables (Schober & Schwarte, 2018).

Further analyses were conducted to determine links between the consumption of maize products and the association with other food items, the province the respondent grew up in, and their home language. For this purpose, contingency tables were created, and tests were done to find any relationships between the dependent (rows) and independent (columns) variables.

Statistical tests for independence were conducted on the rows and the columns of contingency tables in XLSTAT (XLSTAT 1.1, 2018). The Fisher's exact test was used to determine the significance of associations between data in rows and columns. The Fisher's exact test is useful in datasets with small sample sizes, as it is more sensitive in detecting associations in small samples than the Chi-square test (Kim, 2017).

Additional analysis was done to determine which row or column was responsible for the significant difference. The expected cell frequencies under the null hypothesis were calculated and compared to the observed cell frequencies in each row and column. This was used to help identify which cells were contributing the most to the significant differences.

To determine the significant relationships between the province of origin and types of maize products consumed, a binary scale of "Do consume" and "Do not consume" was constructed from an original 6-point scale question in the questionnaire of "never consume", "consume frequently", "I never eat this food", "I eat this food once or twice a year", "I eat this food once or twice a month", "I eat this food more than twice per week", "I did not eat it this past week", "I eat this food more than twice this past week" and "I eat this food at least once or more every day the past week". Regarding food items and side dishes often used with maize products, data were transformed from the 6-point scale to "Do not consume" and "Consume" to determine the relationships between respondents' province or origin and side dishes. It was also transformed from 4 categories to 2 categories. The category "Do consume" was compiled from the "Always", "Regularly" and "Sometimes" categories. The category "Do not consume" was collected from the "Never" category. The Holm-Bonferroni method was used in this analysis to adjust for multiple hypotheses testing while maintaining a balance between controlling the risk of false positives (Type I errors) and reducing the chance of false negatives (Type II errors) and the p-value for these tests was calculated (0.003) (Abdi, 2010). Note that the data were limited and sparse for specific languages and provinces.

RESULTS AND DISCUSSION

Demographic characteristics of respondents

Table 1 summarises the demographic characteristics of the respondents, including factors such as age (Ogundijo, Tas & Onarinde, 2022), gender (Missagia, Oliveira & Rezende, 2013), and education, which may have influenced food preferences (Bartkiene, Steibliene, Adomaitiene, Juodeikiene, Cernauskas, Lele, Klupsaite, Zadeike,

TABLE 1: DEMOGRAPHIC INFORMATION OF THE RESPONDENTS

Age group (years)	n	%
18–24	63.0	63.6
25–35	25.0	25.3
36–59	10.0	10.1
60 and older	1.0	1.0
	99.0	100.0
Gender	**n**	**%**
Male	24.0	24.5
Female	72.0	73.5
Other	2.0	2.0
	98.0	100.0
Languages	**n**	**%**
Afrikaans	32.0	32.3
English	7.0	7.1
IsiXhosa	12.0	12.1
IsiZulu	14.0	14.1
Sesotho	18.0	18.2
Setswana	7.0	7.1
Other (Siswati, Tshivenda, Xitsonga, IsiNdebele, Sepedi)	9.0	9.1
	99.0	100.0
Provinces	**n**	**%**
Eastern Cape	13.0	13.0
Free State	48.0	48.0
Gauteng	11.0	11.0
Kwa-Zulu Natal	11.0	11.0
Limpopo	3.0	3.0
Mpumalanga	4.0	4.0
North West	1.0	1.0
Northern Cape	4.0	4.0
Western Cape	2.0	2.0
I did not grow up in South Africa	3.0	3.0
	100.0	100.0
Education	**n**	**%**
Completed matric	5.0	5.0
Currently studying to obtain a tertiary qualification	44.0	44.0
Attended tertiary education but did not complete qualification	4.0	4.0
Obtained a tertiary qualification	47.0	47.0
	100.0	100.0

Jarutiene & Guiné, 2019). More than half (63.6%) of the respondents were aged 18-24 years, 25.3% were 25-35 years, and 1.0% were 60 years or older. Most respondents were women (73.5%), 24.5% were men, and 2.0% did not associate with either of the genders. Women are vital in food decision-making because there are more female than male-headed households, and they are regarded as nutritional custodians in modern society (Mpanza & Mbatha, 2021).

Almost half of the respondents grew up in the Free State (48.0%), followed by the Eastern Cape (13.0%). The survey was conducted among staff and students in the only public university, which may have explained the large cohort of respondents who grew up there. As expected, 83% of the Sesotho-speaking and 66.7% of the Afrikaans/ English-speaking respondents grew up in the Free State (data not shown). In comparison, 71.4% of the isiZulu-speaking respondents grew up in KwaZulu Natal. Three-quarters (75%) of

TABLE 2: RESPONDENTS' FREQUENCY OF EATING MAIZE PRODUCTS

		Never/ almost never (less than once per year)	Occasionally (Once or twice per month)	Regularly (More than twice per week)	Total
Soft *pap*	n	42	47	11	100
	%	42.0	47.0	11.0	
Stiff *pap*	n	27	37	36	100
	%	27.0	37.0	36.0	
Phuthu pap/ krummelpap/ u mphokoqo	n	32	51	17	100
	%	32.0	51.0	17.0	
Porridge	n	45	44	11	100
	%	45.0	44.0	11.0	
Sour porridge	n	80	17	3	100
	%	80.0	17.0	3.0	
Mageu	n	76	22	2	100
	%	76.0	22.0	2.0	
Maize rice	n	77	17	6	100
	%	77.0	17.0	6.0	
Samp	n	51	41	8	100
	%	51.0	41.0	8.0	
Cornbread	n	75	20	4	99
	%	75.8	20.2	4	
Canned maize whole kernels	n	68	25	5	98
	%	69.4	25.5	5.1	

isiXhosa speakers grew up in the Eastern Cape (data not shown). Census data (Statistics South Africa, 2011) confirms this sample's relationship between home language and province.

Almost half of the respondents had obtained a tertiary qualification (47.0%), followed by respondents currently studying to obtain a tertiary qualification (44.0%). Only 5.0% of the respondents had only completed matric. The high education levels were attributable to the questionnaire being open to staff and students at the university.

Maize product consumption habits

Maize product consumption habits of the respondents were determined by investigating the frequency of eating maize products, province of origin, respondents' home language, and frequency and type of maize product consumed at different meal times. Table 2 summarises the respondents' frequency of eating maize products.

In Table 2, respondents ate stiff *pap* and porridge more often than other forms of maize. Most respondents (73%) occasionally (37%) or regularly (36%) consumed stiff pap, 55% occasionally (44%) or regularly (11%) consumed porridge, and 68% occasionally (51%) or regularly (17%) consumed *phutu pap*. Fermented products such as sour porridge and *mageu w*ere not commonly consumed, with 76% of respondents rarely or never drinking *mageu* and 80% rarely or never eating sour porridge. Respondents may not have been familiar with the fermented products, or food preferences played a role. Other products that were rarely or never consumed were maize rice (77%), cornbread (75.8%), and canned whole maize kernels (69.4%). Thus, it was concluded that at least half of the respondents ate some form of *pap* (soft, stiff, *phuthu* or porridge) at least once or twice a month.

The relationships between the province of origin and the types of maize products consumed are given in Tables 3 and 4. In

TABLE 3: FISHER'S EXACT TEST FOR THE RELATIONSHIP BETWEEN THE PROVINCE OF ORIGIN AND THE TYPE OF MAIZE PRODUCT CONSUMED (P≤ 0.005)

Type of maize product	Fisher's exact test
Soft *pap*	p=0.546
Stiff *pap*	p=0.866
Umphokoqo/phutu pap/ krummelpap	p=0.130
Porridge	p=0.046
Sour porridge	p=0.855
Mageu	p=0.121
Maize rice	p=0.711
Samp	p=0.254
Cornbread	p=0.027
Canned maize whole kernels	p=0.804

Significance level (p≤ 0.005), significant relationships indicated in Bold.

TABLE 4: FISHER'S EXACT TEST FOR THE RELATIONSHIP BETWEEN LANGUAGE AND THE TYPE OF MAIZE PRODUCT CONSUMED (P≤ 0.007)

Type of maize product	Fisher's exact test
Soft *pap*	p=0.851
Stiff *pap*	p=0.464
Umphokoqo/phutu pap/ krummelpap	p=0.266
Porridge	p=0.628
Sour porridge	**p<0.0001**
Mageu	**p<0.0001**
Maize rice	p=0.1
Samp	p=0.014
Cornbread	p=0.021
Canned maize whole kernels	**p=0.002**

Significance level (p≤ 0.007), significant relationships indicated in Bold.

Table 3, after applying the adjusted p-value, using the Holm-Bonferroni method (0.005), no significant relationships were observed between provinces and maize products consumed. The Eastern Cape was the only province with slightly fewer respondents than expected consuming porridge (p=0.046) and cornbread (p=0.027) (Table 3) compared to the other provinces.

The significant relationships between the respondents' home language and the type of maize product preferred are given in Tables 4 and 5. The adjusted p-value, calculated using the Holm-Bonferroni method, is 0.007.

Table 4 shows that significant relationships (p≤0.007) were found between the respondents' home language and the consumption of sour porridge (p<0.0001), *mageu* (p<0.0001) and canned whole kernels (p=0.002). Table 5 indicated that Afrikaans speakers tended not to consume sour porridge or *mageu* but consumed canned whole-kernel corn more than respondents who spoke other home languages. Sesotho speakers consumed sour porridge and *mageu* more than respondents who spoke other languages but tended not to consume canned whole-kernel corn. This indicated a preference for fermented food products among the respondents who were Sesotho speakers. Thus, the data pointed towards a relationship between the home language spoken by a respondent and the consumption of certain maize products, specifically amongst Afrikaans and Sesotho (Table 5).

In Table 6, respondents were asked how frequently they ate maize products during different mealtimes. Only 8.2% of respondents never ate maize-based products for breakfast,

TABLE 5: THE CONSUMPTION OF THE TYPE OF MAIZE PRODUCT BY RESPONDENTS' HOME LANGUAGE

	Sour porridge p<0.0001		Mageu p<0.0001		Canned whole-kernel corn p<0.0002	
Language	No	Yes	No	Yes	No	Yes
Sesotho	4	**14**	4	**14**	**9**	**9**
IsiNdebele	0	1	0	1	1	0
Afrikaans	**29**	3	**29**	**3**	**4**	**28**
Setswana	2	5	1	6	2	5
IsiXhosa	5	7	3	9	7	4
English	5	2	6	1	3	4
Tshivenda	0	1	1	0	1	0
IsiZulu	5	8	4	9	8	3
siSwati	1	1	0	2	1	1
Sepedi	2	0	0	2	1	1
Xitsonga	1	1	0	2	0	1

No: Do not consume; Yes: Do consume, significant relationships indicated in Bold.

TABLE 6: RESPONDENTS' FREQUENCY OF EATING MAIZE PRODUCTS AT DIFFERENT TIMES OF THE DAY

Breakfast	**n**	**%**
Daily	11.0	11.2
Weekly	33.0	33.7
Monthly	26.0	26.5
A few times a year	20.0	20.4
Never	8.0	8.2
	98.0	100.0
Lunch	**n**	**%**
Daily	17.0	17.2
Weekly	25.0	25.3
Monthly	24.0	24.2
A few times a year	17.0	17.2
Never	16.0	16.2
	99.0	100.0
Supper	**n**	**%**
Daily	23.0	23.2
Weekly	34.0	34.3
Monthly	26.0	26.3
A few times a year	12.0	12.1
Never	4.0	4.0
	99.0	100.0

while 44.9% ate maize for breakfast daily (11.2%) or weekly (33.7%), and 26.5% ate maize for breakfast at least monthly. For lunch, 42.4% of respondents ate maize daily (17.25%) or weekly (25.3%), with 33.4% eating maize at lunch a few times a year (17.2%) or never (16.2). For supper, 57.5% of the respondents ate maize-based products daily (23.2%) or weekly (34.3%). Regarding maize consumption for all mealtimes, 91.8% of the respondents ate maize for breakfast, 83.9% ate maize for lunch, and 98.6% ate maize for dinner at least a few times a year or more often. This confirmed that the respondents widely consumed maize products as part of their daily meals.

The type of *pap* that respondents consumed at different times of the day is given in Table 7. Porridge was most consumed at breakfast

TABLE 7: THE TYPE OF PAP RESPONDENTS PREFERRED EATING AT DIFFERENT TIMES OF THE DAY

		Breakfast	Lunch	Supper	Never	Total
Soft pap	n	29.0	9.0	35.0	24.0	97.0
	%	29.9	9.3	36.1	24.7	100.0
Stiff pap	n	9.0	22.0	56.0	12.1	99.0
	%	9.1	22.2	56.6	12.0	100.0
Phuthu pap	n	12.0	31.0	43.0	14.0	100.0
	%	12.0	31.0	43.0	14.0	100.0
Porridge	n	73.0	4.0	3.0	19.0	99.0
	%	73.7	4.0	3.0	19.2	100.0
Sour Porridge	n	34.0	3.0	1.0	61.0	99.0
	%	34.3	3.0	1.0	61.6	99.0

TABLE 8: RESPONDENTS' FREQUENCY OF CONSUMING FOOD ITEMS AND SIDE DISHES WITH MAIZE PRODUCTS

		Always	Regularly	Sometimes	Never	Total
Fresh milk	n	32.0	32.0	26.0	9.0	99.0
	%	32.3	32.3	26.3	9.1	100.0
Buttermilk (*maas*)	n	22.0	23.0	16.0	36.0	97.0
	%	22.7	23.7	16.5	37.1	100.0
Butter/ margarine	n	19.0	20.0	29.0	30.0	98.0
	%	19.4	20.4	29.6	30.6	100.0
Sugar	n	34.0	21.0	18.0	26.0	99.0
	%	34.3	21.2	18.2	26.3	100.0
Vinegar	n	5.0	11.0	14.0	66.0	96.0
	%	5.2	11.5	14.6	68.8	100.0
Cooked cabbage	n	9.0	25.0	29.0	34.0	97.0
	%	9.3	25.8	29.9	35.1	100.0
Spinach (*morogo*)	n	14.0	33.0	22.0	29.0	98.0
	%	14.3	33.7	22.4	29.6	100.0
Pan-fried vegetables	n	7.0	21.0	27.0	43.0	98.0
	%	7.1	21.4	27.6	43.9	100.0
Tomato-based salad	n	11.0	19.0	26.0	41.0	97.0
	%	11.3	19.6	26.8	42.3	100.0
Achar	n	9.0	21.0	24.0	42.0	96.0
	%	9.4	21.9	25.0	43.8	100.0
Chakalaka	n	9.0	28.0	31.0	27.0	95.0
	%	9.5	29.5	32.6	28.4	100.0
Relish (thick onion and tomato condiment)	n	17.0	19.0	31.0	28.0	95.0
	%	17.9	20.0	32.6	29.5	100.0
Meat or vegetable stew or soup	n	40.0	25.0	15.0	15.0	95.0
	%	42.1	26.3	15.8	15.8	100.0
Tomato gravy (sauce made with tomato and onion)	n	29.0	34.0	18.0	16.0	97.0
	%	29.9	35.1	18.6	16.5	100.0
Braaied (barbeque) meat and *boerewors* (sausage)	n	39.0	36.0	19.0	3.0	97.0
	%	40.2	37.1	19.6	3.1	100.0
Cooked eggs (fried, sunny-side up, or scrambled egg on top)	n	23.0	23.0	20.0	31.0	97.0
	%	23.7	23.7	20.1	32.0	100.0

(73%), and stiff *pap* was most consumed at supper (56.6%). *Phuthu pap* (43.0%) was eaten more at supper than other meals. Most respondents (61.6%) never ate sour porridge, however 34.3% ate sour porridge for breakfast. Overall, porridge was mostly eaten for breakfast, while stiff pap and *phutu pap* were mostly eaten for supper.

Food items and side dishes eaten with maize products

Food items and side dishes are usually combined with *pap* but could also be used with other maize products. Therefore, the specific preferences, frequency of consumption, type of maize products, and food items commonly consumed with the maize products were determined. Respondents indicated how often they consumed side dishes with *pap* (Table 8).

The data from Table 8 shows that some consumers always or regularly consumed milk (32.3 + 32.2 = 64.6%), sugar (34.3 + 21.2 = 55.5%), spinach (*morogo*) (14.3 + 33.7 = 48%), meat or vegetable stew and soup (42.1 + 26.3 = 68.4%), tomato gravy (29.9 + 35.1 = 65%), *braaied* meat and *boerewors* (40.2 + 37.1 = 77.3%) and cooked eggs (23.7 + 23.7 = 47.4%) with maize products. Only 9.1% of respondents never consumed maize products with milk, and 3.1% never consumed *pap* with *braaied* meat or *boerewors*. The food items and side dishes that most respondents never consumed with maize were vinegar (68.8%), pan-fried vegetables (43.9%), *achar* (43.8%) and tomato-based salad (42.3%). The data confirmed that respondents ate food items and side dishes with *pap* as part of a meal.

Spearman's correlations (Table 9), which determined the preferred combination of food items or side dishes eaten with maize products, were moderate and strong positive correlations. Combinations included using butter and sugar together (r_s=0.507); combining achar with meat dishes (r_s=0.577); and chakalaka with atchar (r_s=0.734), cooked cabbage (r_s=0.594), meat dishes (r_s=0.502), spinach/*morogo* (r_s=0.634) and tomato salad

TABLE 9: PEARSON'S CORRELATION FOR COMBINATIONS OF FOOD ITEMS CONSUMED WITH MAIZE PRODUCTS

Food items	Atchar	Butter/ margarine	Chakalaka	Cooked cabbage	Mageu	Meat or vegetable stew or soup	Pan-fried vegetables	Sour porridge	Spinach/morogo	Sugar	Tomato based salad	Vinegar
Atchar	1		0.734			0.577						
Butter/ margarine		1								0.507		
Chakalaka			1	0.594		0.502			0.634		0.542	
Cooked cabbage				1		0.667			0.890		0.550	
Mageu					1			0.520				
Meat or vegeta-ble stew or soup						1			0.716			
Pan-fried vegetables							1				0.547	
Sour porridge								1				0.537
Spinach/ morogo									1		0.635	
Sugar										1		
Tomato based salad											1	
Vinegar												1

Significance level ($p \leq 0.05$)

TABLE 10: FISHER'S EXACT TEST FOR THE RELATIONSHIP BETWEEN RESPONDENTS' PROVINCE OF ORIGIN AND THE COMBINATION OF FOOD ITEMS OR SIDE DISHES (P=0.003)

Type of food eaten with maize products	Fisher's exact test
Fresh milk	p=0.171
Maas or buttermilk	p=0.305
Butter or margarine	p=0.373
Sugar	p=0.099
Vinegar	p=0.047
Cooked cabbage	p=0.217
Spinach or *morogo*	p=0.204
Pan fried vegetables	p=0.399
Tomato based salad	p=0.339
Achar	p=0.099
Chakalaka	p=0.053
Relish	p=0.987
Meat or vegetable stew	p=0.178
Tomato gravy	p=0.008
Braaied meat or *boerewors* (barbeque or sausage)	p=0.038
Cooked eggs	**p<0.0001**

Significance level (p=0.003), significant relationships indicated in Bold.

TABLE 11: THE CONSUMPTION OF THE TYPE OF SIDE DISH AND THE PROVINCE OF ORIGIN

Type of side dish	Cooked eggs p<0.0001	
Province	No	Yes
Western Cape	1	1
Northern Cape	3	1
North West	1	0
Kwa-Zulu Natal	0	10
Limpopo	0	2
Free State	15	32
Mpumalanga	2	2
Gauteng	0	11
Eastern Cape	**10**	3
Not South Africa	1	2

No: Do not consume; Yes: Do consume, significant relationships indicated in Bold.

(r_s=0.542). Cooked cabbage was often combined with meat dishes (r_s=0.667), spinach/morogo (r_s=0.890) and tomato salad (r_s=0.550). Meat dishes were often combined with spinach/*morogo* (r_s=0.716), while tomato salad was often combined with pan-fried vegetables (r_s=0.547) and spinach/*morogo* (r_s=0.635). Cabbage, spinach and *morogo* are affordable year-round and are regularly consumed with maize products in South Africa (Acharya, Fanzo, Gustafson, Ingram & Schneeman, 2014). A moderate, positive correlation was found between vinegar and sour porridge (r_s=0.537), which showed that a few respondents preferred the sour taste. Respondents also combined sour *pap* with *mageu* (r_s=0.520).

In Table 10, the adjusted p-value calculated using the Holm-Bonferroni method is 0.003.A significant relationship (p≤ 0.003) between the province of origin and the side dishes consumed was found for cooked eggs. Thus, significantly more respondents from the Eastern Cape than those from the other provinces did not consume cooked eggs with

TABLE 12: FISHER'S EXACT TEST FOR THE RELATIONSHIP BETWEEN LANGUAGE SPEAKERS AND CONSUMPTION OF SIDE DISHES (P<0.008)

Food Items	Fisher's exact test
Fresh Milk	p=0.138
Maas or buttermilk	**p<0.0001**
Butter or margarine	p=0.308
Sugar	p=0.474
Vinegar	**p<0.0001**
Cooked Cabbage	**p<0.0001**
Spinach or Morogo	**p<0.0001**
Pan-fried Vegetables	**p=0.0003**
Tomato based salad	**p=0.002**
Atchar	**p<0.0001**
Chakalaka	**p≤0.0001**
Relish	p=0.651
Meat or Vegetable stew or soup	**p=0.0001**
Tomato Gravy	p=0.278
Braaied meat and boerewors	p=0.709
Cooked Eggs	**p=0.0001**

Significance level p<0.008, significant relationships indicated in Bold.

maize products. To explore the data more, the relationship between the province of origin and the type of food items combined with maize products is shown in Table 11. Respondents from the Free State did not consume vinegar with maize food products, and respondents from the Eastern Cape did not consume tomato gravy or braaied meat and boerewors with maize food products. Thus, it could be concluded that the province of origin was related to consuming certain food items and side dishes combined with maize products.

Fisher's exact test results for the significant relationships between the language of origin and food items or side dishes combined with maize products are given in Table 12. A binary scale was used to determine the significant relationships between the respondents' home language, food items, and side dishes combined with maize products (Table 12). An adjusted p-value (0.008) was calculated using the Holm-Bonferroni method (Abdi, 2010). Significant relationships (p≤0.008) were found for *maas* or buttermilk (p<0.0001), vinegar (p<0.0001), cooked cabbage (p<0.0001), spinach or *morogo* (p<0.0001), pan-fried vegetables (p=0.0003), tomato-based salad (p=0.002), *achar* (p<0.0001), *chakalaka* (p<0.0001), meat or vegetable stew or soup (p=0.0001, cooked eggs (p=0.0001) and language spoken by the respondents.

Further analysis of the data (Table 13) showed that Afrikaans speakers tended not to combine *maas*/buttermilk, vinegar, cooked cabbage, spinach/*morogo*, pan-fried vegetables, tomato-based salad, *achar*, *chakalaka*, or cooked eggs with maize products. Sesotho, IsiXhosa, and IsiZulu speakers tended to consume *maas*/buttermilk with maize products (Table 13). Sesotho and Setswana speakers tended to consume cooked cabbage and spinach/*morogo* with maize products. Setswana-speaking people tended to consume tomato-based salad with maize products, whereas Sesotho- and Setswana-speaking people tended to consume *achar* with maize products. IsiXhosa speakers tended to consume pan-fried vegetables with maize products, while Sesotho- and IsiZulu-speaking respondents tended to consume *chakalaka* with maize products. IsiZulu speakers tended to consume

TABLE 13: THE CONSUMPTION OF LANGUAGE OF ORIGIN AND FOOD ITEMS OR SIDE DISHES COMBINED WITH MAIZE PRODUCTS

	***Maas*/ Buttermilk p<0.0001**		**Vinegar p<0.0001**		**Cooked cabbage p<0.0001**		**Spinach/ *Morogo* p<0.0001**		**Pan-fried vegetables p=0.0003**		**Tomato-based salad p=0.002**		***Achar* p<0.0001**		***Chakalaka* p<0.0001**		**Cooked eggs p=0.0001**		**Meat/veg stew or soup p=0.0001**	
Language	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Sesotho	3	**16**	12	5	0	**18**	0	**18**	3	14	5	12	2	**15**	1	**16**	1	**17**	**0**	**18**
IsiNdebele	1	0	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Afrikaans	**26**	6	**32**	0	**28**	4	**23**	7	**23**	9	**22**	9	**23**	7	**19**	12	**17**	15	**14**	**16**
Setswana	2	5	3	4	0	**7**	0	7	3	4	0	7	0	**7**	1	6	1	5	0	7
IsiXhosa	0	**12**	7	5	1	10	1	11	1	**11**	4	8	6	6	2	9	6	6	0	11
English	5	2	5	2	3	2	4	3	5	2	4	3	5	2	4	2	4	**2**	1	4
Tshivenda	1	0	0	1	0	1	0	1	1	0	1	0	0	1	0	1	0	1	0	1
IsiZulu	2	**12**	4	**9**	2	11	1	12	5	8	4	9	6	7	0	**13**	0	**13**	0	13
siSwati	0	2	1	1	0	2	0	2	0	2	0	2	0	2	0	2	1	1	0	2
Sepedi	0	2	1	1	0	2	0	2	1	1	0	2	0	2	0	2	0	2	0	2
Xitsonga	0	2	1	1	0	2	0	2	0	2	1	1	0	2	0	2	1	1	0	2

No: Do not consume; Yes: Do consume, significant relationships indicated in Bold.

vinegar with maize products, and Sesotho- and IsiZulu-speaking respondents tended to consume cooked eggs with maize food products. For meat or vegetable stew or soup consumption, Afrikaans- and Sesotho-speaking respondents ($p<0.0001$) showed a significantly different proportion to the other languages (Table 13). Afrikaans speakers "do not consume", while Sesotho-speaking respondents "do consume" meat or vegetable stew or soup with maize products disproportionately more than the other language speakers (Table 13). The results showed that the language spoken by respondents influenced the combination of food items and side dishes eaten with maize products.

Maize-based snacks consumption habits

Maize is processed commercially into maize chips and other snacks (Koot, 2022). Popular South African maize-based snacks include Doritos, Fritos, Big Korn Bites, Corn nibs, *Inkobe,* and Cheese Curls (Rose, 2018; Kohler, 2019). These products come in different flavours and different packaging sizes. Simba and Willards are food-manufacturing companies that produce maize -based snacks (Rose, 2018).

Respondents were asked to indicate how frequently they consumed different maize-based snacks (Table 14). About half (57.0%) of the respondents consumed Doritos and Fritos (48.5%) once or twice a month. Over a third of the respondents consumed Big Korn Bites once or twice a month (39.4%) and once or twice a year (36.4%). A total of 32.7% of respondents never ate Corn Nibs, while 31.6% ate them once or twice a year. Approximately half of the respondents (55.6%) never ate *Inkobe* (whole soft-boiled maize) as a snack, while only 30.3% consumed it once or twice a year. Cheese curls were eaten mainly once or twice a month (36.7%). Thus, respondents consumed maize-based snacks and preferred Doritos,

TABLE 14: RESPONDENTS' FREQUENCY OF CONSUMING MAIZE-BASED SNACKS

		Never	Once or twice a year	Once or twice a month	Once or twice a week	Everyday	Total
Doritos	n	4.0	8.0	57.0	28.0	3.0	100.0
	%	4.0	8.0	57.0	28.0	3.0	100.0
Fritos	n	4.0	27.0	48.0	17.0	3.0	99.0
	%	4.0	27.3	48.5	17.2	3.0	100.0
Big Korn Bites	n	9.0	36.0	39.0	10.0	5.0	99.0
	%	9.1	36.4	39.4	10.1	5.1	100.0
Corn nibs (whole fried maize)	n	32.0	31.0	22.0	7.0	6.0	98.0
	%	32.7	31.6	22.4	7.1	6.1	100.0
Inkobe (whole soft-boiled maize)	n	55.0	30.0	9.0	1.0	4.0	99.0
	%	55.6	30.3	9.1	1.0	4.0	100.0
Cheese Curls	n	14.0	29.0	36.0	16.0	3.0	98.0
	%	14.3	29.6	36.7	16.3	3.1	100.0

Fritos and Big Corn Bites at least once or twice a month (Table 14).

CONCLUSION

This study set out to determine the frequency of maize product consumption, and relationships between consumers of different provinces of origin and language speakers who consume maize products, side dishes and snacks.

These findings suggest that pap (soft, stiff, phutu, and porridge) and maize-based snacks were consumed more frequently than other maize products. Porridge was preferred for breakfast, while soft, stiff and *phutu pap* was regularly consumed at supper. Fermented products such as sour porridge and *mageu* were rarely consumed. Various food items and side dishes were regularly combined with maize products, including meat dishes, milk and *maas*, sugar, tomato gravy, and eggs. Popular combinations were butter with sugar, *achar* with meat or *achar* with *chakalaka*. The evidence from this study suggests that the province of origin and language influenced the type of maize products consumed and the foods and side dishes consumed with maize-based products. Language influenced the side dishes consumed more than the province. For example, the Afrikaans-speaking respondents had different habits and consumer patterns from the Sesotho speakers.

These findings opened new perspectives on the consumption of maize products and the side dishes South African consumers tend to eat with maize products and provide a base from which nutritionally improved maize products and snacks can be developed. The exploratory data from this study shows that maize and side dishes consumed with maize products are culturally relevant, and this insight could inform nutrition intervention plans. The study further shows that products could be designed with a specific demographic in mind and with flavour preferences of the food items and side dishes preferred with maize products.

The study was limited in scope and exploratory, and relied on a small, convenient sample. Thus, the results are not generalisable to a broader population. Nevertheless, the findings from this exploratory investigation could inform the development of innovative, consumer-acceptable maize products that could be incorporated into eating habits and consumer patterns in South Africa. Further research needs to be conducted to assess the influence of other factors, such as religion, social and economic factors on eating habits,

and among a larger cohort of consumers. This information could be useful for policymakers and various commercial stakeholders in implementing intervention programmes, such as nixtamalization, to increase food and nutrition security.

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DECLARATION OF INTEREST

The authors report that there are no competing interests to declare.

DATA AVAILABILITY

The data presented in this study are available on request from the corresponding author.

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