

The *South African Journal of Science* follows a double-anonymous peer review model but encourages Reviewers and Authors to publish their anonymised review reports and response letters, respectively, as supplementary files after manuscript review and acceptance. For more information, see [Publishing peer review reports](#).

Peer review history for:

Ronquest-Ross L-C, Sigge G. South Africa's food system: An industry perspective on past, present and future applications of science and technology. *S Afr J Sci*. 2024;120(7/8), Art. #16536.

<https://doi.org/10.17159/sajs.2024/16536>

HOW TO CITE:

South Africa's food system: An industry perspective on past, present and future applications of science and technology [peer review history]. *S Afr J Sci*. 2024;120(7/8), Art. #16536.

<https://doi.org/10.17159/sajs.2024/16536/peerreview>

Reviewer F: Round 1

Date completed: 20 January 2024

Recommendation: Accept / **Revisions required** / Resubmit for review / Decline

Conflicts of interest: None

Does the manuscript fall within the scope of SAJS?

Yes/No

Is the manuscript written in a style suitable for a non-specialist and is it of wider interest than to specialists alone?

Yes/No

Does the manuscript contain sufficient novel and significant information to justify publication?

Yes/No

Do the Title and Abstract clearly and accurately reflect the content of the manuscript?

Yes/No

Is the research problem significant and concisely stated?

Yes/No

Are the methods described comprehensively?

Yes/No

Is the statistical treatment appropriate?

Yes/No/Not applicable/Not qualified to judge

Are the interpretations and conclusions justified by the research results?

Yes/Partly/No

Please rate the manuscript on overall contribution to the field

Excellent/Good/**Average**/Below average/Poor

Please rate the manuscript on language, grammar and tone

Excellent/**Good**/Average/Below average/Poor

Is the manuscript succinct and free of repetition and redundancies?

Yes/No

Are the results and discussion confined to relevance to the objective(s)?

Yes/No

The number of tables in the manuscript is

Too few/Adequate/Too many/**Not applicable**

The number of figures in the manuscript is

Too few/**Adequate**/Too many/Not applicable

Is the supplementary material relevant and separated appropriately from the main document?

Yes/No/**Not applicable**

Please rate the manuscript on overall quality

Excellent/Good/Average/ Below average /Poor
Is appropriate and adequate reference made to other work in the field?
Yes/No
Is it stated that ethical approval was granted by an institutional ethics committee for studies involving human subjects and non-human vertebrates?
Yes/No/Not applicable
If accepted, would you recommend that the article receives priority publication?
Yes/No
Are you willing to review a revision of this manuscript?
Yes/No
Select a recommendation:
Accept / Revisions required / Resubmit for review / Decline
With regard to our policy on ' Publishing peer review reports ', do you give us permission to publish your anonymised peer review report alongside the authors' response, as a supplementary file to the published article? Publication is voluntary and only with permission from both yourself and the author.
Yes/No
Comments to the Author:
The paper South Africa's food system: an industry perspective on past, present and future applications of science & technology addresses an important topic. The paper consists of a rather lengthy background section, a short materials and methods section, results and discussion and concluding remarks.
Consider the following comments as justification for my review of the paper.
Some statements lack evidence in the form of references to support them – notably the first paragraph (L34-36), also L84-85.
The abbreviations SAFBI, SAFBMI, PFBC and FBS are used but not explained in the text. These form an important part of section headings and even the study aim.
In some parts, the tense of descriptions need to be corrected. L146 will be used should be were used. L151 ..the study will use.. should be the study used... See also L 162, 165
I am confused by the aim of the study. Compare L130 – 132 and 136 – did the aim change from one paragraph to the next.
The materials and methods are presented as four parts. Too limited information is provided on the exact methodologies applied which precludes reproducibility of the different parts of the study. For example, a reader will have to search what the Access to Nutrition Index methodology implies, where it was applied previously and why it is presented as a suitable methodology considering that no reference to the methodology is provided. L152 a reference for Access to Nutrition Index methodology is required. L199 how does the ATNI measurement work and how was it applied here? What was the modification? L138 How were the data sets converted into per capita consumption figures? What were the source/s utilised for the purpose? L148 – data analysed how? The methodology and results informing Part 4 on the map for underutilised and emerging food sources to address food security lacks detail on the number of respondents involved. Part 4 refers to a literature review that was conducted – it is not clear whether the review is also presented as part of the results as expected.
The connection/s between the four parts presented in Materials and methods and the “Results and Discussion” section and even the figures is not clear. The conclusion section introduces new information and the conclusions based on the findings of the four parts of the study is not justified clearly.
The authors have provided an explicit statement of approval by an institutional ethics committee for a study that involve human subjects but the details (e.g. number of subjects) is not presented very clearly in

the materials and methods. I note that some assumed respondents are identified as personal communication – did the respondents agree to this?

Some more specific comments

L179 – which study is referred to here? – what is the comparison? Compared to ?

L187 – when was the study conducted – this to put the increase since 2003 into context.

L196 – over what time period is referred to by the statement ...over this time period?

L198 – does bottled include cans – why not rather refer to softdrinks as prepared from cordials and reconstituted cooldrink powders may potentially be part of the category

L202, 207 Which study found? If it is the study reported here then where is the evidence presented? The methodology used is not clear and there is no reference for ATNI.

L223 – Need a reference for this information on Tiger Brands – when was recently launch; same applies for L240 and L241

L226 sentence not clear

L238 clarify if this refers to cell-based meat, cell based seafood and cell-based algae?

L243 how many respondents were involved? And how many were of this view.

L246 When was the report published?

L246 - 249 Reference for this information?

L250 Do you mean according to the exchange rate for 2011?

L250 does that mean the number of full-time researchers remained the same or decreased – ideally expressed on a change in population size basis.

L256 – a reference for the project is required.

L258 – the evaluation of the credibility of this source will be improved if it is made clear who and what this person is e.g. occupation/position, company. Same applies to L260 Bessa Personal communication should be reported as Ms Leah Bessa (role/position, company ; personal communication) to put the statement reported in context.

L296 - 299 A conclusion should conclude on the information that was reported . No totally new information e.g. reference to Israel's innovative technology should emerge in the conclusion that was not presented in the text. At present the conclusion section reads like a personal viewpoint of the authors

Fig 1: Define GHG

Fig 2: The figure needs to be revised? Which measure is indicated on the y and z axes, respectively? For the y axis, the reference point should be 0 and negative values should be indicated downwards from 0. How is per capita kg value consumption indicated as a negative value?

Fig 3 I cannot interpret this fig based on the information provided. It is not clear what the score analysis refers to. The time horizon is not clear to me.

Author response to Reviewer F: Round 1

Some statements lack evidence in the form of references to support them – notably the first paragraph (L34-36), also L84-85.

AUTHOR: These are elaborated further in the Background regarding hunger and spend on food as a % of income.

The abbreviations SAFBI, SAFBMI, PFBC and FBS are used but not explained in the text. These form an important part of section headings and even the study aim.

AUTHOR: I have corrected this to SAFBI and amended FBS to Food Balance Sheets.

In some parts, the tense of descriptions need to be corrected. L146 will be used should be were used. L151 ..the study will use.. should be the study used... See also L 162, 165

AUTHOR: All corrected to past tense

I am confused by the aim of the study. Compare L130 – 132 and 136 – did the aim change from one paragraph to the next.

AUTHOR: I have explained this is a compilation of 4 studies and now numbered them.

The materials and methods are presented as four parts. Too limited information is provided on the exact

methodologies applied which precludes reproducibility of the different parts of the study. For example, a reader will have to search what the Access to Nutrition Index methodology implies, where it was applied previously and why it is presented as a suitable methodology considering that no reference to the methodology is provided. L152 a reference for Access to Nutrition Index methodology is required. L199 how does the ATNI measurement work and how was it applied here? What was the modification?

AUTHOR: All corrected. Have added the reference to the ATNI methodology and described the modifications.

L138 How were the data sets converted into per capita consumption figures? What were the source/s utilised for the purpose? L148 – data analysed how?

AUTHOR: The population data was used consumption data to per capita data.

The methodology and results informing Part 4 on the map for underutilised and emerging food sources to address food security lacks detail on the number of respondents involved. Part 4 refers to a literature review that was conducted – it is not clear whether the review is also presented as part of the results as expected.

AUTHOR: The number of respondents has been indicated now and the fact the literature review is not included in this paper has been stipulated.

The connection/s between the four parts presented in Materials and methods and the “Results and Discussion” section and even the figures is not clear.

AUTHOR: Sub-headings have been provided in the Materials and Methods and Results and Discussion to help provide clarity.

The conclusion section introduces new information and the conclusions based on the findings of the four parts of the study is not justified clearly.

AUTHOR: Have move the new information piece to Results and Discussion

The authors have provided an explicit statement of approval by an institutional ethics committee for a study that involve human subjects but the details (e.g. number of subjects) is not presented very clearly in the materials and methods. I note that some assumed respondents are identified as personal communication – did the respondents agree to this? Yes, I requested their permission.

AUTHOR: Some more specific comments

L179 – which study is referred to here? – what is the comparison? Compared to ?

AUTHOR: Sub-headings have been provided in the Materials and Methods and Results and Discussion to help provide clarity.

L187 – when was the study conducted – this to put the increase since 2003 into context.

AUTHOR: The year has been indicated now.

L196 – over what time period is referred to by the statement ...over this time period?

AUTHOR: Amended the sentence to indicate the role of grants on poverty and nutrition outcomes.

L198 – does bottled include cans – why not rather refer to softdrinks as prepared from cordials and reconstituted cooldrink powders may potentially be part of the category

AUTHOR: Sentence has been deleted.

L202, 207 Which study found? If it is the study reported here then where is the evidence presented? The methodology used is not clear and there is no reference for ATNI.

AUTHOR: Sub-headings have been provided in the Materials and Methods and Results and Discussion to help provide clarity. Reference to ATNI has been provided.

L223 – Need a reference for this information on Tiger Brands – when was recently launch; same applies for L240 and L241

AUTHOR: References have been included.

L226 sentence not clear

AUTHOR: Sentence has been deleted.

L238 clarify if this refers to cell-based meat, cell based seafood and cell-based algae?

AUTHOR: Corrected.

L243 how many respondents were involved? And how many were of this view.

AUTHOR: Corrected.

L246 When was the report published?

AUTHOR: 2019 and have now indicated this.

L246 - 249 Reference for this information?

AUTHOR: Reference indicated.

L250 Do you mean according to the exchange rate for 2011?

AUTHOR: Sentence removed.

L250 does that mean the number of full-time researchers remained the same or decreased – ideally expressed on a change in population size basis.

AUTHOR: Sentence removed.

L256 – a reference for the project is required.

AUTHOR: Reference provided.

L258 – the evaluation of the credibility of this source will be improved if it is made clear who and what this person is e.g. occupation/position, company. Same applies to L260 Bessa Personal communication should be reported as Ms Leah Bessa (role/position, company ; personal communication) to put the statement reported in context.

AUTHOR: I have included positions and company's

L296 - 299 A conclusion should conclude on the information that was reported . No totally new information e.g. reference to Israel's innovative technology should emerge in the conclusion that was not presented in the text. At present the conclusion section reads like a personal viewpoint of the authors

AUTHOR: Moved reference to Results and Discussion

Fig 1: Define GHG

AUTHOR: Spelt the acronym out.

Fig 2: The figure needs to be revised? Which measure is indicated on the y and z axes, respectively? For the y axis, the reference point should be 0 and negative values should be indicated downwards from 0. How is per capita kg value consumption indicated as a negative value?

AUTHOR: Corrected reference point to 0.

Fig 3 I cannot interpret this fig based on the information provided. It is not clear what the score analysis refers to. The time horizon is not clear to me.

AUTHOR: Included reference to time horizons

Reviewer H: Round 1

Date completed: 11 December 2023

Recommendation: Accept / **Revisions required** / Resubmit for review / Decline

Conflicts of interest: None

Does the manuscript fall within the scope of SAJS?

Yes/No

Is the manuscript written in a style suitable for a non-specialist and is it of wider interest than to specialists alone?

Yes/No

Does the manuscript contain sufficient novel and significant information to justify publication?

Yes/No

Do the Title and Abstract clearly and accurately reflect the content of the manuscript?

Yes/No

Is the research problem significant and concisely stated?

Yes/No

Are the methods described comprehensively?

Yes/No

Is the statistical treatment appropriate?

Yes/No/Not applicable/Not qualified to judge

Are the interpretations and conclusions justified by the research results?

Yes/Partly/No

Please rate the manuscript on overall contribution to the field

Excellent/**Good**/Average/Below average/Poor

Please rate the manuscript on language, grammar and tone

Excellent/**Good**/Average/Below average/Poor

Is the manuscript succinct and free of repetition and redundancies?

Yes/No

Are the results and discussion confined to relevance to the objective(s)?

Yes/No

The number of tables in the manuscript is

Too few/**Adequate**/Too many/Not applicable

The number of figures in the manuscript is

Too few/**Adequate**/Too many/Not applicable

Is the supplementary material relevant and separated appropriately from the main document?

Yes/No/Not applicable

Please rate the manuscript on overall quality

Excellent/**Good**/Average/Below average/Poor

Is appropriate and adequate reference made to other work in the field?

Yes/No

Is it stated that ethical approval was granted by an institutional ethics committee for studies involving human subjects and non-human vertebrates?

Yes/No/**Not applicable**

If accepted, would you recommend that the article receives priority publication?

Yes/No

Are you willing to review a revision of this manuscript?

Yes/No

Select a recommendation:

Accept / **Revisions required** / Resubmit for review / Decline

With regard to our policy on '[Publishing peer review reports](#)', do you give us permission to publish your anonymised peer review report alongside the authors' response, as a supplementary file to the published article? Publication is voluntary and only with permission from both yourself and the author.

Yes/No

Comments to the Author:

The article is well-written, and the figures accurately summarise vital findings. Although some of the proposed solutions provided could be seen as 'challenging' to say the least, in my view and opinion it is accurate and demonstrates valuable insight into the food and beverage industry In SA. However, one additional aspect I would recommend including is to reference the current situation in SA and compare this with the UN sustainability goals, especially regarding the 'ZERO Hunger' goal, which I think would be extremely valuable to contextualise the problem statement. Overall, well done!

[See Appendix 1 for Reviewer H's comments made directly on the manuscript]

Author response to Reviewer H: Round 1

The article is well-written, and the figures accurately summarise vital findings. Although some of the proposed solutions provided could be seen as 'challenging' to say the least, in my view and opinion it is accurate and demonstrates valuable insight into the food and beverage industry In SA. However, one additional aspect I would recommend including is to reference the current situation in SA and compare this with the UN sustainability goals, especially regarding the 'ZERO Hunger' goal, which I think would be extremely valuable to contextualise the problem statement. Overall, well done!

Included context of SDG's. Furthermore all changes indicated in the comments in the document have been addressed.

Appendix 1: Reviewer H comments on manuscript

SOUTH AFRICA'S FOOD SYSTEM: AN INDUSTRY PERSPECTIVE ON PAST, PRESENT AND FUTURE APPLICATIONS OF SCIENCE & TECHNOLOGY

Abstract

The South African food system [face severe challenges is failing](#) as increases in hunger, rising food costs, lack of dietary diversity, child stunting, foodborne illnesses, food waste and an obesity epidemic coupled with malnutrition are observed. The study aimed to establish the application of science and technology advances in the food and beverage industry in South Africa in response to food consumption pattern changes since 1994 and how they could be used to address food security challenges. The study found that food consumption shifts have been towards sugar-sweetened beverages, processed and packaged food, animal-source foods, added caloric sweeteners and away from vegetables. These dietary shifts are concerning as it relates to public health. The study found that most commitments to improve the nutrition status of South Africans were limited to corporate social investment strategies and should be extended into core business strategies. Furthermore, the study showed that while the South African food and beverage industry keeps pace with developments in food manufacturing practices, there is little experimentation with non-commercial novel technologies. The expert survey revealed that indigenous African crops and food waste recovery are the two most promising emerging food sources that could be available to South Africans in the shortest timeframe. South Africa has many enabling drivers to become a [global leader powerhouse](#) of food technology advances. However, many barriers need to be overcome so that industry, academia and government collaborate to advance novel food science and technologies to reach commercialisation.

Significance

- Drivers and consequences of food consumption changes in South Africa were modelled and broad food consumption trends between 1994 to 2009/2012 were identified.
- For the first time, the Access to Nutrition Index methodology was applied to South African-owned food companies to identify strategies to enhance nutrition practices. Companies need to do more to deliver affordable and accessible products.
- Drivers and barriers to adopting advanced food science and technology were modelled. A collective ecosystem approach with industry, academia and government mobilisation around critical areas like hunger, malnutrition and poverty could be a way to tackle the failing food system.

Background

33

34 There are clear signs that the South African food system is [failingfacing severe challenges](#), as increases in
35 hunger, rising food costs,
36 lack of dietary diversity, child stunting, foodborne illnesses, food waste and an obesity epidemic coupled with
malnutrition are observed.

37

38 Various [factors affect food consumption](#), including accessibility, availability and choice. Food intake choices
39 are influenced by several factors such as geography, location, season, history, education, demographics,
40 disposable income, government and other support services, urbanisation, globalisation, marketing, religion,
41 culture, social networks, convenience, time and consumer attitudes¹⁻⁴. Consequences are associated with
42 changes to food consumption patterns, including health and environmental impacts¹. It would be expected
43 that changes in food consumption patterns would impact the food and beverage industry through product
44 innovation demand, increased production capacity and efficiency improvements, applications of new science
45 and technology, increased regulation on foodstuffs and advancements in the value chain from raw materials,
46 processing and distribution.

47

48 Various food and nutrition-related studies conducted at provincial or community levels over the past few
49 decades have reported that South Africans adopt more Western-oriented diets. South Africans consume a
50 diet low in dietary variety, with informal urban areas worst affected^{7,8}. Based on a study by Steyn et al.⁹, which
51 analysed dietary surveys, the South African adult population frequently consumed maize, sugar, tea, brown
52 and white bread, non-dairy creamer, brick margarine, chicken meat, full-cream milk, and green leaves. Almost
53 half (48%) of adult South Africans reported eating out of the home. Regarding frequency, most said they ate
54 outside the home monthly (28.7%) and weekly (28.3%).⁷ There has never been a national dietary survey of
55 adults in South Africa, and there was only one national study on food consumption related to children aged 1
56 – 9 years old in 1999^{9,10}. Furthermore, a study by Steyn et al.¹¹ to determine if mandatory fortification
57 implemented in 2003 had improved micronutrient dietary intake concluded that there is a lack of dietary intake
58 studies and again highlighted the need for a national survey of children's dietary intake. Therefore, data on
59 food consumption nationally is outdated and does not include all age groups, nor is there comprehensive data
60 analysing trends in packaged foods and beverages consumption.

61

62 The drivers of food consumption changes since 1994 in South Africa can be described through the
63 environmental scanning technique of political, economic, social, technological, legal and environmental
64 (PESTLE) factors. These ultimately lead to consequences for public health and the food system, as shown in
65 Figure 1.

66

67 The significant political change for South Africa in the last 30 years was the end of Apartheid, culminating in
68 the first democratic election on 27 April 1994. The post-Apartheid Government put various economic and

Commented [A1]: Probably one of the biggest challenges remains cost?

69 transformation plans in place, which resulted in increased income per capita and the rise of the black middle
70 class with significant spending power.¹² After economic and trade restrictions were lifted, social shifts occurred,
71 such as increasing urbanisation, as the black population moved permanently from rural to urban areas looking
72 for a better life.¹³ Unfortunately, the last decade saw a slowdown in economic growth due to policy uncertainty
73 and energy constraints.¹⁴ Despite progressive legislative measures, women remain underrepresented in the
74 workplace¹⁵. More than half the population still lives in poverty, and South Africa remains one of the most
75 unequal countries in the world¹⁶. Unemployment in 2019 was 28.7%¹⁴, with youth unemployment the most
76 significant at 55% in 2019¹⁷.

Commented [A2]: I think there are various other factors, which further contributed to the slowdown of economic growth, not only policy and energy constraints? Maybe elaborate on some of these, i.e. unemployment, social unrest, inflation, lack of basic services (water, sanitation) etc.

77

78 Trade liberalisation post-Apartheid saw international food and beverage companies entering South Africa,
79 thereby increasing competition for local players and forming partnerships. This resulted in rising global brand
80 exposure and marketing to South Africans^{4,18}. Furthermore, supermarkets have grown significantly, especially
81 in township areas, accounting for about 60% of retail sales¹⁹⁻²⁰. The South African food and beverage
82 manufacturing industry is dominated by a limited number of large national and multinational companies that
83 control production capacity and sales across multiple food categories. The ten largest packaged food
84 companies in South Africa accounted for 43.5% of total packaged food sales in 2020.²¹ This is a result of the
85 technical barriers to entry imposed by the apartheid government.

Commented [A3]: It would be interesting to have Rand values added, i.e. the 43,5% = XXX R value and is X % of GDP?

86

87 Access to essential services like water, sanitation and electricity has advanced in post-Apartheid South Africa,
88 with 84% of households in 2020 having access to electricity, up from 50.9% in 1994^{12,16}. This created a
89 demand for durable goods such as refrigerators, ovens and microwaves, offering broader food choices due to
90 the expanded food preparation and storage options. Socioeconomic trends in South Africa, such as
91 urbanisation and population growth, are projected to double the demand for commodities and increase the
92 need for high-value foods like dairy and meat by 200%. As consumers become less trusting of the 'faceless'
93 food and beverage industry and more aware of the effects of food production on the environment, they are
94 increasingly considering product quality attributes such as food safety, nutrition, organic production, fair trade,
95 free range, animal friendly and locally grown when making food choices^{23,24}.

Commented [A4]: I would definitely check my references or at least add better references than the Presidency of SA?

96

97 Regarding legal drivers, the Department of Health has implemented regulations on the food and beverage
98 industry in an effort to improve public health. These regulations require fortifying staple foods, limiting salt in
99 some foods, and taxing sugary drinks.

100

101 Global food production is the single most significant driver of environmental degradation and transgression of
102 planetary boundaries impacting climate change and ecosystem resilience.²⁵ Current food systems are
103 responsible for approximately one-quarter of anthropogenic greenhouse gas (GHG) emissions. They are a
104 leading cause of deforestation, biodiversity loss, freshwater use and water pollution and are also ineffective in
105 feeding people adequately.²⁶ South Africa's food system contributes 15 to 20% of GHG emissions.²⁷ Eighty

106 percent of South African land is suitable for livestock farming; overgrazing on erosion-prone soils has led to
107 widespread land degradation, dramatically reducing soil carbon storage.²² Food production and processing
108 are energy intensive, especially in a country dependent on coal-fired energy sources, substantially increasing
109 the system's carbon footprint²². South Africa is a water-scarce country, with water fast becoming a crisis²⁸. A
110 staggering 10 million tonnes of food (about one-third) go to waste in South Africa²⁹⁻³¹. The bulk of this loss
111 (49%) arises from the processing and packaging stage and 18% from the consumption stage³¹. This is of great
112 concern due to the substantial portion of discarded food still being edible, the loss in potential value if food
113 waste is disposed of together with the related wasted resources and emissions in producing the food in the
114 first place^{30,32}.

115

116 The RethinkX report suggests that the world is on the edge of revolutionary disruption in food and agricultural
117 production.³³ This results in uncoupling from land and sea resources to novel protein sources derived from
118 bacteria, yeasts and fungi³³⁻³⁵. Science and technology are constantly developing to tackle the challenges of
119 globalisation, sustainability, and the requirement for stable and secure supply³⁶⁻³⁸. Regulatory authorities are
120 also putting pressure on the food processing industry to minimise its impact on the environment³⁶⁻³⁸. Moreover,
121 consumers demand safer, higher quality, and minimally processed food. According to a survey conducted in
122 the UK food and beverage industry, the use of advanced technology has been linked to enhancements in
123 product quality, cost savings, and the development of new products, despite the increasing need to improve
124 sustainability and resource efficiency.³⁹ The study identified emerging technology trends, including improving
125 efficiency, productivity, sustainability, and reducing salt and fat content.³⁹ No comprehensive research for
126 South Africa related to applying advanced science and technology developments or emerging technology
127 trends. However, it would be expected that the [SAFBMI](#) has adopted advances in science and technology to
128 keep pace with the evolving South African consumer, regulatory and competitive landscape.

Commented [A5]: What does SAFBMI refer to? South African Food and Beverage Industry.

129

130 This study aims to investigate how SAFBMI has utilised scientific and technological advancements to tackle
131 changes in food consumption patterns since 1994 and how these advancements can address food security
132 challenges faced by South Africans.

133

134

Materials & Methods

135

Establish food consumption shifts since 1994

136 This study aims to examine changes in the consumption of packaged foods in South Africa since the end of
137 Apartheid. The FAOSTAT FBS and Euromonitor Passport databases were used to gather comprehensive and
138 comparable national data on food items consumed. Both exported data sets were converted into per capita
139 consumption figures to account for population growth. Intervals of five-year periods, from 1994 to 2009, for
140 FAOSTAT FBS data and from 1999 to 2012 for EUROMONITOR PFBC data were compared. Time overlaps
141 were examined in 1999, 2004 and 2009.

142 ***Determine science and technology advances by SAFBI***

143 The study will explore how advancements in science and technology and investments made by the food and
144 beverage industry can meet changing food consumption patterns and maintain competitiveness. South African
145 food and beverage industry trade magazines covering reported applications and investments in advanced
146 science and technology developments will be used to source this data. A database was created by collecting
147 articles from the SA Food Review from 1986 to 2012 and the SA Food and Beverage Reporter from 1995 to
148 2012. The data was analysed to identify trends in applying science and technology.

149

150 ***Determine nutrition practices by SAFBI***

151 As the SAFBMI reaches every household and South Africa has significant health concerns, the study will use
152 a modified version of the Access to Nutrition Index (ATNI) methodology to assess how nutrition practices are
153 integrated into the core of business practices. The ATNI is a global initiative that evaluates the largest food
154 and beverage manufacturers' policies, practices and disclosure related to nutrition and the degree to which
155 these are embedded in core business functions. Data was gathered from company websites and annual
156 integrated reports for 2013 and 20. The nutrition performance of the top three South African food and beverage
157 manufacturers over three years (between 2013 and 2016) was then evaluated to understand if improvements
158 are being made in this area.

159

160 ***Establish and map underutilised and emerging food sources to address***
161 ***food security***

162 A literature review will be conducted to identify underutilised or emerging new food sources that could provide
163 a solution to providing safe, affordable and nutritious food for vulnerable South Africans. A survey will then be
164 designed around criteria related to affordability, nutrition, safety, consumer acceptance and regulatory
165 environment. A quantitative expert survey will be conducted with South African food professionals from
166 industry, academia and government to evaluate the identified underutilised or emerging new food sources
167 against a set of criteria to determine the most promising and in what timeframe these could be expected to be
168 available to South Africans. Ethics clearance for the quantitative expert survey was received from the
169 University of [anonymised by journal administrator] on 15 July 2021 with project number [anonymised by
170 journal administrator]. Based on the findings from these combined studies, barriers and drivers will be
171 identified for key role players to utilise and harness science and technology to improve food security for all
172 South Africans.

173

174 **Results & Discussion**

175 Food consumption patterns in South Africa have undergone significant changes over the past few decades
176 and are expected to continue evolving. Over the last few decades, various community and provincial-level
177 studies indicate that food consumption shifts in South Africa have been towards a more Western-orientated
178 diet, with nutritional consequences contributing to increased obesity and other non-communicable diseases.
179 The study's results suggest that people consume more kilojoules per day, with a preference for sugar-
180 sweetened drinks, processed and packaged foods (including vegetable oils), animal-based products, and
181 added sweeteners. Unfortunately, this shift is leading to a decreased consumption of vegetables (as seen in
182 Figure 2). The main factors driving this trend are convenience, nutrition, health, and indulgence. These
183 changes in eating habits are problematic due to their nutritional content and potential impact on public health.

184

185 The consequences of food consumption shifts in South Africa from a public health perspective have
186 unfortunately resulted in increased obesity and other non-communicable diseases^{5,40,41}. Data from the
187 SANHANES-1 survey revealed that 39% of women and 25% of men were obese and that obesity has
188 increased since 2003.⁷ Diabetes affects 12.6% of adult women and 9.7% of adult men.⁷ Unfortunately, South
189 Africa has made limited progress in reducing stunting in children under five years old, with 27% stunted.⁴²
190 Even though the SANHANES-1 survey indicates that anaemia and iron status have improved, poor
191 micronutrient status remains common among young children.⁴³ South Africa suffers from a double burden of
192 disease where over and under-nutrition are a reality. One in five South Africans (24%) in September 2020 was
193 affected by moderate to severe food insecurity, while almost 15% experienced severe food insecurity.⁴⁴ Poorer
194 households can spend more than 40% of their total expenditure on food compared to the national average of
195 13%.⁴³ Unfortunately, most South Africans cannot afford to maintain a healthy diet.⁴⁵ Without government
196 grants, poverty and household food security would have worsened even further over this time.¹⁴

197

198 Fast food, bottled soft drinks, and multinational food companies are often linked to the rise of non-
199 communicable diseases both locally and globally^{4,5}. The ATNI measures how companies incorporate nutrition
200 practices into their business operations. This is conducted independently for the world's largest Food and
201 Beverage companies. No similar assessment or study is available for South African Food and Beverage
202 companies. The study found that most commitments to improve the nutrition status of South Africans were
203 limited to corporate social investment strategies and programmes and should be extended into core business
204 strategies to fully leverage the market and corporate reputation opportunity that this offers. Nutrition could be
205 more explicitly incorporated into business strategy with senior leadership responsibility. Transparency and
206 reporting on research and development (R&D) programmes related to product formulation could be improved.
207 This study found that the market opportunity to reach underserved consumers with optimal affordable and
208 nutritious products has not been realised.

209

210 Food and beverage multinationals traditionally spend far less in R&D (only accounting for 3% of total R&D
211 spent globally in 2016) than other sectors like healthcare, automotive and technology.⁴⁶ The study examined
212 how advances in science and technology and investments made by the food and beverage industry are being

213 utilised to adapt to changes in food consumption patterns and maintain competitiveness. According to the
214 study, SAFBMI seems to adapt well to advancements in food manufacturing, such as automation, quality
215 control, material handling, and centralised distribution centres with warehouse management systems.
216 However, there is a lack of experimentation with non-commercial innovative technologies. Cilliers and
217 Carinus⁴⁷ point out the innovation paradox where established businesses, in an attempt to ensure predictability
218 and maintain high turnover and profits, soon spiral into low-innovation, low-risk, low-reward cycles. Start-ups
219 can quickly innovate and adapt to consumer needs but lack the financial resources and credibility to deliver
220 goods at scale. Some global Food and Beverage companies have created venture capital divisions to invest
221 in food tech start-ups that are seen as an extension of their R&D departments and far less risky than significant
222 merger and acquisition deals.⁴⁶ This is an example for South African Food and Beverage manufacturers to
223 follow. It is promising to see Tiger Brands utilising its recently launched venture capital fund to invest in the
224 plant-based protein start-up Herbivore Earthfoods.

225

226 Food tech start-ups recognise the innovation opportunity with this shift away from traditional agricultural
227 production. Venture investors are increasing investments in food tech start-ups, especially those creating new
228 types of food and production methods.⁴⁸ Global investment into food tech reached a record \$12.8 billion in
229 2021, significantly up from \$2.2 billion in 2017, where half of this investment went to companies creating
230 alternatives to traditionally produced meat, seafood and dairy products.⁴⁸ It is expected that food tech
231 investment is likely to grow further. A further study objective was to identify underutilised or emerging new
232 food sources that could provide safe, affordable, nutritious foods relevant to South Africans. The findings
233 suggest that indigenous African crops and food waste recovery are the two of the most promising emerging
234 food sources available to South Africans in the next 3 - 5 years that meet the need for affordable, nutritious,
235 safe and culturally appropriate food (Figure 3). Fermentation (precision and biomass) and insects for human
236 consumption were assessed to become available to South Africans in less than 5 - 10 years (Figure 3). The
237 two underutilised or emerging food sources thought to have the most extended time frame of 5 - 10 years to
238 commercialisation were cell-based meat and seafood and algae, with cell-based meat and seafood seen as
239 not being able to meet all the criteria of affordable, nutritious, safe and culturally appropriate food (Figure 3).
240 South Africa already has start-ups innovating in cell-based meat (Mzansi Meats and Mogale Meats) and
241 precision fermentation (De Novo Dairy).

242

243 Respondents in this study indicated that for any underutilised or emerging food source or technology to reach
244 the South African retail shelves, there needs to be investment from industry, governments, and academia into
245 research, technical capability building and scale-up infrastructure through commercialisation. According to a
246 report conducted by Mouton et al.⁴⁹, South Africa invests too little in R&D. Gross Domestic Expenditure on
247 R&D (GERD)/Gross Domestic Product (GDP) has remained unchanged at around 0.8% for the last fifteen
248 years compared to an elusive national target of 1%, resulting in South Africa being ranked 44th on GERD/GDP
249 in 2015. South Africa's total public agricultural research spending has increased from an estimated R1.3 billion
250 in 1971 to R1.9 billion in 2014 (both in 2011 prices).⁴⁹ However, the number of full-time researchers in the
251 broad field of agriculture has not increased between the early 1980s and 2014.⁴⁹ Patent applications (a proxy
252 for research and innovation) registered by South African residents are low and have stagnated over the last

Commented [A6]: Why was this extended. I would recommend looking at the complete value chain and especially the barriers to entry with commercialisation (i.e. capacity) of for example precision and biomass fermentation.

253 35 years.⁵⁰ Fortunately, there has been growth in academic pipelines for master's and doctoral graduates,
254 increased publications, and significant participation of black people and women in the R&D workforce^{16,49}.
255 Food sciences and technology feature second in publishing scientific research papers under agricultural
256 sciences⁴⁹. It is promising to see research projects like InnoFoodAfrica trying to increase dietary diversity by
257 developing affordable, nutrient-dense and healthy food products from local African crops. According to
258 KaMshayisa (personal communication), There is also research across multiple academic institutions on
259 insects, from techno-functional properties, allergenicity and microbial aspects to new product development for
260 human food. Bessa (personal communication) states that research in South Africa is relatively cost-effective,
261 and significant research can be conducted at a fraction of the cost to overseas universities. Bessa (personal
262 communication) also pointed out that South Africa lacks pilot plants' scale-up capabilities or co-manufacturing
263 scale-up facilities to bring new technologies to market. This means that trials often need to be conducted
264 overseas, which is complicated, costly and slow.

265

266 The National Development Plan recognises that science, technology, and innovation (STI) are crucial for
267 boosting economic growth, creating jobs, and promoting socioeconomic reform.⁵¹ The 2019 White Paper on
268 Science, Technology, and Innovation strongly focuses on critical themes of inclusivity, transformation, and
269 partnerships.⁵¹ The Department of Science & Innovation offers various funding opportunities, including the
270 Support Programme for Industrial Innovation and the Industrial Innovation Partnership Programme.⁵¹ The
271 Technology Innovation Agency also provides grants, loans, and equity support for technology development
272 and commercialisation.⁵¹ The Technology for Human Resources in Industry Programme facilitates research
273 and development collaborations among private companies, universities, and science councils¹⁶. The
274 government needs to ensure this funding and support for research skills and infrastructure, as well as
275 acceleratory tax incentives for R&D, are accessible and provide an enabling environment for various
276 stakeholders to collaborate and innovate to unlock new food science technologies. The Netherlands
277 Government, in 2022, for example, announced funding of an initial \$60 million to expand and develop its
278 domestic cultivated meat and seafood ecosystem.⁵² The funding will be used mainly to invest in education
279 and innovation in this emerging industry.⁵² It is also evident from the study that for emerging or new food
280 technologies to become available to South Africans, a progressive and **agile regulatory environment** needs to
281 be in place, which is not the case today. Singapore's Food Agency, for example, already approved the sale of
282 cultivated meat in 2020, enabling start-ups like Eat Just to test and scale this technology in that country.⁵³

283

284 According to a 2019 white paper about STI in South Africa, the National System of Innovation is hindered by
285 several factors. These include insufficient and non-collaborative methods for setting an STI agenda, lack of
286 policy coherence and coordination, weak partnerships between key stakeholders (minimal involvement from
287 businesses and civil society), inadequate monitoring and evaluation, insufficient high-level science,
288 engineering, and technology skills for the economy, a small research system, an unfavorable environment for
289 innovation, and significant underfunding.⁵¹ Furthermore, the study found that the barriers described in Figure
290 4 must be overcome so that key stakeholders across the innovation system can collaborate to advance novel
291 food science, technologies, and research to reach commercialisation.

Commented [A7]: Role of BBBEE with these agencies and grants / loans / equity. Does this potentially serve as a challenge?

292

293

Conclusion

294

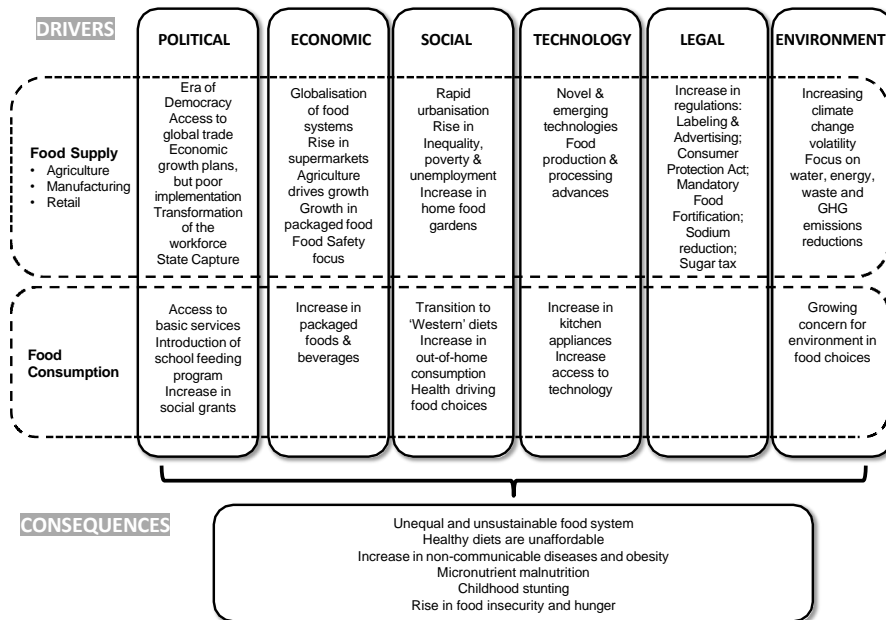
295 South Africa has many enabling drivers to become a [powerhouse-global leader](#) of food technology advances (Figure 1).

296 Similar to how Israel has become known for its innovative technology, entrepreneurial spirit, supportive
297 government policies and investment capital.⁵⁴ Israel now has over 100 companies operating in the alternative
298 protein sector, with investment funding totalling \$114 million in 2020, of which government funding alone was
299 \$18 million.⁵⁴ South Africa has strong research institutions supporting a healthy pipeline of post-graduate
300 students, with research being conducted and published on many underutilised and emerging food
301 technologies and sources. It is cost-effective to conduct research in South Africa, and with local and
302 international funding, food science and technology research could build further necessary skills, capabilities
303 and expertise. South Africa has a robust agricultural sector and an advanced and growing food and beverage
304 manufacturing industry, with recent food tech start-ups conducting research and piloting novel technologies in
305 cell-based and precision fermentation, working towards commercialisation. Unfortunately, there is a lack of
306 pilot plants and scale-up facilities for start-ups and innovators to allow their ideas to scale quickly and reach
307 the market. This often means costly and slow trials offshore. The government could play a significant role in
308 connecting the critical players across the research ecosystem and food value chain, including small-scale
309 farmers, around essential research agendas such as hunger and malnutrition. They could co-invest in the
310 relevant infrastructure for shared facilities where multiple innovators could collaborate to reach scale-up and
311 provide accessible tax incentives for R&D investment to spur the food and beverage industry to overcome
312 their risk aversion to innovating in novel food science technologies. The food and beverage industry could
313 also invest in food tech start-ups to accelerate their commercialisation efforts and reach scale quicker. Joint
314 research collaborations in indigenous African crops and food waste recovery would be an excellent place to
315 start. In this study, they were identified by food professionals across government, academia and industry as
316 the most promising, near-term emerging sources of food to be utilised to achieve affordable, nutritious, safe
317 and culturally appropriate food.

318

319 South Africa must become more resilient to these impacts through collective engagement with critical
320 stakeholders to harness the benefits of novel and emerging food science technologies. Many examples exist
321 of countries doing this for enormous economic and food security benefits. If all stakeholders recognised their
322 responsibility to address the failing food system and transform how food is produced, future diets of South
323 Africans could be far more diverse and nutritious. This could further positively impact food security,
324 employment generation and the overall economy.

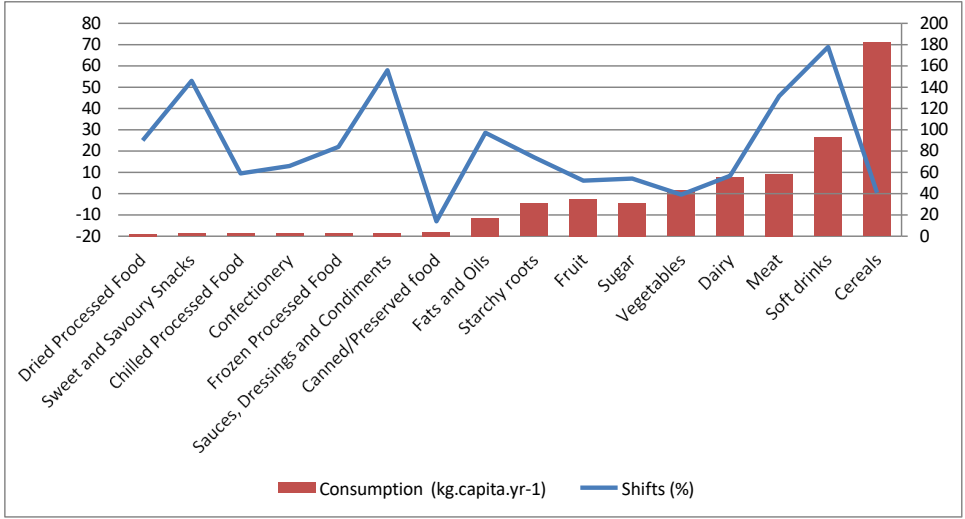
325



326

327 **Figure 1:** Drivers and consequences of food consumption changes in the South African Food and Beverage
 328 Industry since 1994.

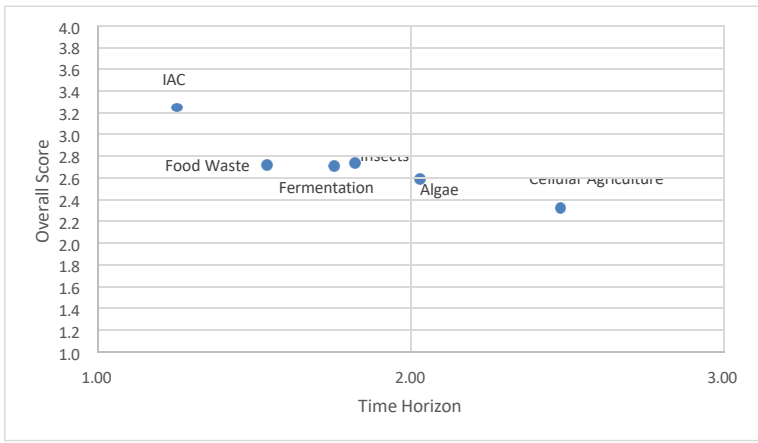
329



330

331 **Figure 2.** Per capita consumption and shifts in consumption of specific food categories in South Africa from
 332 1994/1999 to 2009/2012 (FAOSTAT Food Balance Sheets & EUROMONITOR Packaged Food & beverage
 333 Consumption).

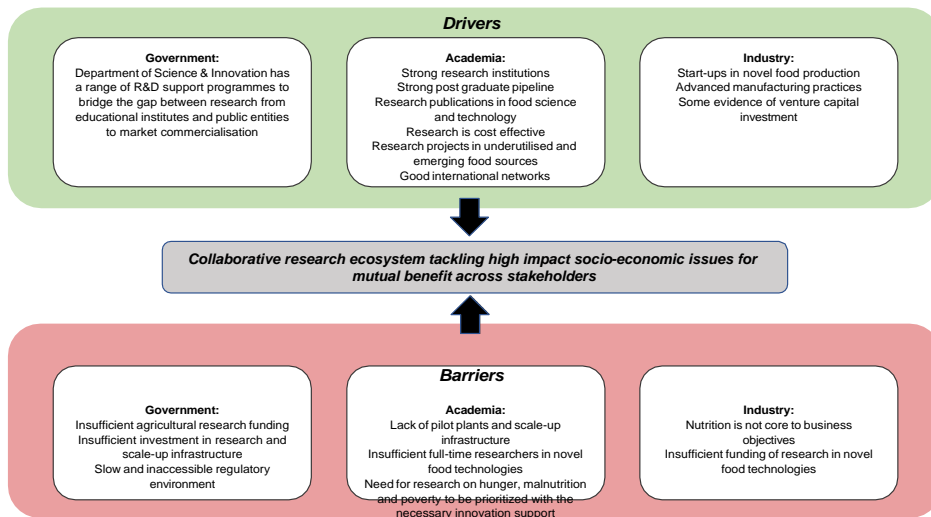
Commented [A8]: Please insert Titles for the primary and secondary Y-axis



334

335 **Figure 3:** Time horizon and overall score analysis for the commercialisation of underutilised and emerging
 336 food sources in South Africa

337



338

339

340 **Figure 4.** Summary of drivers and barriers across critical stakeholders to advancing new food science and
 341 technologies to commercialisation.

342

343

References

- 344 1. Kearney J. Review: Food consumption trends and drivers. *Philos. Trans. R. Soc. Lond., B, Biol.*
345 *Sci.* 2010;365:2793-2807.
346 <https://doi.org/10.1098/rstb.2010.0149>
347
- 348 2. BFAP (Bureau for Food and Agricultural Policy). The South African Agricultural Baseline [document
349 on the Internet]. Available from: <http://www.bfap.co.za>.
350
- 351 3. Wenhold F, Annandale J, Faber M, Hart T. Water use and nutrient content of crop and animal food
352 products for improved household security: A scoping study. Water Research Commission, WRC
353 Report. TT 537/12. 2012.
354
- 355 4. Claasen N, van der Hoeven M, Covic N. Food environments, health and nutrition in South Africa,
356 Working Paper 34. Cape Town: PLAAS, UWC and Centre of Excellence on Food Security. 2016.
357
- 358 5. Kruger HS, Puoane T, Senekal M, van der Merwe MT. Obesity in South Africa: challenges for
359 government and health professionals. *Public Health Nutr.* 2005;8(5):491-500.
360 <https://doi.org/10.1079/PHN2005785>
361
- 362 6. Viljoen AT, Botha P, Boonzaaier CC. Factors contributing to changes in food practices of a black
363 South African community. *JFECS.* 2005;33:46-62.
364 <https://doi.org/10.4314/jfec.v33i1.52875>
365
- 366 7. Shisana O, Labadarios D, Rehle T, Simbayi L, Zuma K, Dhansay A, et al. & SANHANES-1 Team.
367 South African National Health and Nutrition Examination Survey (SANHANES-1). Cape Town: HSRC
368 Press. 2013
369
- 370 8. Labadarios D, Steyn NP, Nel J. How diverse is the diet of adult South Africans? *Nutr. J.*
371 2011;10(33):1-11.
372 <https://doi.org/10.1186/1475-2891-10-33>
373
- 374 9. Steyn NP, Nel JH, Casey A. Secondary data analyses of dietary surveys undertaken in South Africa
375 to determine usual food consumption of the population. *Public Health Nutr.* 2003;6(7):631-644.
376 <https://doi.org/10.1079/PHN2003482>
377
- 378 10. Labadarios D, Steyn NP, Maunder E, MacIntyre U, Gericke G, Swart R, et al. The National Food
379 Consumption Survey (NFCS): South Africa, 1999. *Public Health Nutr.* 2005;8(5):533-543.
380 <https://doi.org/10.1079/PHN2005816>
381
- 382 11. Steyn N, Eksteen G, Senekal M. Assessment of the Dietary Intake of Schoolchildren in South
383 Africa: 15 years after the first National Study. *Nutrients.* 2016;8(509):1-14.

384 <https://doi.org/10.3390/nu8080509>
385
386 12. RSA. The Presidency Republic of South Africa. ISBN 978-0-621-38904-3. Available from:
387 www.thepresidency.gov.za.
388
389 13. Posel D. Have Migration Patterns in post-Apartheid South Africa Changed? In: Proceedings of
390 African Migration in Comparative Perspective Conference, Johannesburg, South Africa. 2003.
391
392 14. Bureau for Economic Research (BER). South Africa's Progress towards its Development
393 Objectives. 2020 Assessment Report [document on the Internet]. Available from:
394 <https://www.ber.ac.za/>
395
396 15. Sinden E. Exploring the Gap Between Male and Female Employment in the South African
397 Workforce. *Mediterr. J. Soc. Sci.* 2017;8(6):37-51.
398 <https://doi.org/10.1515/mjss-2017-0040>
399
400 16. WorldBank. South Africa [document on the Internet]. Available from:
401 <https://data.worldbank.org/indicator/SI.POV.GINI?>
402
403 17. StatsSA. Towards measuring the extent of food security in South Africa: An examination for hunger
404 and food adequacy. 03-00-14. 2019.
405
406 18. Ntloedibe M. South Africa: Food Processing Ingredients Report 2019. USDA Foreign Agricultural
407 Service Global Agricultural Information Network SA1910, Pretoria.
408
409 19. Stroebel L, van Schalkwyk HD. Food retailing and agricultural development. In: Van Schalkwyk
410 HD, Groenewald JA, Fraser GCG, Obi A, van Tilburg A, editors. *Unlocking Markets to Smallholders:
411 Lessons from South Africa*. The Netherlands: Wageningen Academic Publishers; 2012.
412 <https://doi.org/10.3920/978-90-8686-168-2>
413
414 20. Bhana A. The flourishing informal food sector [document on the Internet]. 2018. Available from:
415 <https://www.moneyweb.co.za/news/economy/the-flourishing-informal-food-sector/>.
416
417 21. Euromonitor Passport. Packaged Food in South Africa, Euromonitor International [document on
418 the Internet]. 2020. Available from: [https://www.euromonitor.com/packaged-food-in-south-](https://www.euromonitor.com/packaged-food-in-south-africa/report)
419 [africa/report](https://www.euromonitor.com/packaged-food-in-south-africa/report).
420
421 22. Von Bormann T. Agri-food systems: facts and figures. How South Africa can produce 50% more
422 by 2050 [document on the Internet]. 2019. Available from: www.wwf.org.za/report/agrifood_systems.
423
424 23. Harper GC, Makatouni A. Consumer perception of organic food production and farm animal
425 welfare. *BFJ*, 2012;104(3):287-299.

426 <https://doi.org/10.1108/00070700210425723>
427
428 24. Evans S. South Africans ramping up their efforts to tackle climate change [document on the
429 Internet]. 2021. Available from: [https://mg.co.za/special-reports/2021-09-23-south-africans-ramping-](https://mg.co.za/special-reports/2021-09-23-south-africans-ramping-up-their-efforts-to-tackle-climate-change/)
430 [up-their-efforts-to-tackle-climate-change/](https://mg.co.za/special-reports/2021-09-23-south-africans-ramping-up-their-efforts-to-tackle-climate-change/).
431
432 25. Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S. Food in the Anthropocene:
433 the EAT-Lancet Commission on healthy diets from sustainable food systems. *Lancet*. 2019;393:447-
434 492 [document on the Internet]. Available from: DOI: [https://doi.org/10.1016/S0140-6736\(18\)31788-](https://doi.org/10.1016/S0140-6736(18)31788-4)
435 [4](https://doi.org/10.1016/S0140-6736(18)31788-4).
436 [https://doi.org/10.1016/S0140-6736\(18\)31788-4](https://doi.org/10.1016/S0140-6736(18)31788-4)
437
438 26. Rööß E, Garnett T, Watz V, Sjörs C. The role of dairy and plant based dairy alternatives in
439 sustainable diets. In: *Future Food Reports 3. The research platform Future Food*. Sweden: Swedish
440 University of Agricultural Sciences, 2018.
441
442 27. Global Alliance for the Future of Food. *Untapped Opportunities for Climate Action: An Assessment*
443 *of Food Systems in Nationally Determined Contributions*. n.p.: Global Alliance for the Future of Food,
444 2022.
445
446 28. World Wildlife Fund. *Water* [document on the Internet]. 2021. Available from:
447 https://www.wwf.org.za/our_work/water/.
448
449 29. Institute of Waste Management of South Africa (IWMSA). *Food waste a problem in insecure SA,*
450 *says IWMSA* [document on the Internet]. 2012. Available from:
451 <http://www.infrastructurene.ws/2012/09/12/food-waste-a-problem-in-food-insecure-sa-says-iwmsa/>.
452
453 30. Nahman A, de Lange W. *Costs of food waste along the value chain: Evidence from South Africa*
454 [document on the Internet]. 2013. Available from:
455 [https://researchspace.csir.co.za/dspace/bitstream/handle/10204/7115/Nahman2_2013.pdf?sequenc](https://researchspace.csir.co.za/dspace/bitstream/handle/10204/7115/Nahman2_2013.pdf?sequence=3&isAllowed=y)
456 [e=3&isAllowed=y](https://researchspace.csir.co.za/dspace/bitstream/handle/10204/7115/Nahman2_2013.pdf?sequence=3&isAllowed=y).
457
458 31. Oelofse SHH, Polasi T, Haywood L, Musvoto C. *Increasing reliable, scientific data and information*
459 *on food losses and waste in South Africa. Waste Research Development and Innovation Roadmap*
460 *Research Report, CSIR External Report CSIR/SPLA/SECO/ER/2021/0019/A*. 2021.
461
462 32. Food and Agriculture Organisation of the United Nations (FAO). *Global food losses and food waste*
463 *- Extent, causes and prevention*. Rome: FAO [document on the Internet]. 2011. Available from:
464 <https://www.fao.org/3/i2697e/i2697e.pdf>
465
466 33. Tubb C, Seba J. *Rethinking Food and Agriculture 2020-2030. A RethinkX Sector Disruption*
467 *Report*. 2019.

- 468
469 34. Pyett S, de Vet E, Trindade LM, van Zanten H, Fresco LO. Chickpeas, crickets and Chlorella: our
470 future proteins. Wageningen University & Research [document on the Internet]. 2019. Available from:
471 <https://edepot.wur.nl/496402>
472
- 473 35. Vanhercke T, Colgrave M. What's brewing? Precision food proteins from fermentation. CSIRO
474 Issue 285 [document on the Internet document]. 2022. Available from: [https://ecos.csiro.au/whats-](https://ecos.csiro.au/whats-brewing-precision-fermentation/)
475 [brewing-precision-fermentation/](https://ecos.csiro.au/whats-brewing-precision-fermentation/).
476
- 477 36. Campden BRI. Scientific and technical needs of the food and beverage industry [document on the
478 Internet]. 2012. Available from: www.campden.co.uk.
479
- 480 37. Jermann C, Koutchma T, Margas E, Leadley C, Ros-Polski V. Mapping trends in novel and
481 emerging food processing technologies around the world. IFSET. 2015;31:14-27.
482 <https://doi.org/10.1016/j.ifset.2015.06.007>
483
- 484 38. Bader F, Rahimifard S. Challenges for Industrial Robot Applications in Food Manufacturing
485 [document on the Internet]. 2018. Available from: <https://doi.org/10.1145/3284557.3284723>
486 <https://doi.org/10.1145/3284557.3284723>
487
- 488 39. Leatherhead. Survey: What's most important when it comes to investing in new technology?
489 [document on the Internet]. 2012. Available from: [http://foodstuffsa.co.za/news-stuff/food-science-](http://foodstuffsa.co.za/news-stuff/food-science-and-technology-stuff/2385-survey-whats-most-important-when-it-comes-to-investing-in-new-technology)
490 [and-technology-stuff/2385-survey-whats-most-important-when-it-comes-to-investing-in-new-](http://foodstuffsa.co.za/news-stuff/food-science-and-technology-stuff/2385-survey-whats-most-important-when-it-comes-to-investing-in-new-technology)
491 [technology](http://foodstuffsa.co.za/news-stuff/food-science-and-technology-stuff/2385-survey-whats-most-important-when-it-comes-to-investing-in-new-technology)
492
- 493 40. Popkin BM. Global nutrition dynamics: The world is shifting rapidly toward a diet linked with non-
494 communicable disease. *Am J Clin Nutr*. 2006;84:289-98.
495 <https://doi.org/10.1093/ajcn/84.2.289>
496
- 497 41. Goetjies E, Pavlova M, Hongoro C, Groot W. Socioeconomic Inequalities and Obesity in South
498 Africa - A Decomposition Analysis. *Int. J. Environ. Res. Public Health*, 2021;18, 9181.
499 <https://doi.org/10.3390/ijerph18179181>
500
- 501 42. May J, Witten C, Lake L. South African Child Gauge 2020 Food and Nutrition Security [document
502 on the Internet]. 2020. Available from:
503 [http://www.ci.uct.ac.za/sites/default/files/image_tool/images/367/Child_Gauge/South_African_Child_](http://www.ci.uct.ac.za/sites/default/files/image_tool/images/367/Child_Gauge/South_African_Child_Gauge_2020/ChildGauge_2020_screen_final.pdf)
504 [Gauge_2020/ChildGauge_2020_screen_final.pdf](http://www.ci.uct.ac.za/sites/default/files/image_tool/images/367/Child_Gauge/South_African_Child_Gauge_2020/ChildGauge_2020_screen_final.pdf).
505
- 506 43. StatsSA. Living conditions of households in South Africa, an analysis of household expenditure
507 and income data using the LCS 2014/2015 [document on the Internet]. 2017. Available from:
508 <http://www.statssa.gov.za/publications/P0310/P03102014.pdf>.
509

510 44. StatsSA. How Covid affected food security in South Africa [document on the Internet]. 2022 [cited
511 2022 May 15]. Available from: <https://www.statssa.gov.za/?p=15273>
512

513 45. Temple NJ, Steyn NP, Fourie J, de Villiers A. Price and availability of healthy food: A study in rural
514 South Africa. *Nutrition* 2011;27(1), 55-58.
515 <https://doi.org/10.1016/j.nut.2009.12.004>
516

517 46. Geller M. Food revolution: megatrends turn to small start-ups for big ideas [document on the
518 Internet]. 2017. Available from: [https://www.reuters.com/article/us-food-investment-insight-](https://www.reuters.com/article/us-food-investment-insight-idUSKBN18K18O)
519 [idUSKBN18K18O](https://www.reuters.com/article/us-food-investment-insight-idUSKBN18K18O).
520

521 47. Cilliers T, Carinus A. The innovation paradox: Innovation within the food industry in developing
522 countries and the challenges associated with globalisation. *FST Magazine*. 2022;April:6-7.
523

524 48. Van Romburgh, M. Faux Meat And Dairy Start-ups Consume Nearly Half Of Record \$13B VC
525 Investment Into Foodtech [document on the Internet]. 2022. Available from:
526 <https://news.crunchbase.com/business/food-tech-summit-fake-meat-dairy-vc-startups-investment/>
527

528 49. Mouton J, Basson I, Blanckenberg J, Boshoff N, Prozesky H, Redelinghuys H, et al. The state of
529 the South African research enterprise. DST-NRF Centre of Excellence in Scientometrics and Science,
530 Technology and Innovation Policy [document on the Internet]. 2019. Available from:
531 <https://www.researchgate.net/publication/335857684>
532

533 50. Schmoch U, Pouris A. International patent applications and innovation in South Africa. *SAJEMS*.
534 2021;24(1):a4146. <https://doi.org/10.4102/sajems.v24i1.4146>
535 <https://doi.org/10.4102/sajems.v24i1.4146>
536

537 51. RSA. The Presidency Republic of South Africa. White Paper on Science, Technology and
538 Innovation: Science, technology and innovation enabling inclusive and sustainable South African
539 development in a changing world [document on the Internet]. Available from: www.dst.gov.za.
540

541 52. Selby G. Dutch government invests record €60M to boost cellular meat & agriculture [webpage
542 on the Internet]. 2022. Available from: [https://www.foodingredientsfirst.com/news/dutch-government-](https://www.foodingredientsfirst.com/news/dutch-government-invests-record-%E2%82%AC60m-to-boost-cellular-meat-agriculture.html)
543 [invests-record-%E2%82%AC60m-to-boost-cellular-meat-agriculture.html](https://www.foodingredientsfirst.com/news/dutch-government-invests-record-%E2%82%AC60m-to-boost-cellular-meat-agriculture.html)
544

545 53. Connors E. FOMO drives Singaporeans to lab-grown meat [webpage on the internet]. 2022 [cited
546 21 August 2022]. Available from: [https://www.afr.com/world/asia/fomo-drives-singaporeans-to-lab-](https://www.afr.com/world/asia/fomo-drives-singaporeans-to-lab-grown-meat-20220503-p5ai98)
547 [grown-meat-20220503-p5ai98](https://www.afr.com/world/asia/fomo-drives-singaporeans-to-lab-grown-meat-20220503-p5ai98).
548

549 54. Good Food Institute (GFI). Israel State of Alternative Protein Innovation Report 2021 April
550 [webpage on the Internet]. 2021. Available from: <https://gfi.org/il/>