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Editorial

In defence of organic – and radical agroecology

Lawrence Woodward was a founder and the Director of the Organic Research Centre – Elm Farm for 30 years. In 2001 he was awarded an OBE for services to organic farming, having played a pivotal role in the strategic and practical development of the organic sector in the UK and internationally. He is a director of Beyond GM and Whole Health Agriculture, and is a member of the Gaia Foundation Seed Sovereignty Programme. Lawrence is deeply engaged in articulating and developing the underlying wholistic concepts of organic food and farming; and how they relate to food quality and health under today's social, economic and environmental conditions.

The last few years as seen a burgeoning use of the term agroecology within farming and food circles, not just at farm level but throughout the media, amongst policy makers, politicians and in business. In many ways this is very welcome but not when it is accompanied by the side-lining and even denigration of the term and practice of organic.

The undermining of organic

I hesitate to identify it as a systematic but the ignoring or criticising organic seems to be becoming commonplace.
For example, The Landworkers' Alliance, the UK voice of La Via Campesina, if it mentions organic at all, tends to be dismissive in the "and Brutus is an honourable man" genre. Its head of policy was recently quoted as saying "Our criticism of organic is that it doesn't go far enough. They [organic farms] may look after the soil and have no pesticide usage, but it might be grown in a big monoculture, somewhere overseas, growing luxury crops that can be exported." "The organic standards are a basic sort of thing; they don't necessarily cover all aspects of agroecology like the social aspects." "Agroecology goes further than the simple nature-friendly production methods that are found in organic farming. It links up the entire food system, from workers' rights to health, investigating power in the food system and corporate control".

In a series of articles discussing the relationship of organic, agroecology and regenerative approaches Dr Andrea Beste quoted highly critical comments from Lauro Mocha from the "Agricultura Urbana" in Argentina which are in a similar vein:
"Organic certification, as it is established in Argentina, is expensive, costs a lot of money and deprives us of the freedom for our local, smallholder agriculture. What is organic-certified in Argentina is intended for export to the USA and Europe anyway; these are completely different structures. We are interested in regional added value and in valuing the food produced

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locally, in valuing the work that goes into it and the people who do it. From our point of view, it doesn't make much sense to loose part of the added value that our producers gain into expensive certification processes. What would be their benefit?"

Dr Beste pointed out that the experience in Brazil is different. "Since 2003 there has been a national eco-label and a significant domestic organic market. In 2015, 2 million hectares of certified organic land were farmed in Brazil, by 15,000 certified farmers and producers. Brazil has the largest domestic organic market in Latin America."

There is no reason to doubt the veracity of Lauro Mocha's experience or perspective but it is not a universal one. The problem is the narrative – "organic is limited and is driven by business and certification" – is becoming widespread, is unjustifiably damaging the reputation of the organic movement and sector, is being used to promote an agroecology umbrella approach and is beginning to affect the perceptions of commentators, the media and policy makers across the policy spectrum.

In defence of organic

What is especially egregious is that this narrative skates over the fact that most organic farming in the world is carried out by small farmers, family farmers engaged with domestic (territorial) markets a long way for corporate control, and that of agroecology in practice is composed of organic farmers and growers – both certified and non-certified.

It is also an inaccurate narrative, which dismisses the work of large numbers of organic farmers, researchers, community and business initiatives over decades and which fails to acknowledge the positive impacts the organic sector and movement has had of food, farming and the environment and the lives of many people in all parts of the world.

The organic movement is a massive force for change in the "majority countries" and the Global South. The "From the Field" section of Ifoam's Organic Without Boundaries website gives sense of just how widespread and powerful organic farming is in those countries.

Similarly, the much vaunted IDDRI study "An agroecological Europe in 2050 Ten Years for Agroecology modelling" is based entirely of production and cost figures from organic farms. The authors acknowledge this – even though you have to dig a bit to find it. However, the promotion of this work is around entirely around an agroecological narrative. Arguably, an accurate study title would include, might even be "An organic, agroecological Europe in 2050".

This is far from the only piece study where the performance and benefits or certified organic production have been inveigled into support for the agroecology umbrella. Evidence used to state benefits for biodiversity, soil health, food quality from agroecology is often taken from studies of organic farms or organic research.

The UK Food, Farming and Countryside Commission's "Farming for Change" report is an especially appalling example of this. It purports to be a pathway to an Agroecological future and is almost entirely based on evidence from organic farms. The farmer case studies it highlights are all organic farms, yet you search in vain for a mention of organic in the report or its recommendations.

This is in the context of where to government support for organic farming in the post-Brexit era is in a parlous state. Organic farming organisations are struggling to be heard and to persuade the government that organic should even maintain its current (and rather modest) position in farming policy let alone increase it.

The threat to principled organic and radical agroecology

Organic farming is not a subset of agroecology, although many, including people in the organic sector talk of it in that way, There is certainly a kinship between organic principles and radical agroecology as characterised by the movement for food sovereignty and social justice. There is a shared or similar vision which is values based and is radical and transformative – not just in agriculture but through farming and food to wider social transformation. It is worth noting that one of the first international conferences on agroecology was organised as the "Sixth International Scientific Conference of the International Federation of Organic Agricultural Movements" in 1986. A number of people who have been at the forefront of the emergence of agroecology have also been part of the principled organic movement.

But there are some differences around wholistic concepts relating to the integrity of the organism which may influence technology choices. However, the most

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pressing issue of the moment is the threat to both radical movements by the increasing separation from underpinning concepts of agronomic techniques. The reports mentioned above all focus on agronomic techniques devoid of principle and conceptual.

The upshot is a bewildering situation where, for example, a farmer using agrochemicals, or a farmer sending livestock products long distances to be processed, or a farmer using large amounts of bought in compost and a farmer operating a near closed system without agrochemical inputs and selling into local or defined ethical markets can all be called agroecological This undermines the viability of genuine organic and agroecological producers, it undermines integrity and credibility and, it derails the push for radical transformation of farming and food.

There is no doubt it is happening: The FAO, in its Strategic Framework 2022-31, (para 36) highlighting the importance of "innovative technologies" solutions, was explicit in calling agroecology one of the "entry doors to support the development of (these) emerging sectors". Of course, "innovative technologies" is short-hand for genetic engineering, synthetic biology and related technologies.

It will help the FAO to learn that one of the leading, hitherto organic, organisations, the Soil Association has recently published a report that these "innovative technologies" are "values-neutral" and along with Artificial Intelligence and "big data" can "accelerate a transition to agroecology".

The narrative of agroecology as a menu of agronomic techniques, not defined, not codified in law, can be picked up or dropped by farmers as they will and is attractive to government, business, establishment academics and, regrettably some NGOs because is relatively easy and cheap as a policy and, crucially, is not too disruptive to existing structures.

"Junk Agroecology" is the striking title report by Friends of the Earth International, Crocevia and the Transnational Institute which describes how business-more-or-less-as-usual objectives can be pursued under the guise of agroecology. This is a different version of "corporate organic"

The radical organic movement and the radical agroecology movement should be working together against this and the disingenuous FAO and others. Side-lining and denigrating organic isn't a good basis for working together.

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Using moringa oleifera seed cake and compost as organic soil amendments for sustainable agriculture in Valencia orange orchard

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Valencia orange, Moringa oleifera seed cake, Compost, Soil hydrophysical properties, Water productivity, Yield.

This work was conducted during two consecutive seasons, 2016/2017 and 2017/2018, at Experimental Research Station of National Research Centre at Nubaria, El Behiera governorate, Egypt. Twelve-year-old Valencia orange trees (*Citrus sinensis* L. Osbeck) budded on Volkamer lemon rootstock, grown in sandy soil under drip irrigation system were used as plant materials to study the effect of six organic soil amendment treatments on hydrophysical soil properties, soil water retention, soil water movement, water productivity, plant nutrient contents, yield and fruit quality. Treatments namely, moringa seed cake (MC) 100% (3 tons/fed), 1 moringa seed cake: 2 compost (COM), 1 moringa seed cake: 1 compost, 2 moringa seed cake: 1 compost, compost 100% (3 tons/fed) and control (none moringa seed cake and none compost). Results showed that the application of moringa seed cake combined with compost at 2:1 achieved the best results in terms of soil properties and water productivity of Valencia orange trees. This, in turn, improved nutritional status and increased the productivity of trees and fruit quality compared to the control.

1. Introduction

Oranges from the Valencia orange tree (*Citrus sinensis* L. Osbeck) are among the most consumed fruits because of their high Vitamin C content. Moreover, it is considered one of Egypt's main export fruits (Martí et al., 2009). Valencia orange trees are cultivated successfully in Egypt, but the trees planted in newly reclaimed soils face many challenges, including poor nutrient content and low soil organic matter and leaching nutrients, that affect tree growth and fruit quality. Such conditions require alternative agricultural practices to improve soil properties.

Recycling agricultural residues is crucial for augmenting soil organic amendments and achieving the best agricultural management; however, climate change valorises residues and participating in the circular economy and zero waste contributes to carbon sequestration (Almendro-Candel et al., 2018). Using organic fertilisers maintains soil components and productivity by increasing soil biological activity and overall soil stability with a positive correlation with microbial biomass. Also, it provides efficient use of nutrients and energy from traditionally managed soil. Organic

fertilisation promotes primary metabolites, including soluble carbohydrates, chlorophyll pigments, carotenoids and secondary metabolites such as proteins, polyphenols and auxins (Saviozzi et al., 2002; Bejan and Vișoiu, 2010).

At present, agricultural production management techniques focus on a greater commitment to environmental sustainability. Organic farming is accepted by the European Union and FAO as an alternative to traditional agriculture and accepted as environmentally friendly (Martínez-Alcántara et al., 2016). In organic systems, soil management involves using mowed or tilled cover crops, animal manures, composts, and organic fertilisers that increase soil organic matter (SOM) whilst providing a steady release of nutrients to the crops as the organic matter breaks down. Exogenous organic matter applications improve soil chemical and physical properties and biological functions (Diacono and Montemurro, 2015).

Compost amendments are most frequently used to provide essential nutrients to rebuild soil physic-chemical properties and re-establish microbial populations and activities. Lakhdar et al. (2009); Hemdan (2014) elucidated that incorporating compost in the sandy soil improves soil's hydrophysical properties, including soil bulk density, void ratio, soil porosity and available water in the soil, hydraulic conductivity, and mean diameter of soil pores. The positive effects of compost on aggregate stability, bulk density, porosity, infiltration rates and total water holding capacity of soils can also be improved. In some studies, the effect of applied compost on soil water retention was evaluated, and results showed that compost amendment increased plant available water (Cogger, 2005; Carter, 2007; Mylavarapu and Zinati, 2009).

Synthetic fertilisers as sources of plant nutrients are associated with land and soil degradation and environmental pollution besides their high cost. Moringa oleifera is promoted as a safe, natural alternative, being investigated to ascertain its effect on the growth and yield of crops (Phiri, 2010). Different parts of this plant contain a profile of important minerals, proteins, vitamins, β carotene, amino acids and various phenolic that provide a rich and rare combination of zeatin with several flavonoid pigments (Nagar et al., 1982; Siddhuraju and Becker, 2003; Anwar et al., 2007). Nitrogen availability is considered the critical factor affecting the yield of organic production systems (Clark et al., 1999). Organic fertilisers are slow-release sources for nitrogen resulting in a deficiency in crop yield (Pang and Letey, 2000). Soil fertilisation by Moringa oleifera seed cake leads to plant growth enhancement within a short period of its application compared to other organic matters from animal dung and plant compost, which require long periods for decomposition and use of caution (Villablanca, 2007). Moringa oleifera is an edible and extremely safe cultivated variety of the genus moringa belonging to the Moringaceae family (Mahmood et al., 2010). It offers many benefits in food supplements, medicine, nutrition, water treatment, green manure, and natural fertiliser (Fatma et al., 2020), in soil and water conservation and to decrease greenhouse gas mission (Daba, 2016).

Moringa seed cake is ready after the extraction of moringa oil from the seeds, and it is obtained from a cold-pressing method. Moringa cake is rich in protein content, about 60% and as a powder contains all the essential amino acids; phenylalanine, valine, threonine, tryptophan, isoleucine, methionine, leucine, and lysine. Additionally, cysteine (or sulphur-containing amino acids), tyrosine (or aromatic amino acids), histidine and arginine (Jahn, 1988). Moringa oleifera seed cakes have been shown to increase the mineral content of soil and increase the yield of maize crops compared to the control (Emmanuel et al., 2011).

Organic fertilisers derived from moringa oleifera seed processed with the proper procedure can increase the soil aeration and richness of indigenous invertebrates, specialised endangered soil species, beneficial arthropods, earthworms, symbionts and microbes (FAO, 2010). Stricevic et al. (2011) mentioned that the AquaCrop model could be used with a high degree of reliability in practical management, the simulations of biomass, yield, and water demand. Therefore, the purpose of this study was to test the performance of two organic fertilisers, moringa seed cake and compost, alone or mixed, on soil properties, nutrient uptake, yield and fruit quality, and water productivity Valencia orange.

2. Materials and Methods

2.1. Experimental conditions and plant material

The study was carried out through two successive sea-

sons, 2016/2017 and 2017/2018, on 12-year-old "Valencia" orange trees (*Citrus sinensis* L. Osbeck) budded on Volkamer lemon rootstock, planted at 3 x 4 m (350 trees fed $^{-1}$), grown in sandy soil under drip irrigation system at Experimental Research Station of National Research Centre at Nubaria, El Behera governorate Egypt. The chemical and mechanical properties of soil are presented in Table (1), and the water irrigation analysis is shown in Table (2). Trees were selected at random as uniform in their vigour growth as possible and received the same horticultural practices, except for the purpose of this study. The experiment followed a complete randomised block design on 24 trees as six treatments were applied. Each tree was considered a replicate; four replicates trees per each treatment.

2.2. Treatments

Six organic amendment treatments were used:

1. Moringa seed cake 100% (3 tons/fed)
2. 1 Moringa seed cake: 2 Compost
3. 1 Moringa seed cake: 1 Compost
4. 2 Moringa seed cake: 1 Compost
5. Compost 100% (3 tons/fed)
6. Control (3 tons/ fed farmyard manure)

Farmyard manure, compost and moringa seed cake were added in December during both seasons in trenches close to the root system under the tree canopy after being mixed with part of the surface soil and followed by irrigation. The physical and chemical properties of farmyard manure, compost and moringa seed cake are shown in Tables (3, 4 and 5). Moreover, 50% of recommended doses of synthetic fertilisers by the Ministry of Agriculture and Land Reclamation in Egypt for the sandy soils of nitrogen (60 kg N /fed/ year), phosphorus (30 kg P_2O_5 /fed/year) and potassium fertilisers (50 kg K_2O /fed/ year) were applied in different rates during both seasons.

Table 1. Analytical data of the studied soil of orchards farm (before studied treatments application)

Mechanical analysis (%)						
Sand	**Silt**	**Clay**	**Texture**			
84.2	11.8	4.0	Loamy sand			
Chemical soil characteristics						
pH	**EC dSm^{-1}**	**$CaCO_3$ %**	**O.M. %**			
7.79	1.6	2.0	3.54			
Available macronutrients (%)			**Available micronutrients (ppm)**			
N	P	K	Fe	Zn	Mn	
0.78	0.32	0.46	8.8	4.2	3.2	
Soluble cations (me/l of soil past extract)				**Soluble anions (me/l of soil past extract)**		
Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}+HCO_3^{-}	Cl^{-}	So_4^{--}
8.7	4.0	2.3	1.0	0.52	11.48	4.0
Hydro-physical analysis						
Bulk density g cm^{-3}	Total porosity %	Saturation %	Field capacity %	Wilting percentage %	Available water %	Hydraulic conductivity m day^{-1}
1.6	39.62	27	15.7	7.2	8.5	11.2

Table 2. Analysis of irrigation water.

Properties	**pH**	**EC dSm^{-1}**	**K^{+}**	**Na^{+}**	**Mg^{+2}**	**Ca^{+}**	**$SO4^{-2}$**	**HCO^{-3}**	**$CO3^{-2}$**	**Cl^{-}**
Value	7.88	0.54	0.45	0.3	2.25	2.3	0.41	1.7	-	3.2

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Table 3. Physical and chemical properties of the farmyard manure

Properties	**Values**
Moisture content (%)	29.5
pH (1:10)	6
EC (1:20) dS/m	1.4
Organic matter (%)	25.5
Macro element (%)	
Total Nitrogen	0.85
Phosphorus	0.14
Potassium	0.22
Magnesium	0.25
Micro element (ppm)	

Table 4. Physical and chemical properties of the compost

Properties	**Values**
Moisture content (%)	25-30
pH(1-10)	7.5
EC (1-10) (dS/m)	1.5
Organic matter (%)	57
Organic carbon (%)	50
C/N ratio	18:01
Macro element (%)	
Total nitrogen	1.4
Phosphorus	2.82
Potassium	0.3
Magnesium	0.47
Micro element (ppm)	
Zinc	378.8
Iron	26
Manganese	30

Table 5. Physical and chemical properties of moringa seed cake

Properties	**Values**
Moisture content (%)	4.9
pH	4.8
EC (dS/m)	3.20
Organic matter (%)	79.8
Carbohydrate (%)	16
Protein (%)	24
C/N ratio	12.14
Macro element (%)	
Total Nitrogen	3.8
Phosphorus	0.61
Potassium	0.7
Magnesium	0.31
Micro element (ppm)	
Zinc	18.8
Iron	12.5
Manganese	40

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2.3. Measurements

2.3.1. Leaf mineral contents

Twenty leaves were taken in late August from ten shoots of the current spring growth cycle randomly distributed around the tree/ replicate. Samples were dried at 70°C till constant weight and finely ground and digested in a mixture of perchloric: sulphuric acid (1:3 v/v) for determination of the following nutrient elements: total nitrogen (%) using the modified micro – Kjeldahl method as outlined by Cottenie et al. (1982), phosphorus (%) was estimated as described by Chapman and Pratt (1961), potassium was measured photometrically using flame photometer outlined by Cottenie et al. (1982). Iron, zinc, and manganese as ppm were spectrophotometrically determined using atomic absorption spectrophotometer (PerkinEl-mer 100 B).

2.3.2. Total carbohydrates content

Total carbohydrates content in leaves powder was determined as a percentage according to Dubois et al. (1956).

2.3.3. Yield (kg/tree)

At harvest time, the yield was calculated as kg/tree by multiplication number of fruits/tree x average fruit weight.

2.3.4. Fruit quality

At harvest, ten fruits from each replicate were randomly selected to determine fruit quality as follows:

- Percentage of juice: Fresh fruits were ground in an electric juice extractor for freshly prepared juice, then juice weight and percentage of juice was evaluated.
- Percentage of total solids solid (TSS %): It was expressed using Digital refractometer PR32 (0.32% Atago Palete ATago. CO. LTD. Japan).
- Percentage of total acidity content (TA %): It was determined by titrating 10 ml juice from each sample using NaOH (0.1N) phenolphthalein (ph. th) as an indicator. The acidity was expressed as g of citric acid/100ml juice according to (AOAC, 2000) and then calculated TSS/ TA ratio.
- Ascorbic acid (vitamin C): It was determined by using 2.6 dichlorophenolindophenoldye and 2% oxalic. Vitamin C content was calculated as mg /100 ml juice (AOAC, 2000).

2.3.5. Determination of studied soil hydrophysical properties

- Soil bulk density and total porosity were determined according to Dewis and Freitas (1970).
- Soil water retention values were carried out using the pressure membrane apparatus (Loveday, 1974). The moisture content of the soil was determined gravimetrically.
- Soil water transmission properties: Saturated hydraulic conductivity was determined under constant parameter head (m day^{-1}) as described by Singh (1980).

$$K= HAT/QL$$

- Where; K: hydraulic conductivity coefficient, Q: volume of water being passed through the soil column at time (T), L: length of soil column, H: hydraulic head, A: cross-section area. Mean diameter of soil pores (μm): Mean diameter of soil pores was calculated using the equation described by Dielman and De Ridder (1972) as follows:

$$d = (6.177637\sqrt{K} \qquad \text{(for water at 20°C)}$$

Where d: soil mean pore diameter in microns, K: hydraulic conductivity in m day^{-1}.

2.3.6. Irrigation water requirements

The investigation was conducted out under the drip irrigation system as 4 emitters per tree, emitter charge is 4 litre/hour, reference evapotranspiration (ETo) was calculated using meteorological data at El-Behira in Egypt according to Penman-Monteith equation (Allen et al., 1998) for both seasons 2016/2017and 2017/2018.

The irrigation water applied 3200 m^3/ fed was calculated according to the following equation (Doorenbos, 1992):

$$IW= ((ET_o*K_C*K_r*I)/Ea* (1-LR)) *4.2$$

Where; IW is Irrigation water requirement m^3 / fed, ET_o is Reference evapotranspiration, K_c is Crop coef-

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ficient with No weed control= 0.85, K_r is Reduction factor= 0.75, I = Irrigation interval, Ea is Irrigation efficiency = 90%, LR is Leaching requirement = 10% of the total water amount.

2.3.7. Water productivity

Water productivity was calculated by Aquacrop model version 6, FAO paper 66 (Steduto et al., 2012) as follows:

$$WP= (B/\sum(Tr/ET^o)) (CO_2)$$

Where, B is the biomass produced cumulatively (kg per m^2) for most crops, Tr is the crop transpiration (either mm or m^3 / unit surface), with the summation over the period in which the biomass is produced, and WP is the water productivity parameter kg of biomass per m^3 of water transpired. The WP parameter is based on the atmospheric evaporative demand and the atmospheric CO_2 concentration to simulate future climate scenarios. Conservative and non-conservative crop parameters for orange obtained from various sources are shown in (Table 6).

2. 4. Statistical Analysis

Treatments were arranged as experiments in a complete randomised block design. The obtained data of both seasons were subjected to analysis of variance (one way ANOVA test) using CoStat - Statistics Software Computer program. Least significant difference (LSD) was used to compare between means of treatments according to Duncan (1955) at a probability of 5 %.

Table 6. Conservative and non-conservative crop parameters for orange obtained from various sources

Non-conservative parameters	**Orange**
Base temperature (°C) below which crop development does not progress	8.0
Upper temperature (°C) above which crop development no longer increases with an increase in temperature	40.0
Number of trees per hectare	600.0
Maximum effective rooting depth (m)	2.0
Harvest Index (HIo) (%)	90.0
Conservative parameters	
Water Productivity normalized for ETo and CO_2 (WP*) (gram/m^2)	17.0
Water Productivity normalized for ETo and CO_2 during yield formation (as % WP*)	100.0
Minimum air temperature below which pollination starts to fail (cold stress) (°C)	8.0
Maximum air temperature above which pollination starts to fail (heat stress) (°C)	40.0
Excess of potential fruits (%)	60.0
Canopy growth coefficient (CGC): Increase in canopy cover (fraction soil cover per day)	0.104
Maximum canopy cover (CCx) in fraction soil cover	0.900
Canopy decline coefficient (CDC): Decrease in canopy cover (in fraction per day)	0.080
Crop coefficient when canopy is complete but prior to senescence (Kcb,x)	0.150
Maximum root water extraction (m^3water/m^3soil.day) in top quarter of root zone	0.024
Maximum root water extraction (m^3water/m^3soil.day) in bottom quarter of root zone	0.006
Effect of canopy cover in reducing soil evaporation in late season stage	60.0
Soil water depletion factor for canopy expansion (p-exp) - Upper threshold	0.50
Shape factor for water stress coefficient for canopy expansion (0.0 = straight line)	3.0

Source: AquaCrop model as described by ((Raes et al., 2009; Steduto et al., 2009).

3. Results

Macro-element leaf contents

Results in Table (7), revealed that the application of fertilisation with moringa seed cake and compost improved N, P, K and Mg leaf contents of Valencia orange trees compared to control.

Nitrogen leaf content: Adding moringa seed cake in combination with compost at 2:1 reflected the highest nitrogen leaf content (2.80 & 2.83 %) compared with other treatments in both seasons, respectively. Also, use moringa seed cake + compost at 1: 1 was not significantly different from using moringa seed cake alone in the first season. In the second season, there were no significant differences between applying moringa seed cake and compost at 1: 2 or 1: 1 of them whereas, control gave the lowest value of nitrogen leaf content (2.21 & 2.55 %) during both seasons under the study.

Phosphorus leaf content: In the first season, moringa seed cake in combination with compost at 2:1 recorded the highest phosphorus leaf content followed by combination with moringa seed cake and compost at 1: 1 followed by combination with moringa seed cake and compost at 1: 2. Where applying either moringa seed cake alone or compost alone were non-significant differences. In the second season, also moringa seed cake in combination with compost at 2:1 recorded the highest phosphorus leaf content followed by compost alone then moringa seed cake + compost at 1: 1. Meanwhile, there was no significant difference between applying moringa seed cake + compost at 1: 2 or moringa seed cake alone or control.

Potassium leaf content: In the first season, moringa seed cake + compost at 2:1 and compost alone gave the maximum values (1.58 %) of potassium leaf content with the same statistical level, meanwhile there were no significant differences between using moringa seed cake alone and control. In the second season, moringa seed cake + compost at 2:1 resulted in maximum values (1.88 %) of potassium leaf content. Whereas, application with moringa seed cake + compost at 1: 1 gave the minimum values (1.25 & 1.66 %) of potassium leaf content during the two seasons, respectively.

Magnesium leaf content: In the first season, application with moringa seed cake + compost at 2: 1 gave the highest value (0.49 %) of magnesium leaf content. In the second season, moringa seed cake alone or moringa seed cake + compost at 2:1 or 1: 2 resulted in no significant differences between them. There were also no significant effects among compost alone and moringa seed cake + compost at 1:1. The control gave the lowest value of magnesium leaf content during both seasons under the study.

Table 7. Effect of organic fertilization with moringa seed cake and compost on leaves macro-element contents of Valencia orange trees.

Treatment	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Magnesium (%)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
100% MC	2.76b	2.78b	0.12d	0.12d	1.48ab	1.77c	0.44d	0.48a
1 MC: 2 COM	2.75c	2.77c	0.13c	0.12d	1.38bc	1.81b	0.45c	0.48a
1 MC : 1 COM	2.76b	2.77c	0.14b	0.13c	1.25c	1.66f	0.46b	0.47b
2 MC :1 COM	2.80a	2.83a	0.17a	0.18a	1.58a	1.88a	0.49a	0.48a
100% COM	2.21d	2.62d	0.12d	0.17b	1.58a	1.72d	0.43e	0.47b
Control	2.21d	2.55e	0.11e	0.12d	1.45ab	1.68e	0.42f	0.45c

Where: COM (Compost) and MC (Moringa seed cake). The same letter within each row indicates no significant differences according to LSD test (P= 0.05).

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Micro-element leaf contents

Results in Table (8), showed that compost or moringa seed cake application each alone or together significantly increased leaf micro-element contents than control. The highest values were recorded by using moringa seed cake in combination with compost at 2:1. Meanwhile, the lowest values were recorded by control in the first and second seasons.

Percentage of total carbohydrates

Table (8) shows that in the first season, using moringa seed cake in combination with compost at 2:1 recorded the highest percentage of total carbohydrates in leaves (47.57 %) followed by application of moringa seed cake in combination with compost at 1:1 then 1:2, However, no significant differences were found in the application of moringa seed cake alone and compost alone. The observation in the second season reveals that applying moringa seed cake + compost at 1:2 gave the highest value of for percentage of total carbohydrates (48.26 %) followed by treatments moringa seed cake in combination with compost at 1:1, moringa seed cake in combination with compost at 2:1, moringa seed cake alone and compost alone without significance. On the other hand, the lowest percentage of total carbohydrates value (40.19 & 40.41 %) was recorded by control in both seasons, respectively.

Yield

Results in photos (1& 2), Table (9) show that applying moringa seed cake in combination with compost had a significant effect on tree yield and total yield per fed (Fig.1) compared with the control. In this respect, application of moringa seed cake in combination with compost at 2:1 gave the highest significant value in both studied seasons (98.33 & 98.67 kg/tree) followed by application of moringa seed cake + compost at 1:1 (88 & 91.67 kg/tree), while no significant differences were recorded by application of moringa seed cake + compost at 1:2 or moringa seed cake alone or compost alone in the first season and among seed cake alone or compost alone in the second seasons. Meanwhile, the lowest significant value (76.67 & 77.67 kg/tree) was recorded by control in both seasons, respectively.

Table 8. Effect of organic fertilization with moringa seed cake and compost on leaves micro-element contents and total carbohydrates of Valencia orange trees

Treatment	Iron (ppm)		Zinc (ppm)		Manganese (ppm)		Total carbohydrates (%)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
100% MC	70d	78d	71e	45.39d	45.39d	66b	45.39d	45.39d
1 MC: 2 COM	67e	80c	85c	46.67c	46.67c	58d	46.67c	46.67c
1 MC : 1 COM	73c	85b	92b	47.25b	47.25b	65c	47.25b	47.25b
2 MC :1 COM	77a	88a	100a	47.57a	47.57a	72a	47.57a	47.57a
100% COM	75b	77d	80d	45.37e	45.37e	56e	45.37e	45.37e
Control	70d	75e	25f	40.19f	40.19f	53f	40.19f	40.19f

Where: COM (Compost) and MC (Moringa seed cake). The same letter within each row indicates no significant differences according to LSD test (P= 0.05).

Figure 1. Photos of Valencia orange trees in December 2016 before using moringa seed cake and compost.

Figure 2. Photos of Valencia orange trees in March 2018 showing the productivity after using moringa seed cake and compost.

Fruit quality

As for fruit weight, presented in Table (9), treatment with moringa seed cake + compost at 2:1 gave the heaviest fruits (311 & 370 g) in both seasons, respectively while the lightest fruit weight was recorded by the control (276 & 280 g) in the first and second seasons, respectively.

Regarding the percentage of juice, the obtained results show that use of moringa seed cake in combination with compost at 2:1 recorded the highest significant value compared with other treatments (75.57 & 76.86 %) in both seasons, respectively followed by application of moringa seed cake + compost at 1:1 (71.46%) in the first season and moringa seed cake alone (74.36%) in the second season. Meanwhile, control

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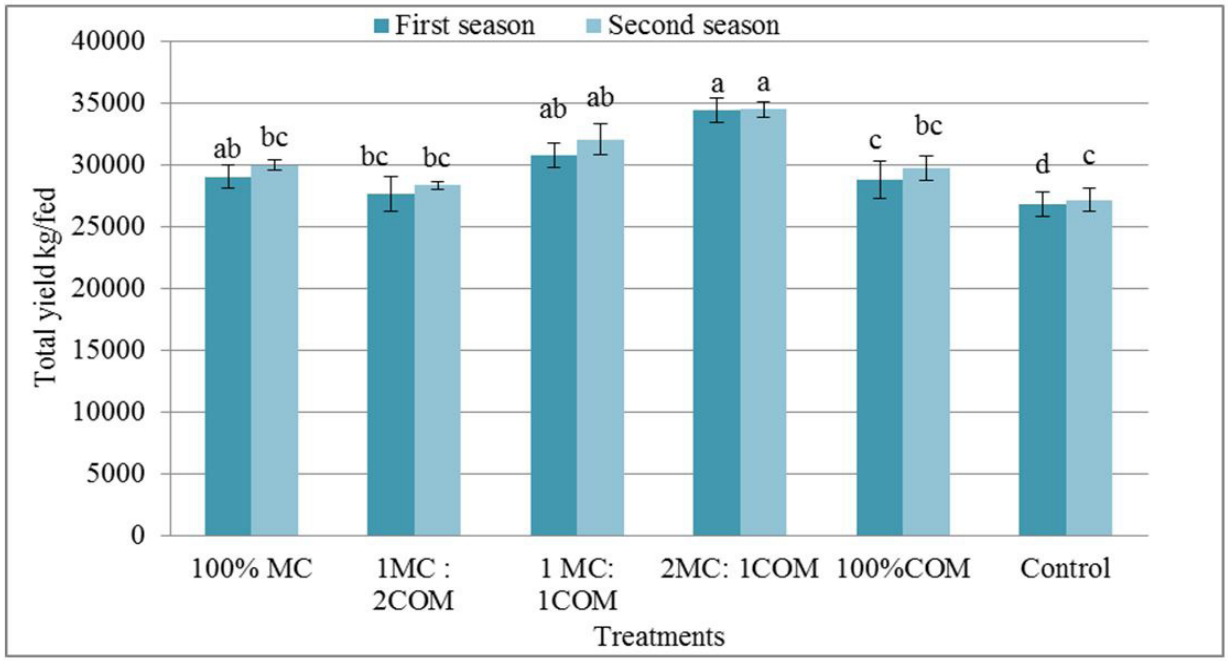

Fig. 3. Effect of organic fertilisation with moringa seed cake and compost on total yield/fed of Valencia orange with standard errors. Where: COM (Compost) and MC (Moringa seed cake). Different letters in a figure show significant differences according to LSD test (P= 0.05).

recorded the lowest values (50.31& 51.45%) in both seasons, respectively.

Ascorbic acid (vitamin C) content (also shown in Table 9) was highest in the application of moringa seed cake in combination with compost at 2:1 (34.55 & 34.46 mg/100 ml) followed by application of moringa seed cake in combination with compost at 1:1 (33.89 & 33.58 mg/100 ml) in the two seasons of the study, respectively. The lowest vitamin C value was recorded by control (29.19 & 30.44 mg/100 ml) in the first and second seasons, respectively.

Regarding total soluble solids in juice (TSS), in the first season treatment with compost alone gave the highest TSS value (12.7 %) (Table 10), while in the second season application of moringa seed cake in combination with compost at 1:2 gave the highest value followed by moringa seed cake in combination with compost at 2:1 (13.33 & 13.17 %), respectively and without significance. The lowest value of TSS was recorded by control treatments (11.13 & 12 %) in the first and second seasons, respectively. Total acidity percentage (TA) was lowest in treatments with moringa seed cake + compost at 2:1 (1.04 %) and in moringa seed cake + compost at 2:1 and 1:2 without significance (1.01%) in both studied seasons, while the highest acidity content was obtained with control (1.07%) in the first and second seasons. Concerning TSS/TA ratio (Table 10) the highest ratio was recorded by treatment with moringa seed cake + compost at 2:1 in the first season and by treatment with moringa seed cake + compost at 1:2 followed by 2:1 without significance in the second season. The lowest TSS/ TA ratio was recorded by control treatment in the first and second seasons.

Soil hydrophysical properties

Incorporating moringa seed cake with compost improved the hydrophysical properties of sand soil, soil water transmission and soil water retention in the studied area during both seasons. Applying moringa seed cake in combination with compost at 2:1 achieved the lowest value of soil bulk density, highest values of total porosity and void ratio (Table 11 and Fig. 4). The decrease percentages of soil bulk density was (22.66 and 23.33%), the increase percentages of total porosity were (29.02 and 30.65 %), and void ratio were (66.23 and 72%) over the soil not treated with moringa seed cake or compost during the first and the second seasons respectively. However, the control gave the highest value of bulk density and the lowest

values of total porosity and void ratio during both seasons under the study.

Soil water retention

As a result of enhancing the hydrophysical soil characteristics, the increments in soil available water, field capacity and saturation per cent, as shown in Fig. (5) and Table (12), were detected by adding each of moringa seed cake and compost either alone or mixing them compared to the control. Moringa seed cake riches with compost at ratio 2:1 achieved the highest values of soil available water, field capacity and saturation per cent. The increase percentages were (66.28 and 70.45%), (66.2 and 70.44%) and (66.25 and 70.43 %) in soil available water, field capacity and saturation per cent over the soil that received neither of moringa in where the lowest values were recorded during both of the seasons, respectively.

Table 9. Effect of organic fertilization with moringa seed cake and compost on yield and fruit weight, juice% and Ascorbic acid of Valencia orange

Treatment	Yield (kg/tree)		Fruit weight (g)		Juice (%)		Ascorbic acid (mg/100 ml)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
100% MC	83.00bc	85.67bc	281d	312c	65.42d	74.36b	31.43c	31.11e
1 MC: 2 COM	79.00bc	81.00cd	288c	355b	66.39c	68.80c	32.57b	32.91c
1 MC : 1 COM	88.00ab	91.67ab	300b	282e	71.46b	60.14d	33.89b	33.58b
2 MC :1 COM	98.33a	98.67a	311a	370a	75.57a	76.86a	34.55a	34.46a
100% COM	82.33bc	85.00bc	280d	295d	57.64e	58.39e	30.75d	32.16d
Control	76.67c	77.67d	276e	280f	50.31f	51.45f	29.19e	30.44f

Where: COM (Compost) and MC (Moringa seed cake). The same letter within each row indicates no significant differences according to LSD test (P= 0.05).

Table 10. Effect of organic fertilization with moringa seed cake and compost on TSS %, TA% and TSS /TA ratio of Valencia orange

Treatment	TSS (%)		TA (%)		TSS /TA ratio	
	1st	2nd	1st	2nd	1st	2nd
100% MC	12.47d	13.03ab	1.06b	1.03c	11.76bc	12.65ab
1 MC: 2 COM	12.57b	13.33a	1.06b	1.01e	11.86c	13.20a
1 MC : 1 COM	11.93e	12.80ab	1.05c	1.05b	11.36bc	12.19b
2 MC :1 COM	12.50c	13.17a	1.04d	1.01a	12.02a	13.04a
100% COM	17.70a	12.40bc	1.06b	1.02d	11.98ab	12.16b
Control	11.13f	12.00c	1.07a	1.07a	10.40d	11.21c

Where: COM (Compost) and MC (Moringa seed cake).The same letter within each row indicates no significant differences according to LSD test (P= 0.05).

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Table 11. Effect of organic fertilization with moringa seed cake and compost on soil hydrophsical properties

Treatment	Bulk density (g/ cm³)		Total porosity (%)		Void ratio	
	1st	2nd	1st	2nd	1st	2nd
100% MC	1.21cd	1.22cd	54.46ab	53.95bc	1.20ab	1.17c
1MC: 2COM	1.24bc	1.24c	53.04bc	53.09c	1.13bc	1.13c
1 MC: 1COM	1.20cd	1.19d	54.55ab	55.04b	1.20ab	1.22b
2MC: 1COM	1.16d	1.15e	56.11a	56.52a	1.28a	1.3a
100% COM	1.30b	1.3b	50.77c	50.93d	1.03c	1.04d
Control	1.50a	1.5a	43.49d	43.26e	1.20ab	1.17c

Where: COM (Compost) and MC (Moringa seed cake). The same letter within each row indicates no significant differences according to LSD test (P= 0.05).

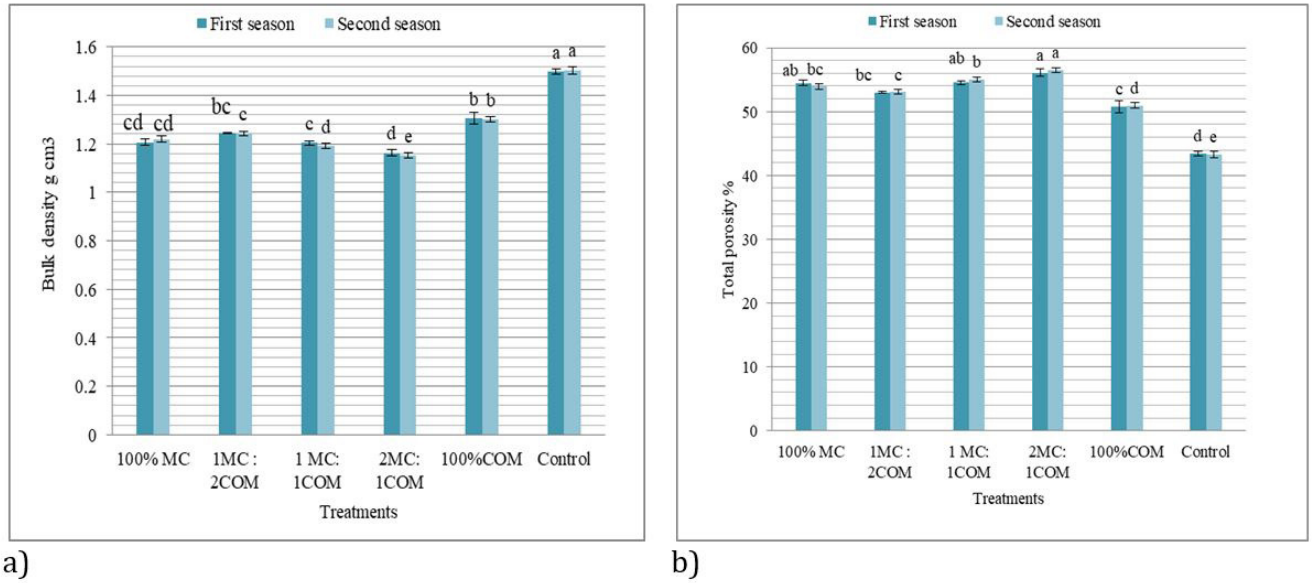

Figure. 4. (a & b) Effect of organic fertilization with moringa seed cake and compost on soil bulk density and total porosity % with standard errors. Where: COM (Compost) and MC (Moringa seed cake). Different letters in a figure show significant differences according to LSD test (P= 0.05).

Soil water transmission properties

Results in Fig. (6) reveal that compost or moringa seed cake application either alone or together significantly decreased hydraulic conductivity than the control; the decline percentages in hydraulic conductivity were (52.48 and 71.88%) over the control during the first and second seasons, in the sequence. The lowest values were recorded by using moringa seed cake in combination with compost at 1:1 followed by the combination at 2:1. Meanwhile, the highest values were recorded by control in the first and second seasons. Also, the mean diameter of soil pore decreased more than control at the rate of (31.5 and 47.02%) in the two seasons, respectively (Table 12).

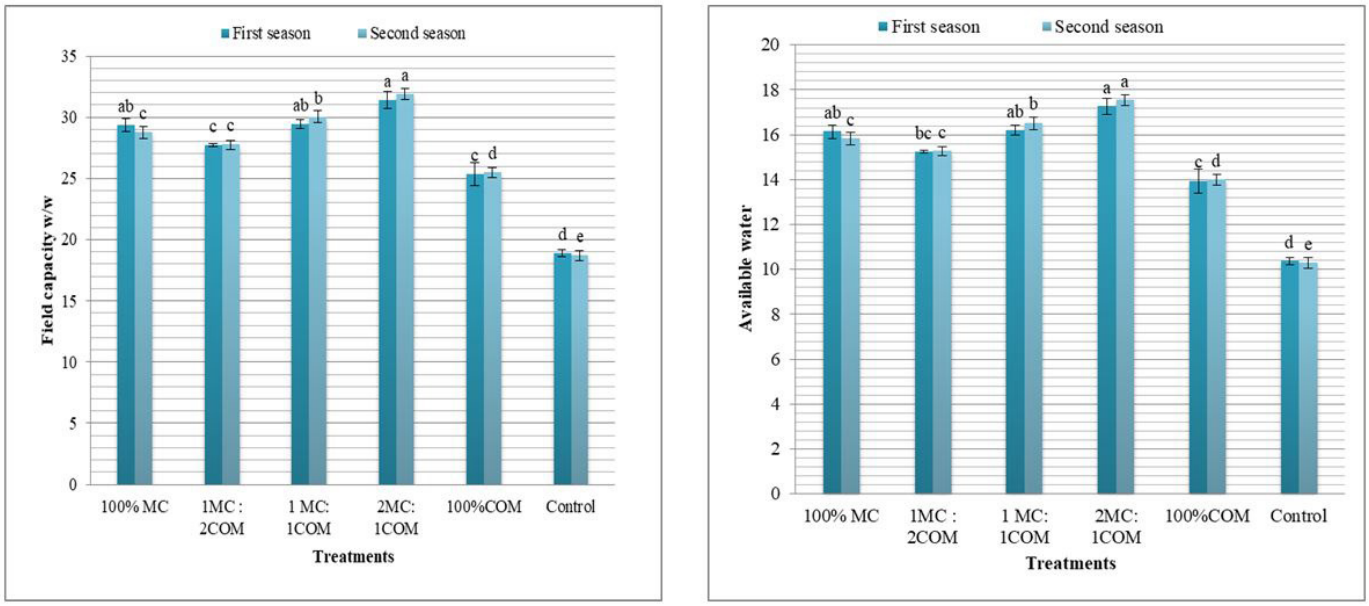

Figure. 5. (a & b) Effect of organic fertilization with moringa seed cake and compost on field capacity and available water of studied soil with standard errors Where: COM (Compost) and MC (Moringa seed cake). Different letters in a figure show significant differences according to LSD test (P= 0.05).

Table 12. Effect of organic fertilization with moringa seed cake and compost on soil water retention

Treatment	Soil available water		Field capacity (w/w)		Saturation (%)		Mean diameter of pore (µm)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
100% MC	16.14ab	15.81c	29.34ab	28.75c	45.14ab	44.23c	18.43b	15.13c
1MC: 2COM	15.24bc	15.27c	27.71c	27.76c	42.63bc	42.71c	17.34c	15.92b
1 MC: 1COM	16.19ab	16.52b	29.44ab	30.03b	45.29ab	46.2b	13.27d	9.68e
2MC: 1COM	17.26a	17.54a	31.38a	31.89a	48.28a	49.05a	15.08a	14.31d
100% COM	13.93c	14.01d	25.33c	25.47d	38.98c	39.18d	18.04b	15.19c
Control	10.38d	10.29e	18.88d	18.71e	29.04d	44.23c	19.38a	15.13c

Where: COM (Compost) and MC (Moringa seed cake). The same letter within each row indicates no significant differences according to LSD test (P= 0.05).

Water productivity

Water productivity was calculated by Aquacrop program sourced by FAO Paper 66. Results in Table (13) and Fig. (7) display that moringa seed cake and compost either alone or mixed increased the measured Valencia orange water productivity. Incorporating moringa seed cake with compost at 2:1 is superior to other treatments, where the measured water productivity values attained (10.75 and 10.79 Kg/m^3) during the first and the second seasons, respectively and the simulated water productivity achieved (11.26 and 11.30 Kg/m^3), in the same sequence. Meanwhile, the lowest significant values of measured water productivity and simulated water productivity (8.38 & 8.49 and 8.78 & 8.89 Kg/m^3) were recorded by control in both seasons, respectively.

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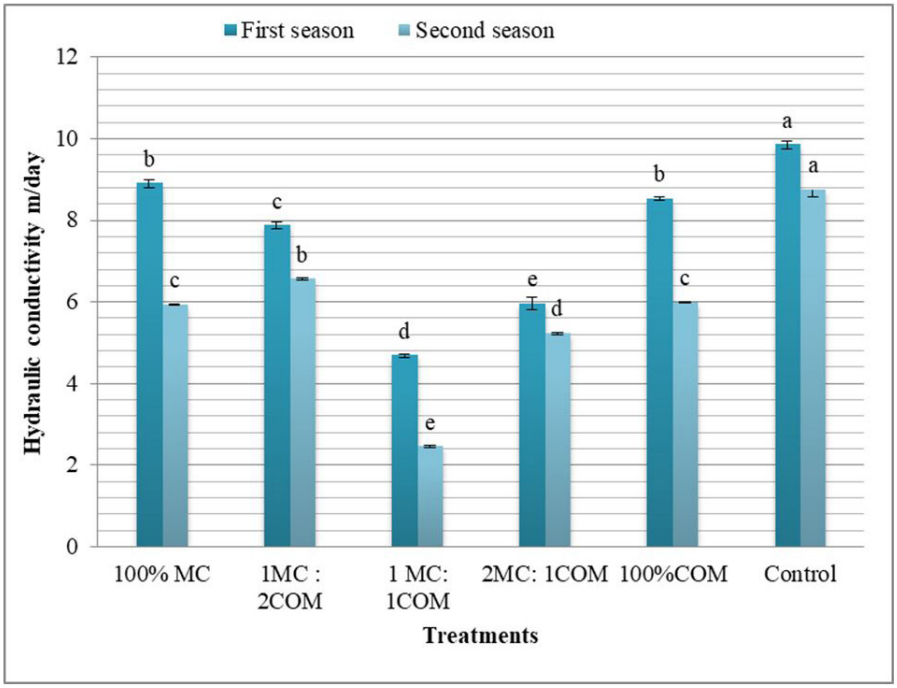

Figure.6. Effect of organic fertilisation with moringa seed cake and compost on hydraulic conductivity of studied soil with standard errors. Where: COM (Compost) and MC (Moringa seed cake). Different letters in a figure show significant differences according to LSD test (P= 0.05).

Table13. Effect of organic fertilization with moringa seed cake and compost on water productivity of Valencia orange

Treatment	Water requirement (m^3/fed)	Yield (kg/fed)		Measured water productivity (Kg/m^3)		Simulated water productivity (Kg/m^3)	
		1st	2nd	1st	2nd	1st	2nd
100% MC	3200	29050ab	29983.33bc	9.08ab	9.37bc	9.51ab	9.81bc
1MC: 2COM	3200	27650b	28350bc	8.64b	8.86bc	9.05b	9.28bc
1 MC: 1 COM	3200	30800ab	32083.33ab	9.62ab	10.03ab	10.08ab	10.50ab
2MC: 1 COM	3200	34416.67a	34533.33a	10.75a	10.79a	11.26a	11.30a
100% COM	3200	28816.67ab	29750bc	9.01ab	9.29bc	9.43ab	9.74bc
Control	3200	26833.33b	27183.33c	8.38b	8.49c	8.78b	8.89c

Where: COM (Compost) and MC (Moringa seed cake). The same letter within each row indicates no significant differences according to LSD test (P= 0.05).

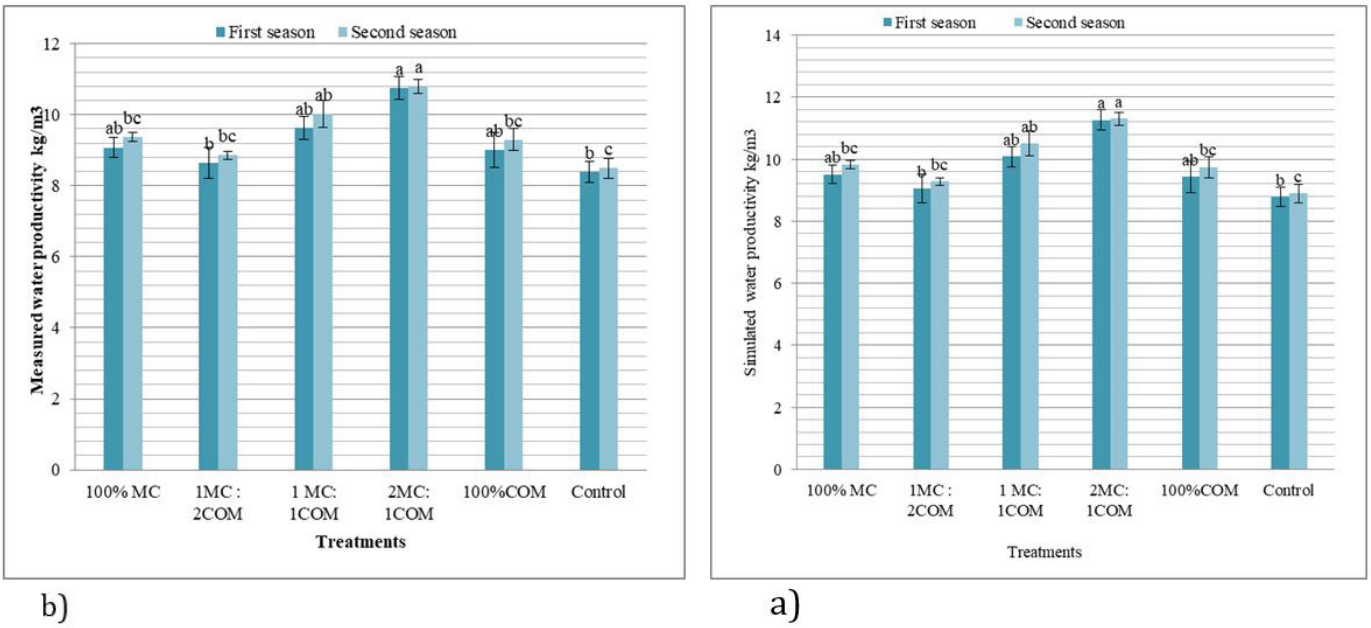

Figure 7. (a & b) Effect of organic fertilisation with moringa seed cake and compost on measured and simulated water productivity of Valencia orange with standard errors. Where: COM (Compost) and MC (Moringa seed cake). Different letters in a figure show significant differences according to LSD test (P= 0.05).

4. Discussion

Due to the scarcity of alternative organic amendments in developing countries, crop residue can achieve positive effects on soil quality, soil organic matter, and soil moisture retention, enhanced nutrient cycling, and decreased soil loss, among other environmental and soil health benefits (Turmel et al., 2015). Cautious organic amendments use for sustainable agriculture is essential to enhance soil properties and simultaneously reduce harmful environmental impacts (Masunga et al., 2016).

Compost is a readily available amendment with beneficial effects on the physical, chemical, biochemical and biological properties of the soils. Moreover, compost-based treatments can exert protective effects against plant diseases occurrence and/or stimulate an enhanced plant physiological status with improvements in quantity and quality of crop productions. It increases not only organic matter in the soil, but also the available phosphorus and the exchangeable potassium, calcium, and the other micro-elements, and affects soil pH, encourages the proliferation of soil microorganisms, increases microbial population and activity of microbial enzymes (Liguori et al., 2015).

Moringa oleifera flowers, immature pods, seeds and leaves are rich sources of vitamins, minerals, proteins and other important phytochemicals. The leaves and seeds contain proteins and essential amino acids, which are important for human nutrition. Seeds provide protein electrolytes that can be used in water purification (James and Zikankuba, 2017).

Therefore, this investigation was carried out on sandy soil under a drip irrigation system to evaluate using moringa oleifera seed cake and compost as organic soil amendments for sustainable agriculture in Valencia orange orchard. Moringa oleifera seed cake has a low value of C/N ratio, and it was not applied during the composting process but mixed after compost maturity. Using organic residues with a low value of C/N ratio for obtaining compost can lead to nitrogen loss to the atmosphere through the volatilisation of ammonia during the recycling process (Azim et al., 2018).

Testezlaf et al. (2007) found that the root system distribution of Valencia orange trees by dry weight of the roots had diameters equal to or less than 1.5 mm. The soil layer from (0.0–0.4 m) showed a larger percentage of root, with a reduction of root concentration from the end of the tree canopy to between

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rows for all evaluated trees. Also, the soil layer from (0.0-0.3 m) showed a larger percentage of roots and until 2 m horizontal distance from the trunk (Júnior et al., 2012). There are studies confirming that most root water depletion takes place at 0.6 m soil depth (Obreza and Boman, 2002; Hemdan, 2003). So, soil amendment treatments were incorporated in the 0.0-0.4 m soil layer * 1 m horizontal distance from the trunk of the Valencia orange tree.

Soil properties

The results as compared to the control in Table (11) indicate an increase in the hydrophysical properties of the soil which in turn improved the Valencia orange yield. In detail, incorporating moringa seed cake with compost improved the hydrophysical properties of sand soil, soil water transmission and soil water retention in the studied area, this observation is in agreement with the findings of Hemdan (2014) and Jain and Kalamdhad (2020). This may be due to the use of moringa seed cake compared with compost and farmyard manure amendments as shown in Tables (3, 4 and 5) which led to the increase in organic matter and organic nitrogen and the decrease in organic carbon thus decrease in soil bulk density.

Bauer and Black (1981) confirmed that soil bulk density adversely relies on soil organic matter content and significantly impacts water penetration or root growth. The smallest soil bulk density values and the greatest total soil porosity were observed in the soil treated with moringa seed cake in combination with compost at 2:1 ratio. Incorporating agriculture residues in the soil as sustainable practice has improved soil properties (e.g. bulk density, porosity, and saturated hydraulic conductivity) and attains zero waste in agriculture production and thus better soils management (Almendro-Candel et al., 2018).

With respect to soil water retention, the increments in soil available water, field capacity and saturation per cent detected improved when adding each moringa seed cake and compost either alone or mixed compared to the control. This finding agrees with Santibáñez and Varnero (2014). Soil moisture content is the most effective factor of root zone on plant roots growth (Obreza and Boman, 2002; Júnior et al., 2012). Compost encourages the microbial activity of microbial enzymes in the soil (Liguori et al., 2015), thus increases soil water retention by enriching moringa seed cake with compost.

These results are in agreement with Pandey and Shukla (2006); Carter (2007); Hemdan (2014); Jain and Kalamdhad (2020) who showed that compost increased soil water retention (field capacity and soil available water) in sandy soil nevertheless declined the hydraulic conductivity of sandy soil and mean diameter of soil pores. Accordingly mixing compost with moringa seed cake enriched the organic matter and led to improving soil water retention and transmission.

Water productivity

Applying moringa seed cake and compost either alone or mixing both of them increased measured Valencia orange water productivity. This may have been associated with soil water retention (field capacity and available water) improvement as abovementioned by adding soil organic amendments (compost and moringa seed cake). Similar patterns were observed by (Cogger, 2005; Carter, 2007; Calzolari et al., 2009; Mylavarapu and Zinati, 2009; Hemdan, 2014; Mansour et al., 2019; Jain and Kalamdhad, 2020). These results are in agreement with (Stricevic et al., 2011; Mansour et al., 2019; Mansour et al., 2020). Steduto et al. (2012) reported that the Aquacrop simulation model is dependent on many influences such as climate, soil, irrigation water, etc., stimulates vegetative growth, biomass, yield and water productivity. Calibration results showed closed matching between values measured and those simulated by the Aquacrop model.

Application of the combinations of moringa seed cake with other organic soil amendments on varied crop types in the moringa plant ecosystem could be suggested. This may lead to attaining safe soil management for best crop yield and water productivity.

Some nutrient contents of Valencia Orange leaves

Nitrogen, phosphorus, potassium, magnesium leaf contents were observed as higher as compared to control for single compost application. Other researchers observed similar patterns (Farahzety et al., 2013; Hemdan, 2014; Sharma et al., 2017), single moringa seed cake application (Emmanuel et al., 2011; Sinha et

al., 2011; Lee et al., 2018) or together at different ratios. The combination of moringa seed cake with compost at a ratio of 2:1 showed the highest nitrogen, phosphorus, potassium, magnesium leaf contents during both seasons as compared to other combination treatments where moringa seed cake was added alone or along with other ratios. This study agrees with the findings of (Emmanuel et al., 2011) on the application of moringa seed cake conducted on maize farms. This may be due to the application of moringa seed cake with compost and the improved soil chemical and hydrophysical properties because the cake organic matter contains high macro and micronutrients. (Emmanuel et al., 2011; Baiano and Morra, 2017; James and Zikankuba, 2017; Jain and Kalamdhad, 2020) showed the significant increments in porosity suppressed the leaching of the nutrients, observed the higher amount of total nitrogen and available phosphorus concentration in the soil.

According to Hartz et al. (2000), the nitrogen mineralisation rate of manures and composts was relatively low. N recovery averaged 11%, 6%, and 2% of total amendment N for manure, manure compost, and plant residue compost, respectively. The rate of mineralisation of amendment C had almost reduced to the soil organic C level in 4 and 16 weeks for compost and manure in the same sequence. Also, Azeez and Van Averbeke, (2010) showed that increasing the N rates of manures will improve their potential as plant nutrient sources. Complementing the manures with N fertilisers will increase its quality and influence and achieve integrated nutrient management.

On the other hand, Moringa seeds cake quickly dissolves in the same applied period (Emmanuel and Emmanuel, 2011). The low C/N ratio of moringa seed cake indicates that this would be an effective source of nutrients through rapid mineralisation reactions. It contains a high protein content of up to 68.6 % (Martín et al., 2010), and mixing with compost enhances the essential microbial activity for its decomposition, which positively affects the cultivated crop.

Incorporation of varied organic amendment combinations in the soil positively influenced soil physicochemical properties; hydrolases of C and N, microbial biomass carbon, mineralisation of the important organic elements have been promoted by soil enzymatic and biological activity. So, soil fertility and plant nutrient uptake have been improved (Frankenberger and Dick, 1983; Tejada et al., 2008; Elnasikh et al., 2011; Emmanuel et al., 2011; Sinha et al., 2011; Yuan et al., 2020).

Compost or moringa seed cake application either alone or together significantly increased leaf micro-element contents than the control. The highest values were recorded by using moringa seed cake in combination with compost at 2:1, as the moringa seed cake has supported the microbial activity of soil and hence enhanced the soil properties and simultaneously increased the macro and micronutrients availability in the soil to be consumed by the plant (Emmanuel et al., 2011).

Total yield and fruit quality

All applied treatments, either sole compost or moringa seed cake applications or mixed, significantly affected the yield of Valencia orange trees compared with the control; similar patterns were detected by others (Emmanuel and Emmanuel, 2011; Sinha et al., 2011; Iren et al., 2015; Lee et al., 2018). One important finding implied in this study is that despite a lower application percentage of compost (33.3%) in combination with a higher percentage of moringa seed cake (66.6 %), it showed the highest increment of total yield per feddan (Fig.1). Moringa is a good source of essential minerals and sulphur-containing amino acids. Ngigi and Muraguri (2019) analysed moringa oleifera seeds by inductively coupled plasma optical emission spectroscopy and observed the highest amounts of K and Mg with values of 15,930.5 and 2229.3 mg kg^{-1}, respectively. Elnasikh et al. (2011), Mohammed et al. (2014), and Lee et al. (2018) detected that applying neem seed cake as soil amendment significantly increased electrical conductivity, acidifying capacity, exchangeable calcium, iron, zinc, manganese and copper availability. In addition, soil microbial biomass and soil enzymatic activities and plant nutrient uptake have been enhanced by the combination of soil amendments, and this was consequently reflected on Valencia orange yield (Sinha et al., 2011; Scotti et al., 2015; Lee et al., 2018; Scotti et al., 2018). In contrast, Sinha et al. (2011) found that the amendment combination consistently positively affected all soil fertility and plant growth parameters. However, Lee et al. (2018) noticed

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that incorporating beef cattle manure compost at 30 ton ha^{-1} and mixed oilseed cake applications at 3 ton ha^{-1} increased onion bulb yield.
Moringa seed cake in combination with compost at 2:1 recorded the highest percentage of total carbohydrates in leaves, fruit weight, percentage of juice, Ascorbic acid (vitamin C) content, total soluble solids in juice (TSS), TSS/TA ratio and lowest total acidity percentage followed by application of moringa seed cake in combination with compost at 1:1. The results agreed with Liguori et al. (2015), who reported that compost has improved watermelon yield quality. Yassin and Ismail (1994) and others revealed that cotton and sunflower seed cakes increased cowpea plant growth in sandy, sandy loam and clay-loam soils, respectively. In addition, oilseed cakes positively affected plant health by suppressing parasitic nematodes in soil rootzone. Scotti et al. (2018) observed that defatted seed cakes have different chemical analyses and positive effects on soil microbiota. As the result of assessing seed cakes as a soil amendment, it can be permitted to invest the by-products of seed oil extraction as the coproducts for sustainable agriculture. Such research should be applied to varied crop types in different ecosystems to attain the best soil management for optimum crop water productivity.

5. Conclusion

This study demonstrated that incorporating moringa seed cake with compost improved the hydrophysical properties of soil, soil water retention, and transmission, reflecting the vegetative growth and nutritional status of trees. This, in turn, improved the productivity of Valencia orange and fruit quality compared to the control. Therefore, the study recommends applying moringa seed cake combined with compost at a 2:1 ratio to maximise growth, yield and quality of Valencia orange grown under new-reclaimed lands (sandy soils). This approach also provides a natural organic fertiliser that improves the soil's physical properties and can partially replace various synthetic soil fertilisers. In addition, the results using the Aquacrop model indicate an opportunity to increase the yield potential and simulated crop water productivity under climate change scenarios.

Conflict of interest

The authors hereby declare that there is no conflict of interest.

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Food enhancers usage in home food preparation among the young working women in Malaysia: A qualitative study

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Food enhancers; home food; food preparation; usage; young working women; Malaysia

This paper explores the usage of food enhancers in food preparation among young working women in Malaysia. The study informants were drafted using the purposive snowball strategy to participate in a semi-structured interview in this qualitative study. The interview data were recorded and analysed according to the research aims. The majority of the informants claimed that they used food enhancers to enhance the flavour and taste while reducing cooking time and minimising preparation processes. In addition, as they understood the adverse effect of food enhancers, the informants avoid using them and will only opt for them whenever their cooking time is scarce. The study findings contribute to a growing literature on the consumption of food enhancers among young women, a critical aspect of the modern Asian family structures. Its findings reinforce the need for public awareness to promote controlled consumption of food enhancers and additives, especially among modern households.

1. Introduction

In today's era, family life is complicated and more demanding than before. As the cost of living in urban and rural areas is drastically increasing (Handbury, 2019), family expenditure is also affected, whereby family expenses have skyrocketed compared to before (Esposito et al., 2017). These changes indicate that a single income or man as a family's breadwinner is no longer appropriate (Keller et al., 2019). The women's involvement in the workforce is apparent to lessen the changes in family structures and the household composition (Minz & Munda, 2020). Over the last half-century, the percentage of working women has increased enormously and is currently becoming an important support system for household income (Halim et al., 2016; Yavorsky et al., 2019). Their specific involvement in supporting the household's socio-economic influences their house chores, especially in food preparation behaviours (Méjean et al., 2017).

The working women's role as the primary provider of family food, a critical aspect of the Asian family structures, has changed in Malaysia, a newly industrialised nation known for its highly successful economic-development policies (Jamil et al., 2019). As a consequence, the amount of time spent on home food preparation have also been declining. Due to time

constraints and ready prepared or convenient food, most opt to use instant foods and food enhancers for home food preparations (Lakshmi et al., 2019; Méjean et al., 2017; Taillie, 2018). One supposition is that working women are more interested in time-saving food products, leading to increased consumption of food enhancers.

According to Abdulmumeen et al. (2012), food enhancers are categorised under the food additive group. Food enhancers include natural sources and synthetic compounds, where the natural food enhancer has been commonly used for many years (Deshpande & Deshpande, 2017; Mirza et al., 2017). The International Food Information Council (IFIC) stated that food enhancers improve the nutritional value of foods and make them more appealing to the consumer by increasing the texture, taste, colour and consistency of the foods (Cody et al., 2012). Food enhancers help increase the shelf life of the foods and build flavour (Inetianbor et al., 2015; Neelam & Mishra, 2018) due to the synergistic effect on food preparation (Carocho et al., 2014). The most popular food enhancer used worldwide is monosodium glutamate (MSG) which introduced the taste of umami to the food industry (Meadows, 2003). Another food enhancer typical for food preparation is bouillon cube such as chicken, beef, or bacon stocks (Swarts, 2012).

In Malaysia, food enhancers are undoubtedly attractive and a popular option that aid in food preparation and production, specifically for marinating, seasoning, and flavouring. Many local and international food manufacturers successfully penetrated the world market, including Malaysia, by producing various food enhancers (Akora, 2019). These food enhancers are readily available in multiple marketplaces, including small grocery shops in rural areas. Although food enhancers are proven to enrich the food products' flavour and lessen the cooking time processes, many researchers argue the adverse effect on the human body system (Niaz et al., 2018). Based on the works of literature, many published studies focus on scientific approaches such as the effect of food enhancers on the human body (Abdul-Hamid et al., 2017; Husarova & Ostatnikova, 2013; Mustafa et al., 2017; Obayashi & Nagamura, 2016) however, with less attention on the user perspectives.

Therefore, qualitative research into the usage of food enhancers in food preparation is likely to be insightful by exploring the nuances of young working women's perceptions and behaviour. This study's main objective is to understand whether food enhancers are becoming a norm in food preparation among young working women in Malaysia. Further, this study aims to understand the phenomena and fill the study gaps by identifying the underlying reasons for food enhancer use. This study also explores the types of food enhancers commonly used and how their usage becomes a norm among young working women in Malaysia.

1.1 Women, food preparation and food enhancers

Previously, women were the central figure in caring for and preparing food for their families (Allen & Sachs, 2012; Sharif et al., 2014; Tilly & Scott, 2016). However, women's participation in the job market changed how home food preparation was handled. Furthermore, the younger generation enjoys a socialised environment, easy-going behaviour and is much more educated than other generations (Black, 2010; Jerome et al., 2014; Miller et al., 2013; Sharif et al., 2021). Nonetheless, despite women's active involvement in the workforce, they still play a significant role in managing the household (Ishak et al., 2019; Sharif et al., 2014). Similarly, many researchers argued that the increase of women in the workforce had not resulted in a considerable shift in household responsibilities (Cerrato & Cifre, 2018; Plickert & Sterling, 2017; Schaner & Das, 2016). As reported, on average, working women still hold primary responsibility for their home, family life, and childcare than men, despite some duties, if any, are delegated to the house servant. Kuhns and Saksena (2017) noted that a single young woman spends less time preparing food than married women as they prefer home cooking (Lam & Adams, 2017). However, it is challenging to prepare food from scratch due to time restrictions; therefore, convenience food products and materials are preferred.

Based on previous research, food enhancers are identified as the most prominent food additives (Badora et al., 2019). They can substitute the need for salt, spices, and herbs in-home food preparation and mass food production preparations (Muhammad et al., 2011). Food enhancers add taste quality to the food, which improves palatability with minimal alteration towards the food ingredients' intensity. Eventually, the synthet-

ic food enhancer, which is low in manufacturing cost, was vastly introduced to enhance the modern world's food flavour (Badora et al., 2019). Since then, food enhancers have been increasingly accepted as kitchen aids to simplify cooking (Abdulmumeen et al., 2012).

With advances in food technology, food enhancers are gaining wide use around the world. However, there were only a few studies done on the usage of food enhancers in food preparation. Chen and Oldewage-Theron (2004) revealed that most residents in Vaal Triangle, South Africa, used food enhancers in their food preparation. Similarly, Kim et al. (2017) did a study among South Koreans. They found that the demand for liquid seasoning of food enhancers grew more than 50 per cent every year, leading to an increased supply of condiments in the food market. One of the popular food enhancers used worldwide in food preparation is Monosodium Glutamate (MSG) (Meadows, 2003). MSG had been cited as one of the most used food enhancers globally, and in the early twenty-first century, the acceptance of this new flavour enhancer increased and continued to do so (Sand, 2005; Tracy, 2016; Regnier-Davies, 2014; Zhu et al., 2020).

Even though food enhancers are becoming a common choice in food preparation, specific guidelines on the amount of food enhancers used by consumers are lacking (Wang & Adhikari, 2018). A recent study even claimed that most consumers were unaware of food enhancers' functions and advantages (Al-Azawi et al., 2020; Bawaskar et al., 2017). Besides, the vast majority of the younger generation claims they eat or intend to eat healthy foods. However, their food choices would suggest otherwise, since they generally go for sausages, bacon, burgers and chips, rather than salads, sandwiches and fruit – the type of foods that use many food enhancers and additivities (Bawaskar et al., 2017).

2. Methods

2.1. Sample and population

A qualitative interview approach was deemed more suited to the study aim and thus was applied for information gathering. Based on the grounded theory, the study population are the young working women in Malaysia who used food enhancers in their food preparation. Eligibility for the interview study required that the respondents were full-time Malaysian working women, aged between 26 to 40 years old, with at least one child living in the household and residing in the Klang Valley. The age range used was based on the definition of Malaysian young women employees as reported by Jamil et al. (2019). The purposive sampling strategy was used during the interview stage, and theoretical saturation was used as a procedure to ensure data collected from the sample were sufficient. The potential informants were identified through personal contact and with the help of friends. To reflect the characteristics of a Klang valley population, a sample of five respondents from Kuala Lumpur, Shah Alam, Petaling Jaya, Subang Jaya, Cheras, Kajang, Selayang Baru area was identified. As there are seven locations in Klang Valley, a sample of 35 informants were predetermined and subsequently contacted via telephone, obtaining permission to be interviewed. The interview dates and times were then arranged based on the working women's convenience and wishes, which required unlimited flexibility on the researcher's part.

2.2. Interview questions

Semi-structured interview questions were utilised to obtain in-depth data and to understand the research phenomenon. These open-ended questions were used to avoid any potentially biased responses and to discover rather than prescribed. The development of the research guide was based on the study specification and relevant literature search. Table I shows a list of primary questions from the research guide.

The interview questions range from informants' demographic profiles, reasons for using the food enhancer, types of food enhancer commonly used, and the frequency of food enhancers in home food preparation. Owing to different educational levels among the informants, the Malay language version of the semi-structured questions was used after translating from the language expert's English version.

2.3. Procedure for information gathering

At the initial stage, face-to-face interviews were planned to be undertaken. However, due to the Movement Control Order (MCO) in line with the pandemic of Covid-19 in February 2020, only 15 informants

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Table 1. Primary questions from the research guide.

Topic	Primary Questions
Cooking behaviour	Do you cook for your family during the weekdays?
Choice of menus	What type of menu do you cook for your family during weekdays?
Knowledge about food enhancers	Have you heard about food enhancers?
Usage of food enhancers in food preparation	Do you use food enhancers for cooking for your family?
Types of food enhancers commonly used.	What type/brand of food enhancers do you usually use?
Reasons using food enhancers	Any reason for using food enhancers during food preparation?
Food enhancers as a norm in food preparation	Do you think that using food enhancers in cooking preparation is a norm among Malaysians?

agreed to be interviewed. The rest of the informants were unable to join as most of them were overwhelmed with home office working conditions and managing their families during the Covid-19 movement control order. The interview sessions were done via video calls using the Google Meet platform. Despite some issues on the willingness to participate due to Covid-19, the video call interview sessions were successfully undertaken, and the responses met the saturation point. It is worth mentioning that, before the interview sessions, informants were explained that their participation was voluntary, and all the information provided is strictly confidential and that their names will not be revealed. Written consent was acquired from the informants. All of the interviews were tape-recorded, and on average, each interview lasted between thirty minutes and one hour. As each interview ended, transcription was done instantly.

The recorded data were transcribed immediately after the in-depth interviews were conducted, in line with Bryman (2010) findings on the importance of transcribing as soon as discussions are done. On top of the informants' exact words, other significant data such as hesitation, noise, language, and others were also recorded to avoid data outliers, bias judgment, and other factors that might impact the findings. The coding process was manually done and followed by qualitative data analysis using ATLAS.ti version 8. The themes and sub-themes in the research were identified through inductive and deductive approaches. Codes were categorised, and the subthemes, themes and main domains were identified. To assure content validity, inter-rater reliability tests were assessed and found acceptable with a Kappa score of 0.78.

3. Results

Due to the flexibility in understanding how people represent themselves, express and share their experiences. The name of the informants are not disclosed to preserve confidentiality, thus throughout the analysis, they are known as "informant."

3.1. Informant profiles

During the interview session, information such as workplace location, occupation, age, distance to the workplace, and the number of children was noted. All interviewees were working women age between 26 and 40 years old. The youngest informants age was 29 years old with one child, and the eldest informant was 40 years old with five children. Most informants work in the Klang Valley and commute to their workplace between 5km and 20km.

3.2. In-depth interview responses

3.2.1. Cooking behaviour

In response to the first question, most informants stressed that although they reached home slightly late and tired, they still intended to cook dinner for their family. Most of them managed to allocate time to cook after arriving home. They believed that cooking and meal time would help strengthen the bond between

family members. Below are the few responses given by the informants.

"Undeniably, I am a bit tired and exhausted after finished work, but as my husband preferred to be with the children, especially during dinner time thus, I make a point to cook although with simpler dishes. My family is not fussy with the simple cooking as they understand my situation. I could say, we don't eat out during the working days, however, during the weekend, in particular, we did go out for dinner" INFORMANT 3

"As I am staying close to the working place, I have no problem cooking for my families. Not to say I am good at it, but I enjoy cooking for my family. I feel happy when my husband and kids enjoy my cooking. Simple food is sufficient for them. With four children, I have to feed them with my own cooking" INFORMANT 12

"Yes, I cook for my family….. Although I have limited time but comfortable doing that rather than buying at the restaurant. It is my responsibility as a wife and mother" INFORMANT 6

3.2.2. Choice of menus

Most informants cook simple food and choose easy or quick dishes as frequent menus for their family dinners. The menu selections are also subject to time constraints. Fried chicken, fish, beef, anchovy, sardine and vegetables are the main courses frequently cooked. Besides that, fried rice and rice vermicelli are also alternatives considered by them. Some informants stressed that western menus such as the french-fries, frozen breaded chicken, breaded fish, and bolognese spaghetti are also the options. Below are some of the verbatim answers.

"Working as an assistant restaurant manager, my shift is not fixed. If my working shift is from 9.00 am to 6.00 pm, I will cook for my husband and kids. Fried chicken and stir-fried vegetables are the dishes. For the afternoon shift, I normally prepare food in the morning and chill it in the fridge. My husband and kids only preheat them" INFORMANT 2

"…. A simple menu, of course, is my option, which requires less time. My favourite family menus are Sambal Ikan Bilis (anchovies), stir-fried vegetables, fried eggs, or omelette. I sometimes cook fried rice, fried mee or mee hoon" INFORMANT 5

"Due to the short distance from my house to the working place, I have no issue preparing food for my family dinner. I do not have a specific menu to cook, but it depends on my mood and my husband and kids. Stir-fried vegetables, fried chicken, and fish soup are some examples. Sometimes, I prepare french fries, frozen breaded chicken, breaded fish, spaghetti are the options" INFORMANT 3

3.2.3. Knowledge about food enhancers

Most informants revealed that food enhancers increase and enhance the flavour and taste of the food they cook. They also claimed that food enhancers reduce cooking time, cut down numbers of ingredients and spices used, and facilitate the preparation processes and time needed in the kitchen. They claimed that food enhancers were also used for marinating food items – making them flavourful and tenderised. Informants knew that most of the food enhancers come as powder, liquid, or spices. Below are the comments quoted by the informants.

"Yeah….. food enhancers increase the flavour and taste of the cooked food. Fried vegetables will taste better with the food enhancer" INFORMANT 5

"Food enhancers are the kitchen aid that helps to reduce the time of preparing food. We don't need to add fresh ingredients, which require more time to peel, chop, and cook. Enhancers will give a quick flavour and make food tastier" INFORMANT 9

"Hmm….. What I understand about food enhancers is that they are used to enhance the flavour of the foods. At the same time, it helps to make food tastier. Older generation like my mother and grandmother, in particular, do not like to use food enhancers in their cooking compared to my generation" INFORMANT 13

3.2.4. usage of food enhancers in food preparation

The majority of the informants claimed that food enhancers are part of their food preparation process. Some of them use them for soup and stir vegetables. The most common answer for use was to increase the

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flavour and taste of the cooked food. Many agreed that foods without enhancers would taste different and bland or tasteless, even after salt and sugar are used as a seasoning. Some said the perfect food taste could not be obtained without the usage of food enhancers. On the other hand, the advertisements on the television, media, and friends' recommendations influence them to use the food enhancers. Also, the price most of the food enhancers are affordable. Below are the verbatim answers by the informants.

"In my food preparation, I felt much more confident about the taste and favour of food enhancer. That's the reason why I like to use food enhancers in soup making. It tastes like the real flavour of anchovies. Moreover, the price of it is not high and much more convenient for using it" INFORMANT 6

"It depends on what menu I need to cook. If I don't have time to prepare from scratch, a food enhancer is my additional flavour. Undoubtedly, food enhancers are a good choice in food preparation as it helps prepare food faster, quicker and tastier. I don't say that I use food enhancers too often. Sometimes advertisement in the media influences us" INFORMANT 15

"Honestly…… I am not so much into food enhancers; salt, pepper and sugar are enough for my family and me. However, sometimes, it is difficult for me to get the flavour and taste without using the food enhancers. Thus, sometimes I use a little bit of it in cooking" INFORMANT 11

3.2.5. Types of food enhancers commonly used

Powder, liquid, cubes, seasoning and spices are food enhancers available in the market. In response to the types of food enhancers used in the food preparation, most working women admitted that the powder and cube form is their preferred choice than the liquid and spices form. The powder and cube form of food enhancers, according to them, are convenient and easy to use. The powder form is easily added to the food prepared like stir-fried vegetables, curry, and fried noodles. The cubed chicken is usually diluted and used to create a stock to enhance chicken soups or other soups. The informants' response is as below.

"*Honestly…. out of five common types of food enhancers: powder, cubes, liquid, seasoning and spices, the first two are my choices. I used powder and cubes form in enhancing the taste and flavour of my food prepared. The cubed chicken, cube anchovy is my option in preparing soup while powder is used in fried rice and fried vegetables*" INFORMANT 1

"For me, powder and cubes are much convenient. Just sprinkle it on fried vegetables and mix them well. I need not use salt or pepper because powder enhancers are kind of tasty already. When making a soup, the chicken cubes are becoming based. Just mix with hot water. Easy, you know" INFORMANT 9

"At home, I have different types of food enhancers that I use for cooking, either powder, cube, liquid and seasoning. I used all of them, but it depends on the types of food prepared" INFORMANT 13

3.2.6. Brands preferences of food enhancers

Although the brand names cannot be mentioned here, most informants share the same idea about it, whereby they are mostly choosing the most popular brand of food enhancers. Some informants stated that the taste is slightly different, although the appearance of the food enhancers is almost identical in powder, cubes, liquid, or seasoning. Some brands with less fat taste good, while some contain a lot of fat, and the taste is fair. They claimed that the fat does not appear while the food is still hot, but it is solidified when cold. It is worth mentioning that the media and friends' experience influenced their inclination toward a particular brand. Below are the verbatim quotations.

"For me,….. brands of food enhancers play an important element. Some brands contain a lot of fat, some brands a lot of MSG. Although some of the best brands are slightly expensive due to the flavour and taste..... The price does not matter. Honestly, after getting advice from friends and advertisements, I only use those from a good and acceptable brand," INFORMANT 14

"I am very picky; thus, I only opt for popular brand food enhancers. How do I come to know about a good food enhancer? In fact, before sticking to one that I have been using now, I tried a few brands. Different brands carry different tastes and flavours. We make a comparison when we use it and tasted them…." INFORMANT 13

3.2.7. Reasons using food enhancers in food preparation

Information gathered from the interview revealed that most informants did not use food enhancers for every cooking preparation, especially during the weekend, as they have more time to plan for cooking. Many of them manifestly stressed that food enhancer usage depends on the types of food they prepare. In other words, food enhancers will only be used if time is scarce. Again, it is interesting to note that most informants understood that using excessive food enhancers in the long term may increase and trigger allergic reactions and possibly lead to unhealthy eating habits. The informants' responses are attached:

"Not in every cooking, you know…. only in certain menus. Of course, I will use tom yam paste or tom yam cube if I am making tom yam, similarly, for chicken soup. I don't think food enhancers are suitable to be added in Asam Pedas or Masak Lemak". INFORMANT 10

"Could say once a week… really depends on the types of food cooked. I normally use food enhancers in fried products like fried rice, fried noodles and vegetables. Mind you..... I used a little bit only, too much of food enhancer in the long may cause unhealthy eating habits" INFORMANT 7

"I use food enhancers to cut down any step that requires time for cooking processes. But only a small amount of food enhancers are used - only during the working day, not at the weekend. My cooking is much more elaborate on the weekend" INFORMANT 3

3.2.8. Food enhancers as a norm in food preparation

Almost all the informants believed that food enhancer use is still not a norm among young working women in Malaysia. Most of them stressed that food enhancer usage depends on the types of food they prepare. Despite that, as working women and due to time constraints, they admitted their intention to use food enhancers is slightly higher than older generations. Furthermore, they revealed that many types of food enhancers are available in the market and promoted in many media-influence channels. Notably, they also admitted that food enhancers are increasingly popular, but it has not reached the extent of becoming the norm. Below are some of the informant's verbatim comments.

"Looking at the whole scenario, I don't think the usage of food enhancers in the food preparation among our generation is becoming a norm or something that is always used. To me personally, I use them once a while in a soup and other products" INFORMANT 4

"Compared to my mother's generation, the usage of food enhancers is more prevalent in my generation. Busy and hectic life cause us to use them in certain food preparation but not excessive or every day. I don't want it to become a habit of using them in every dish..... I use them whenever necessary. I think other women of my generation might share the same thought" INFORMANT 12

"Although food enhancers are gaining popularity with many products in the market…. the usage of it is still under control or something that is not considered a must-use item in every household food preparation. I think women use it based on the suitability of the food prepared. However, I must admit that the usage of it is in the increasing trend" INFORMANT 14

4. Discussion

The study results indicate that young, working women consumers possessed high awareness of food enhancers with relatively little insights into the origins and food enhancers' effect. They mainly took to mass media as a primary source of information about food enhancer usage. Their risk perception about food enhancers played a more important role in their concern about the ingredients, caused by the influence of information they obtained from the mass media. The present study also addressed food preparation behaviours among young working women. Our findings seem to reflect two key behaviours: greater attention paid in planning and organising healthy food and the high value placed on meal purchasing, preparation, and eating. It includes the importance of eating together as a family and preferring homemade foods. Quite a fascinating fact is that the results point towards changing attitudes and motives regarding food preparation among young working women (Zhong et al., 2018). Based on the study findings, these young working women are undoubtedly committed to their

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duties as wives and mothers, a result noted in other similar studies(Cerrato & Cifre, 2018; Tilly & Scott, 2016).

Over the last decade, consumers have become increasingly concerned about health risks posed by food consumption. However, with time limitations, food enhancers were utilised as an option to minimise the process of food preparation, such as chopping, peeling and sautéing and others (Kuhns & Saksena, 2017).

This finding corroborated sufficiently with Koyratty et al. (2014) that food enhancers enhance and improve the flavour and, at the same time, helps to give colour to food products. Besides, Zhong et al. (2018) noted that affordable price is why women use food enhancers. The significant sources of information received on food enhancers are through radio, television, friends, and relations that help influence consumers' use of food enhancers in food preparation.

Al-Azawi et al. (2020) proposed that food enhancers act as kitchen aids and enhance their flavour and taste. Due to the ability to absorb and quickly dilute, powder and cube forms of food enhancers are preferred. Another promising finding from this study is that the informants manifestly realise the long-term consequences of excessively using food enhancers in food preparation (Mustafa et al., 2017). Besides, the informants indicate that food enhancer usage is still not becoming a norm or culture despite a much higher consumption than the older generation.

5. Conclusion

The social and economic developments have changed the human way of life. Likewise, food preparation has adjusted accordingly to modern lifestyles. There is increasing usage of food enhancers, a shred of evidence why food enhancers products are receiving great demand. Young working women prefer home cooking, and food enhancers are just complementary in their home food preparation. They will only be used when necessary as they are aware of the adverse effect of such usage. Thus, a robust awareness and educational drive towards proper food enhancer use may help encourage quality and safe home food preparation. Knowledge of the meal preparation, cooking and consumption behaviours may inform practical health promotion strategies. Therefore, the increasingly diverse community needs to explore other potential behavioural differences based on demographic and psychographic factors.

Although this research produced interesting findings, there are some research limitations; thus, the results warrant further exploration. The first limitation is related to the data collection method. Owing to the Covid-19 pandemic and movement control order (MCO), a video call interview was done; hence, the number of participants is limited, and the discussion depth is distorted. Next, only fifteen informants were able to be telephone interviewed as many were reluctant to be involved. Besides, due to time constraints, only selected questions were used in the interview sessions. As a result, limited findings and information were obtained from informants. Moreover, the results obtained could not be generalised. Hence, it suggested that replication be done using a focus group discussion setting with broader sample size.

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Conflict of interest

The authors declare no conflict of interest.

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Determination of fat, salt and sodium contents of selected fast food items available for sale in Colombo city, Sri Lanka: An approach to colour coding of fast foods

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Fast food has become a popular trend among Sri Lankan population. However, the nutritional facts of these food items are scantly found in Sri Lanka. This study aimed to analyse fat, salt and sodium contents of selected fast food types sold in Colombo city with an attempt to assign colour codes. A questionnaire-based survey was conducted to identify the fast food consumption patterns of the target population. The fat, salt and sodium contents of most preferred fast food types were selected based on the survey, namely; Chinese fish roll (CR), *wade* (WD), chicken *koththu*(CK), chicken fried rice (FR) and doughnut (DG) were analysed using soxhlet, titration and flame photometry methods. The survey results showed that 73.80% of respondents were students, 79.30% were between 18-25 years of age. Among the respondents, 68% preferred to consume fast foods between main meals, and most (57.3%) preferred to consume chicken-based foods. When comparing the analytical results with international guidelines, a serving portion of the selected fast food items did not exceed ($p>0.05$) the DV (daily value) of fat. However, CK and FR exceeded ($p<0.05$) the DV of salt and sodium. Further, when comparing the calculated fat and sodium as a percentage of DV (DV%) with the established DV% references, CK and FR were identified as high-fat foods. All the selected food types were identified as high-sodium foods. When comparing the results obtained for fat with Sri Lankan colour coding regulations, WD and DG were red, while CR, CK, and FR were amber in colour. Considering the salt content, only DG was designated with amber, whereas the other four types of food were categorised under red in colour. This study showed that frequent fast-food consumption is associated with elevated fat, salt and sodium intake and would create a risk of exceeding the relevant DVs. Therefore, the attempt to assign colour code for fast-food would be a great approach to raise nutritional awareness among Sri Lankan population towards fast food.

1. Introduction

Globalisation and urbanisation have influenced the eating habits of people. As a result, there is a tendency to adopt convenient food patterns such as fast food (Ashakiran & Kiran, 2012). Nowadays, there is a rising demand for fast foods due to their exhilarating sensory attributes, convenience and relatively low prices. However, fast food has become a concern, particularly in urban areas due to its high consumption and other quality characteristics that are known to harm public health. Based on reported data, food

and health specialists recommend minimal fast-food consumption due to the possible associations between fast-food intake and the prevalence of non-communicable diseases in a population (Jayawardena et al., 2013). Previous research on fast food showed that they could be considered as poor-quality diets (Rekha et al. 2013) since they contain high amounts of processed meat, refined carbohydrates, sodium, total fat, trans fats, saturated fats, and cholesterol (Bahadoran et al., 2015). The growing body of evidence suggested that the frequent consumption of fast food is associated with the occurrence of various diseases such as; obesity, type-2 diabetes, hypertension and cardiovascular diseases (Bahadoran et al., 2015; Charlton et al., 2007; Johnson et al., 2010; Stender et al., 2007).

International regulatory bodies like the World Health Organization (WHO) and Food and Drug Administration (FDA) have established criteria and recommendations regarding the daily value of fat and salt. The "Daily Value" (DV) of a particular nutrient is defined as the "reference amounts of nutrients to consume or not to exceed each day" (FDA, 2020a). According to the guidelines issued by WHO, "adults should consume less than 2,000 mg of sodium and at least 3,510 mg of potassium per day". Moreover, they have established the recommended maximum salt intake as 5 g per day for adults (WHO 2020). The FDA recommends that individuals should consume no more than 2,300 milligrams of sodium per day (FDA 2020a; Pineo 2018). In terms of fats, FDA has set the daily value of total fat at 78g (FDA 2020b).

The fast-food industry has gained more popularity among the Sri Lankan population and has in some ways altered traditional diet patterns (Rasanthika and Gunawardena, 2013). A range of fast-food types is available for sale in local food outlets, yet, their nutritional data are scarce. Since fast food is consumed at a high frequency, an approximate estimate of nutritional components in fast food should be made to raise consumer awareness for daily fat, salt and sodium intake. The nutritional profiling of fast food would help to reduce the risk of exceeding DV of these components recommended by WHO and FDA. In an attempt to approach nutritional profiling, the Ministry of Health in Sri Lanka has developed a colour code labelling system of solid and semisolid food items to indicate the sugar, salt, and fat contents to enhance consumer awareness and precautionary measures. As a result, Food (Colour Coding for Sugar, Salt and Fat) Regulations (2019) were published by the Minister of Health, Nutrition and Indigenous Medicine under Section 32 of the Food Act, No. 26 of 1980. Currently, only salt, sugar and fat contents from packaged solid and semi-solid food items are controlled by this food regulation. Therefore, the primary objective of this study was to find out the most preferred fast food types in food outlets of Colombo city and to analyse fat and salt contents to assign colour codes for these food items according to the Sri Lankan food colour coding regulations (2019). Moreover, this study aimed to compare these fast foods' total fat, salt and sodium content with the international criteria and elaborate on the extension to which these components fulfil the daily requirement. Therefore, the findings of this study would be helpful to bring awareness to the general public on the nutritional quality of fast food.

2. Materials and methods

2.1 Data collection

School children, university students, employees and non-employees in Colombo city, who were in the age range from 18-40 years, were identified as the target population. Those with a permanent residence, temporary residence in the Colombo municipal council (CMC) area, and who came to the CMC area regularly and consumed foods from food outlets in Colombo city from October to November 2018 were included in the study. A voluntary online survey was conducted using a questionnaire. The survey results were used to identify the fast food items that were consumed frequently during the specified period.

2.2 Development and the pre-test of the questionnaire

The development and pretesting of the questionnaire were done before conducting the survey. Before the proper survey, an exploratory survey was done to identify the consumption frequency of fast food and the relevant fast-food items to be included in the final questionnaire. A preliminary questionnaire was developed with a sample population of 25 respondents (n=25). This group included people from different categories: school children, college students such as university students, employees, and non-employees from the Colombo city area. The proper questionnaire

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was developed using the details that were obtained through the preliminary questionnaire.

An undeclared pre-test was conducted to check the validity of the questionnaire. For that purpose, a representative sample of respondents comprised of 15 (n=15) were selected from the target population. The developed proper questionnaire was distributed among the representative population, and the responses were observed. The pre-test results were compared with the expected results and checked the ability of each question to interpret the domain of interest. Modifications were done to the questions that were not able to provide a sufficient intended outcome.

2.4 Sample collection and preparation

During the survey, the respondents were guided to vote for the most preferred fast food items (up to 8 items) from the list. The overall percentage of preference for each fast-food type was calculated by dividing the "number of votes for a particular food type" by "total number of respondents" and converting to percentage values. According to the results, five different types of fast food items were selected for compositional analysis: Chinese fish roll (fried roll filled with fish), *wade* (fried lentil cake), chicken *koththu* (tempered shredded wheat flour roti with chicken), chicken fried rice (tempered rice with chicken) and doughnuts. Ten food outlets were identified from different areas of Colombo city to collect samples of selected food items. The unit weight of each sample was weighed, homogenised separately and analysed in triplicate. The moisture of homogenised samples was removed at 105 °C until two consecutive weighing were less than 0.1% deviation, and they were ground into fine particles using a grinder (Sisil, 02 Jar Mixer Grinder, 350 W). Samples were stored in an airtight package at -4 °C until taken for analysis. The study was conducted from October 2018 to February 2019.

2.5 Determination of fat

Total fat content was determined by adopting the soxhlet method given in AOAC (2005) and described by Akmar et al. (2013). Five grams of moisture-free homogenate was used with hexane (GC grade, ≥ 99%, boiling point- 69 °C, purchased from Sigma – Aldrich, France) at 70 °C for 6 -7 h to extract fat in the extraction unit. The solvent evaporation was done using a rotary evaporator at 70 °C followed by oven drying at 70 °C until the difference of two consecutive weighing was less than 0.1%.

2.6 Determination of salt

The salt content of fast food was determined according to the method described by Khan and Martin (1983). Five grams of dried homogenised food sample was soaked in 20 mL of distilled water for 3 min while stirring intermittently. After filtering, a 10 mL aliquot of the filtrate was mixed with 5 drops of 5 % potassium dichromate and titrated against 0.1 N silver nitrate solution. Method validation was done by spiking the known weight of analytical grade NaCl with the known weight of the sample and then by analysing the recovery results.

2.7 Determination of sodium

Quantitative detection of sodium was done following the method described by Ranst et al. (1999) with some modifications. Accurately 1-3 g of dried fast-food sample was ashed at 525 °C for 6 -8 h. The ashen sample was digested using 5 mL of 6M nitric acid by gentle boiling followed by adding 5 mL of 3M nitric acid and reheating for a few minutes. The digested extract was filtered while warm into a 50 mL volumetric flask using an ashless filter paper (Whatman, 42, ashless, 110 mm). The extract was topped to 50 ml with deionized water and diluted with 1% nitric acid to obtain values between the calibrations. The samples were analysed using the flame photometer (Jenway, PEP 7, Japan), calibrated with a 0,5,10,15,25,30 µg/mL standard sodium solution series. Method validation was done by spiking the known volume of sodium standard (AAS grade) with a known weight of the sample and by measuring the recovery. The amount of sodium coming from salt was subtracted from the analysed total sodium content to obtain the value for sodium contribution from other sources apart from salt (sodium*). The sodium content coming from salt was calculated as 2.5 g of salt equivalent to 1 g of sodium (Harvard Health Publishing, 2010).

2.8 Statistical Analysis

Results were statistically analysed using Minitab 15 software at α=0.05 (95% confidence interval). The difference of the mean values obtained for fat, salt, sodi-

um and sodium* contents of five fast food items were statistically analysed based on randomised block design (RCBD) using a general linear model considering the selected food outlets (n=10) as blocks and the type of fast food as the treatment (n=5). When the F values were significant, mean differences were compared using the Tukey test at a 5% significance level. One sample t-test (upper tailed) was conducted for values of fat, salt and sodium obtained for serving portions with the relevant DV specified by WHO and FDA.

3. Results

3.1 Online survey

One hundred and fifty (150) people answered the questionnaire. The results gathered from the survey are summarized in Table 1 and Figures 1 and 2. According to Table 1, the majority of respondents were female; therefore, the results could be biased towards the female population. The highest proportion (79%) of the respondents represented 18-25-year-olds, and around 74% of the respondents were students. Furthermore, the majority of the respondents preferred to consume chicken-based food items.

Figure 1 shows the respondents' preference for different food items. According to figure 1, the descending order of preference was obtained for fried rice (83.29 %), *koththu* (67.30 %), *wade* (54.7 %), Chinese roll (52.70 %) and pastry (50 %). Among confectionaries, doughnuts had the highest preference (28.70 %). Following the results depicted in Table 1, the respondents prioritised chicken -based foods when selecting food

Table 1. Demographic characteristics of respondents who participated in the questionnaire survey

Character		Percentage (%)
Gender	Male	37.30
	Female	62.70
Designation	Student	73.80
	Employee	24.80
	Non- Employee	1.4
Age	18-25 years	79.30
	26-35 years	19.30
	15-17 years	0.8
	36-50 years	0.6
Food preference	Chicken-based foods	57.30
	Fish-based foods	9.3
	Egg-based foods	20
	Vegetable-based foods	13.30
Time preference to eat fast food	As the main meal (Breakfast, Lunch, Dinner)	32
	In between main meals	68

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items. However, fish Chinese rolls were selected for analysis due to less availability of chicken and vegetable Chinese rolls in food outlets. Considering this information on preference for food items, Chinese fish roll (CR), *wade* (WD), chicken *koththu*(CK), chicken fried rice (FR) and doughnut (DG) were selected for this study.

The consumption frequency of the most preferred fast food items by the respondents is described in Figure 2. It shows that a more significant number of respondents tend to consume these fast food types less than two times per week. Moreover, a considerable number of respondents consumed these fast food 2-4 times per week. A comparatively small proportion of respondents consume these foods 5-7 per week, while some respondents consumed them up to 8-9 times per week.

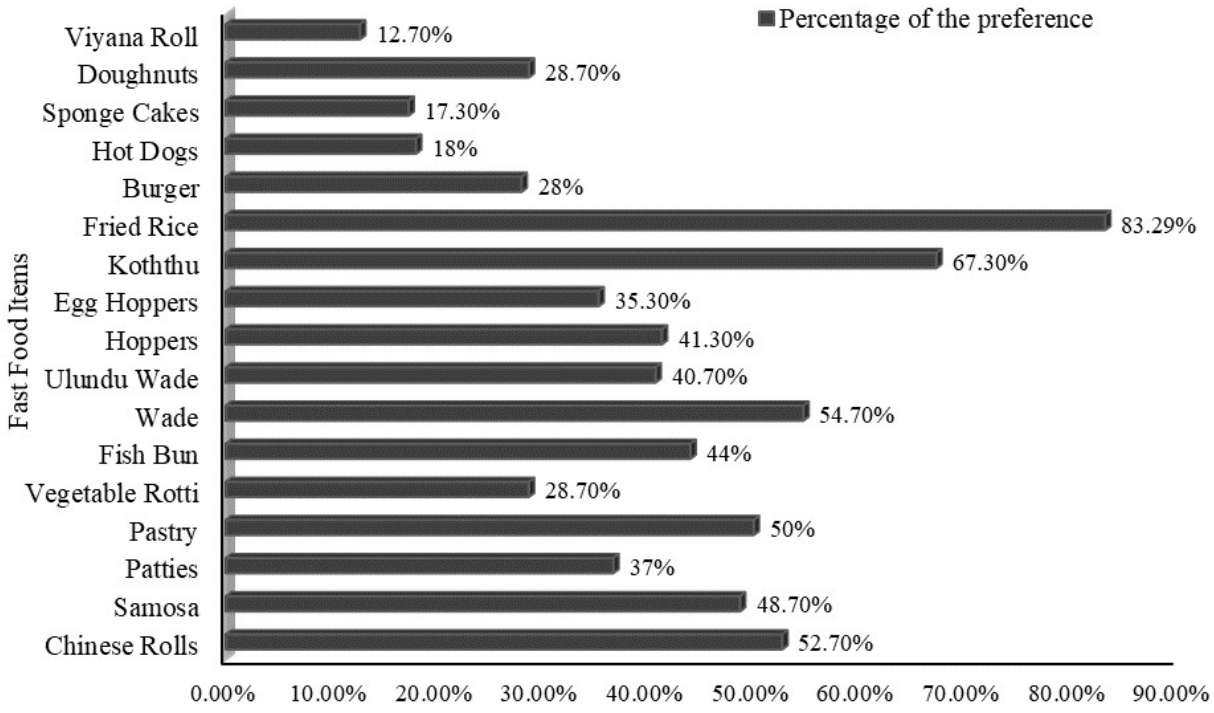

Figure 1. Preference for different food items by respondents

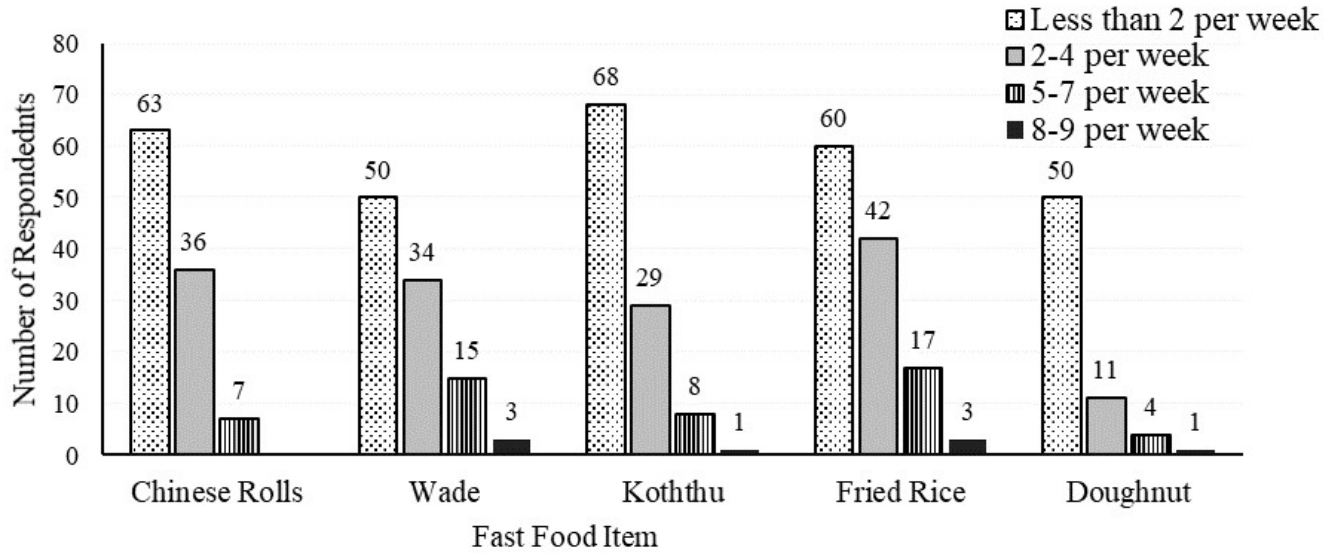

Figure 2. The frequency of consumption of fast food: Chinese rolls, *wade*, *koththu*, fried rice and doughnut by respondents.

3.2 Fat content

Table 2 shows the mean values for total fat content and the contribution to calorie intake of selected fast foods. According to the data, *wade* (18.86 ± 1.65 g) and doughnut (18.69 ± 4.26 g) resulted in significantly highest ($p<0.05$) fat contents in 100 g portion of food while chicken fried rice showed the lowest (5.19 ± 1.28), which was not significantly different ($p>0.05$) from chicken *koththu*. When considering the fat content in one serving, chicken *koththu* resulted in a significantly high ($p<0.05$) amount of fat (46.31 ± 7.27 g) while Chinese roll gave the lowest value (6.17 ± 1.97). The mean fat percentage of *wade* in this study was compared with a previous study conducted by Jayasinghe and De Silva (2014), which was 16.68 g / 100 g dry weight.

FDA has specified the DV for total fat as 78 g, based on a diet that provides 2,000 calories per day. Moreover, the guidelines stated that "5% DV or less of total fat per serving is considered low while 20% DV or more of total fat per serving is considered high" (FDA, 2020b). When comparing with the results, the mean fat values of a serving portion of these food items did not significantly exceed the DV (78 g) ($p>0.05$). However, chicken *koththu* and fried rice were identified as foods with high total fat contents, based on the calculated DV% (Table 2). Fat is a major calorific source and provides 9 calories from each 1 g of fat (FDA, 2020b). The calorie contribution from fats in a serving size of each fast food item was calculated (Table 2). According to the data, one serving of chicken *koththu* (416.77 kcal) and chicken fried rice (249.48 kcal) noticeably contributed to the daily calorie intake. In Sri Lanka, *koththu* and fried rice are consumed as main meals. Since fat extracted from chicken *koththu* was providing more than 400 calories per serving (table 2), it can be identified as a high-calorie food according to the FDA guidelines (FDA, 2020c)

3.3 Salt content

Table 3 shows the mean salt contents of selected fast foods. According to the data, *wade* (2.69 ± 0.58) had significantly ($p<0.05$) highest salt content when considering 100 g of food. Meanwhile, doughnuts resulted in the lowest salt content (1.15 ± 0.13 g), where the value was not significantly different ($p>0.05$) from the results obtained for chicken fried rice and chicken *koththu*. When considering a serving portion, Chicken *koththu* (12.06 ± 2.30 g) resulted in the highest amount of salt, which was significantly ($p<0.05$) different from the others. Whereas doughnut showed the lowest salt content (0.84 ± 0.19 g) and the values obtained for Chinese fish roll and *wade* did not show any significant difference ($p>0.05$) with doughnut. However, previous studies on the salt content of Sri Lankan

Table 2. Mean total fat content compared with the daily value of fat (78g) and calories (2000 kcal) for adults

Food "type"	Fat(g) / 100g of food	Fat (g) content in a serving of food	Calculated % of fat (in a serving of food) as DV (78 g)	Calculated calories from fat, in a serving of food (kcal)	Calculated % of calories from fat (In a serving of food) as DV (2000 kcal)
CR (n=10)	9.33 ± 2.27^{b}	6.17 ± 1.97^{a}	7.91	55.50	2.77
WD(n=10)	18.86 ± 1.65^{c}	10.79 ± 4.16^{b}	13.83	97.08	4.85
CK(n=10)	$6.56 \pm 1.27^{a,b}$	46.31 ± 7.27^{d}	59.37	416.77	20.84
FR (n=10)	5.19 ± 1.28^{a}	27.72 ± 6.82^{c}	35.54	249.48	12.47
DG(n=10)	18.69 ± 4.26^{c}	14.55 ± 6.56^{b}	18.65	130.91	6.55

CR: Chinese fish roll, WD: *Wade*, CK: Chicken *koththu*, FR: Chicken fried rice, DG: Doughnut, DV: Daily value. Each value in the 2nd and 3rd columns of the table represents the mean (mean ± standard deviation) of ten samples collected from ten different food outlets. The means bearing different superscript letters in the same column are significantly different ($p < 0.05$). The mean weight (g) of serving portion of fast food items; CR, 65.5 ± 8.39; WD, 56.4 ± 18.68; CK, 712± 54.96; FR, 534.6 ± 27.51; DG, 77 ± 17.79

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fast food are not available for comparison. According to the WHO guidelines, the DV for salt is less than 5 g per day for adults (WHO 2020). When comparing the obtained mean value of salt with the DV for salt, one serving of chicken *koththu* and chicken fried rice exceeded the DV of salt significantly ($p<0.05$) while the salt contents of the rest food items remained below DV.

3.4 Total sodium content

Table 4 shows the mean values of total sodium and sodium* obtained for each fast food item. As depicted in the data, *wade* had the highest value of sodium (1.60 ± 0.62 g) while doughnut (0.80 ± 0.29 g) had the lowest value in 100 g. However, the values varied within a narrow range where only *wade* and doughnut were significantly different from each other ($p<0.05$). In contrast, the other three food types did not show a significant difference ($p>0.05$) with the results of *wade* and doughnut. When comparing the results obtained for a serving portion, Chicken *koththu* had the highest sodium value (8.85 ± 3.47 g), which was significantly different ($p<0.05$) from other food items. Meanwhile, doughnut (0.59 ± 0.18 g) contained the lowest value, which was not significantly different ($p>0.05$) from the values obtained for Chinese fish roll and wade.

No significant difference ($p>0.05$) was observed among values obtained for sodium* in 100 g of food. Chicken *koththu* (4.14 ± 2.70 g) showed the highest sodium* content in a serving portion though the value was not significantly different ($p>0.05$) from the sodium* content of chicken fried rice. The lowest sodium* content was observed in doughnut (0.27 ± 0.15), and this value did not show a significant difference ($p>0.05$) with the values obtained for Chinese fish rolls, *wade* and chicken fried rice. The FDA guidelines have specified the DV of sodium as less than 2.3 g per day (FDA, 2020a; Pineo, 2018). When compared with given DV with the results of this study, the mean sodium content of a serving of chicken *koththu* and chicken fried rice was significantly ($p<0.05$) higher than the respective DV.

As a general guide, FDA states, "5% DV or less of sodium per serving is considered low while 20% DV or more of sodium per serving is considered high" (FDA, 2020a). When comparing these reference values with the calculated DV% of fast foods considering the total sodium (Table 4), all the selected fast food types were able to identify as foods with high sodium contents. However, when considering the DV% of sodium coming from other sources apart from salt, Chinese fish rolls, chicken *koththu* and chicken fried rice exceeded the 20 DV% claiming their high sodium contents.

The overall results of this study showed that the fat, salt, and sodium contents coming from these foods largely depended on the serving portion's size. As Chinese fish roll, *wade* and doughnut are sold as small serving portions, people may tend to eat more than one serving of the same food or more than one type of fast food. Data given in Table 1 shows that the majority of the respondents (68%) prefer to consume fast food in between main meals. Therefore, for these respondents, the consumption of these foods can act as an additional source of these nutrients, and there is a

Table 3. Mean salt content of fast food compared with the daily value of salts (5g) for adults

Food type	Salt (g) / 100g of food	Salt (g) content in a serving of food	Calculated % of salt (In a serving of food) as DV(5g)
CR (n=10)	2.09 ± 3.56^{b}	1.37 ± 0.33^{a}	27.4
WD(n=10)	2.69 ± 0.58^{c}	1.48 ± 0.5^{a}	29.6
CK(n=10)	$1.70 \pm 0.33^{a,b}$	12.06 ± 2.30^{c}	241.2
FR (n=10)	1.45 ± 0.64^{a}	7.72 ± 3.44^{b}	154.4
DG (n=10)	1.15 ± 0.13^{a}	0.84 ± 0.19^{a}	16.8

CR: Chinese fish roll, WD: *Wade*, CK: Chicken *koththu*, FR: Chicken fried rice, DG: Doughnut, DV: Daily Value. Each value in the 2nd and 3rd columns of the table represents the mean (mean ± standard deviation) of ten samples collected from ten different food outlets. The means bearing different superscript letters in the same column are significantly different ($p < 0.05$). The mean weight (g) of serving portion of fast food items; CR, 65.5 ± 8.39; WD, 56.4 ± 18.68; CK, 712± 54.96; FR, 534.6 ± 27.51; DG, 77 ± 17.79

Table 4. Mean values of the sodium content of fast food compared with the daily value of sodium (2.3 g) for adults

Food type	Total sodium (g) / 100g of food	Total sodium (g) content in a serving of food	Calculated % of total sodium (in a serving of food) as DV (2.3 g)	Sodium* (g)/ 100 g of food	Sodium* (g) in a serving of food	Calculated % of sodium* (in a serving of food) as DV (2.3 g)
CR (n=10)	$1.38 \pm 0.57^{a,b}$	0.93 ± 0.50^{a}	40.43	0.72 ± 0.42^{a}	0.50 ± 0.36^{a}	21.74
WD(n=10)	1.60 ± 0.62^{b}	0.89 ± 0.4^{a}	38.70	0.63 ± 0.40^{a}	0.35 ± 0.24^{a}	15.22
CK(n=10)	$1.25 \pm 0.50^{a,b}$	8.85 ± 3.47^{c}	384.78	0.59 ± 0.39^{a}	4.14 ± 2.70^{b}	180.00
FR (n=10)	$1.02 \pm 0.53^{a,b}$	5.42 ± 2.79^{b}	227.82	0.46 ± 0.34^{a}	$2.42 \pm 1.79^{a,b}$	105.22
DG(n=10)	0.80 ± 0.29^{a}	0.59 ± 0.18^{a}	25.65	0.35 ± 0.24^{a}	0.27 ± 0.15^{a}	11.74

CR: Chinese fish roll, WD: *Wade*, CK: Chicken *koththu*, FR: Chicken fried rice, DG: Doughnut, DV: Daily Value. sodium*; sodium contribution from other sources apart from salt. Each value in the 2nd, 3rd, 5th and 6th columns of the table represents the mean (mean ± standard deviation) of ten samples collected from ten different food outlets. The means bearing different superscript letters in the same column are significantly different ($p < 0.05$). The mean weight (g) of serving portion of fast food items; CR, 65.5 ± 8.39; WD, 56.4 ± 18.68; CK, 712± 54.96; FR, 534.6 ± 27.51; DG, 77 ± 17.79

chance to exceed the relevant DV. The range of each fat, salt and sodium of a particular fast food sample obtained from different fast food outlets (10 outlets) varied within a broad range. The variation could be due to the implementation of different culinary practices as the ingredients and preparation methods could vary according to the chef's interest and with the preference of customers.

Sri Lankan government has imposed food colour coding regulations 2019 for solid and semi-solid foods concerning sugar, salt and fat contents. In this system, the term fat refers to the total fatty acids in the form of triglycerides and salt refers to the total salt in the food, in the form of sodium chloride (food (colour coding for sugar, salt and fat) regulations, 2019). The summary of the colour coding labelling of selected fast food items is shown in Table 5.

Summary of Table 5 depicted that *wade* and doughnut could be indicated with red colour while chicken fried rice, chicken *koththu* and Chinese fish roll could be indicated with amber colour based on their total fat contents. Considering the salt contents, only doughnut could be indicated with amber colour, whereas the other four types of food were assigned to the red colour category (food (colour coding for sugar, salt and fat) regulations, 2019).

4. Discussion

The rate of fast food consumption among children and adolescents has increased steadily and rapidly during recent years. This nutritional transition can significantly impact those individuals as these fast foods possess a low dietary quality (Rouhani et al., 2012).

According to a study performed by Jayasinghe and De Silva (2014), the majority of students of a Sri Lankan university tend to consume fast food daily and at least once a day. The vast prevalence of fast foods services would act as one of the main reasons for the rising consumption of these foods. It is reported that the geographical concentration of fast food outlets is interrelated with negative health effects of a population, including the rising number of all-cause mortality and comorbidities associates with overweight and obesity (Kruger et al., 2014). Further, the consumption frequency of fast food was associated with the occurrence of risk for cardiovascular diseases, insulin resistance, obesity and diabetes (Bahadoran et al., 2015; Rouhani et al., 2012). Further, it is reported that the consumption of fast food for two times or more per

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Table 5. Colour coding for fat and salt content of 100g of solid and semisolid foods compared to selected fast food items. Source: Food (Colour Coding for Sugar, Salt and Fat) Regulation (2019), Section 32, Food Act, No 26/1980.

Colour	Fat g / 100g	Salt g / 100g	Fast food items (Fat)	Fast food items (Salt)
Red	More than 17.50	More than 1.25	*Wade* and doughnut	*Wade*, Chinese fish rolls, chicken *koththu*, chicken fried rice
Amber	3 to 17.5	0.25 to 1.25	Chinese fish rolls, chicken *koththu*, chicken fried rice	Doughnut
Green	Less than 3	Less than 0.25	-	-

week would raise the risk of having various non-communicable diseases (Bahadoran et al., 2015).

This study showed that the selected fast food types contain considerably high amounts of total fats, some with high DV% that contribute to a plentiful amount of calories (Table 2). However, an indiscriminate intake of saturated fats and calories can occur if the fat intake exceeds 35% of an individual's daily calorie requirements (Dhaka et al., 2011). Therefore, elevated daily consumption of fast food would increase the possibility of exceeding these specifications. Excessive calorie intake is known to directly impact the increment of body weight (WHO, 2004). According to Table 2, the total fat content in 100 g of food was high in deep-fried food items; wade, doughnut, Chinese fish rolls than the others. Previously, Jayasinghe and De Silva (2014) have analysed the proximate composition of selected fast food varieties sold in Sri Lanka. They also have reported relatively higher total fat contents in 100 g of egg rolls, vegetable roll and *wade*, which were prepared by deep-frying than in vegetable roti. Moreover, they stated that consuming a unit of one of these fast foods once a day would provide a maximum of 151.99 kcal of dietary energy.

Most of the fast-food sold at Sri Lankan food outlets is prepared by deep-frying. Cutlets, Chinese rolls, French fries, doughnuts, samosa, patties, and *wade* are some common examples. This cooking method results in the high-fat content of deep-fried food items. Regardless of the calories that come from fat, these fats can cause detrimental health issues. During the frying process, the composition of food and the frying medium itself is modified through the oxidation, hydrogenation and polymerization processes. When the same oil is used repeatedly for the frying process, the fatty acid composition of the oil is altered due to its deterioration. These degraded products could be absorbed by food during the frying process (Cahill et al., 2014). The reuse of deep-fried oil for fast food preparation would increase the possibility of imposing negative health impacts associated with fast food consumption (Goswami et al., 2016). Therefore, it indicates that an in-depth study is needed to identify the contribution of fast food to the well-being of the Sri Lankan population.

Salt intake can be considered a public health issue in many countries due to the prevalence of diseases associated with high salt intake, such as hypertension, stomach cancer, heart and kidney diseases, stroke, obesity and osteoporosis (Rekha et al., 2013). Therefore, WHO has targeted the development and implementation of strategies to reduce the daily salt intake of the population (WHO, 2020). However, according to the findings given in Table 3, fast food consumption would be a challenge to accomplish this task as they contained a high amount of salts, and more often, they were found to exceed the recommended DV. Salt consumption is directly interrelated with sodium consumption, and the results of this study supported this statement. According to the DV% values, the selected fast food types were identified as high sodium foods. (Table 4). Sodium intake was directly associated with human blood pressure, which is a major risk factor for cardiovascular diseases (Johnson et al., 2010).

Salt is the primary source of sodium in the diet, responsible for around 90% of it. Approximately one

teaspoon of salt is reported to contain 2300 mg of sodium (American Heart Association, 2019) and 2.5 g of salt is found to be equivalent to 1 g of sodium (Harvard Health Publishing, 2010). In contrast, sources such as monosodium glutamate (MSG), baking soda, curing salt like ingredients also contribute to the total sodium content of the diet (Cobb et al., 2012). However, the data depicted in Table 4 showed that the sodium from other sources are also noticeably contributing to total sodium content. Thus, some food items were identified as high sodium foods based on DV%, regardless of the sodium coming from salt (FDA, 2020a). This could be due to the addition of other sodium-based ingredients as discussed above and the naturally found sodium in raw food materials used for fast food preparation.

The results of this study emphasise the importance of establishing colour coding guidelines for the sodium content of fast foods in addition to the salt content. Regarding the adverse impacts of sodium on human health, international food labelling regulations and most dietary guidelines demand to include the sodium content in nutritional details (FDA, 2020a). According to Liem et al. (2011), the manufactured foods and the foods consumed from restaurants contribute to 75% of sodium in the diet. Sodium increases saltiness, enhances sweetness, and reduces bitterness, thus contributing to food's sensory attributes. Since the flavour of processed foods depends on the sodium content, it will be challenging to reduce the sodium in processed foods (Johnson et al., 2010). However, some researchers claim that a 15% reduction in sodium intake would prevent about 8.5 million global deaths associated with cardiovascular diseases over 10 years (Asaria et al., 2007; Liem et al., 2011).

The approach for colour coding of fast foods could be identified as a great milestone with regard to public health nutrition in Sri Lanka. This can be used to attract and raise the awareness of fast-food consumers by assigning a colour logo rather than using numerical values. The results depicted in Tables 2, 3 and 4 elaborated the compliance of fat, salt and sodium with the international criteria. The results emphasised the ultimate importance of applying the Sri Lankan colour coding regulation for fast foods sold in food outlets and thereby, fast-food consumers can have proximate knowledge of their daily intake of fat, salt and to what extent it complies with the relevant DV. The colour coding labelling is applied for various Sri Lankan food items sold in containers and packages. Nevertheless, colour coding of fast food types would become a challenge as they come with a large number of varieties and also due to their diversified preparation methods. However, the summary of the colour coding of the selected fast foods of this study would be an educative fact for Sri Lankan fast-food consumers. It would provide an initial step for future implementations regarding this purpose.

5. Conclusion

The lack of proper nutritional data of fast food available for sale in Sri Lanka has become a burden for improving public health. This study showed that the intake of fat, salt and sodium, sodium comes from fast food varied according to the food type and the weight of the serving portion of fast food. Among the selected food types, the highest total fat, salt and total sodium contents in 100 g of food resulted in wade. The highest total fat, salt, both total sodium and sodium* were contained in chicken *koththu* and was identified as a high-calorie food in a serving portion. In contrast, its salt and total sodium contents significantly ($p<0.05$) exceeded the relevant DV and thus was found to be a high-fat food based on DV%. Overall results showed that the frequent consumption of Chinese fish roll, wade, chicken *koththu*, chicken fried rice and doughnut could cause health issues as they contribute to a large daily intake of fats, sodium and salt. There is a possibility to exceed the relevant DV of these nutrients, depending on the size of the serving portion and the number of portions consumed per day. The results of this study emphasised the importance of employing colour coding regulations for fast foods. Following the criteria given by the colour coding system for fat, *wade* and doughnut were assigned with red colour while Chinese fish roll, chicken *koththu*, chicken fried rice were assigned with amber. Considering the salt content, only doughnut was assigned with amber colour, whereas the other four types were red. This study plays an important role in alarming consumer awareness concerning the nutritional quality of fast food. All these findings suggest that consciousness regarding the nutritional values and the consumption frequency of these fast food is essential and measures should be taken to regulate fast food quality and sales

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in Sri Lanka.

Conflict of Interest Statement

The authors declare that there is no conflict of interest. Besides, the funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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Data Availability

The data supported the findings of this study will be provided by the corresponding author upon request.

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Farmers' perceptions on climate change and adaptation strategies in Yendi Municipality, Ghana

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It is common to hear and read about climate change in the literature, media, and interpersonal discussions among farmers and environmental groups. Farmers' understanding of climate change differs amid these discussions because of individual experiences and perceptions after many years of farming. Rainfall is declining, and the temperature is rising are the common perceptions farmers hold on climate change which they see as adversely affecting agriculture. In moments of such adversity, farmers think about what adaptation measures to implement. The objectives of this study were to find out what farmers perceive as climate change, what they consider as the causes of the change, and how they adapt to climate change. Methods used for collecting data were administering questionnaires to farmers in six towns in the Yendi Municipality, obtaining information through focused group discussions, and talking to agricultural extension officers. Data analysis was done using Excel software. The results show farmers are aware that the climate is changing. The changes are perceived as a result of bad farming practices, including cutting down trees, the influence of supernatural forces in preventing rainfall, and changes in wind direction which deprive communities of rainfall. Adaptation measures to cope with climate change mentioned by the farmers include crop diversification to plant drought-resistant crops and diversify from high grass consuming ruminants to low grass consuming ones. The paper concludes that the government should assist farmers to adapt fully to climate change, otherwise, food security will be hampered.

1. Introduction

Climate change refers to changes in the statistical properties of climate systems persisting for decades and could last for about 30 years resulting in climate variability and extreme weather events (Australian Academy of Science, Undated). The Intergovernmental Panel on Climate Change (IPCC) has argued that total human Green House Gas (GHG) emissions continued to rise from 1970 to 2010, with the highest emissions occurring from 2000 to 2010 (IPCC, 2014). Recent climate reports show that between 2015 and 2019, there have been a continued increase in carbon dioxide (CO2) levels at a rate of 20%, which is higher than the previous five years (Olivier & Peters, 2020; World Meteorological Organization, 2019). The in-

crease in atmospheric carbon due to climate change contributes to less predictable weather patterns, making it difficult to cultivate lands in countries that rely on rainfall for farming (National Geographic, 2020). The United Nations (UN) advocates for urgent and ambitious climate change mitigation and adaptation, as well as a rights-based approach to climate action (UN, 2021; UN, 2019).

A major driving force of such emissions is agriculture which is believed to be responsible for releasing 10 - 12% of greenhouse gases such as carbon dioxide, nitrous oxide, and methane (Dai et al., 2021; Gołasa et al., 2021; IPCC, 2007). As a result, the earth's global temperature has increased by 0.740C from 1906 to 2005 and is expected to increase further by 6.40C on average in the 21st century (IPCC, 2007). The rise in global temperature has contributed to increased earth surface temperature and variations in rainfall (Collier et al., 2008). However, it is unclear to scientists and farmers what the future holds as it is difficult to predict in absolute terms what will happen except to use models to simulate climate change scenarios that are likely to occur in the future (Challinor et al., 2007).

Despite the awareness of climate change in the world's scientific community, scientific knowledge among farmers on climate change in developing countries like Ghana is lacking as such, negatively affecting agricultural production which also affects food security (Wood et al., 2021). The objectives of this paper are to find out what farmers in the Yendi municipality perceive as climate change, what they consider as the causes of the change, and how they are adapting to the new phenomena. A review of literature on farmers' perception of climate change and adaptation strategies are discussed in the next section.

1.1. Literature review

1.1.1. Farmers perception of climate change

According to Whitmarsh & Capstick (2018), climate change perception is a complex issue that can be attributed to different social, psychological, and environmental constructs like knowledge, beliefs, attitudes, and concerns about how the climate in an area is changing. Perceptions on climate change can be influenced and shaped by the characteristics of the person perceiving it, their experience, culture, occupation, the information that the person received, and at times the age of the person in question (van der Linden, 2015). African farmers are aware of climate change (Antwi-Agyei & Nyantakyi-Frimpong, 2021; Zougmoré et al., 2021); however, the majority of farmers do not have the capacity to handle the impacts of climate change. In the Central region of Ghana, farmers' perception of climate change focuses on a rise in temperature over time but not on reduction in rainfall, even though scientific data shows a reduction in rainfall as a major indicator of climate change (Dadzie, 2021).

Fierros-González & López-Feldman (2021) observed that literature on climate change in Latin America has increased since 2000 but not up to the volume of literature in Africa and South-East Asia (Karki et al., 2020). In Ghana, some amount of literature exists on climate change in general. However, it is quite limited when it comes to farmers' perceptions of climate change in the northern regions and the mitigative measures to cope with climate change. In developed countries such as Italy, Germany, and France, climate change has been perceived by farmers as a change in climate over the past decades (Mwaniki, 2016). Rokhani et al. (2020) identified factors influencing farmers' perceptions of climate change in developed and developing countries. In developed countries such as France and Switzerland education on climate change is done using scientific data, unlike Ghana, a developing country where minimal education is done using scientific data.

In China, farmers' perceptions of climate change are high as China's central government has prioritised such climate change issues since 2009 (Wang & Zhou, 2020). In Thailand and Vietnam, the geographic location of farmers influences their perception of climate change (Waibel et al., 2018). In the United States of America, tribal farmers believe that climate change has occurred as a result of anthropogenic activities which are causing harm to human society (William et al., 2014).

1.1.2. Adaptation to climate change

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as 'Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm

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or exploit beneficial opportunities' (IPCC TAR, 2001; 5). Various types of adaptations can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (IPCC TAR, 2001). According to Burton et al. (2006), these adjustments reduce the negative effects of climate change on people's health and well-being. Adaptation to climate change takes various forms that are passive, reactive or anticipatory. They aimed at ameliorating the adverse consequences associated with climate change (Smit & Pilifosova, 2003). A study on farmers' adaptation strategies in South Africa, Zambia, and Zimbabwe revealed that farmers focus on long-term changes in rainfall, temperature, and farm-level adaptation measures (Global Environment Facility, 2018). Adaptation to climate change involves a wide range of options such as crop selection and distribution strategies across different agro-climatic zones. It also involves substituting new crops for old ones that are seen as not capable of coping with climate change (Easterling, 1996; Njeru et al., 2016).

Cultivating different crop varieties that adapt appropriately to soil and prevailing environmental conditions at specific places in terms of drought and waterlogged soils are further adaptation measures (Salick & Byg, 2007). According to the FAO (2007), long-term adaptation strategies of farmers include changes in the way the land is used, the use of new land management techniques and technologies and water-use efficiency techniques. In Ethiopia, strategies adopted by farmers and livestock keepers include shifts in livestock types, where goats and sheep are preferred to the rearing of camels that consumes a lot more pasture. Other farmers have fish farms in addition to keeping livestock (Gebre & Kifle, 2009).

2. Methods

2.1. Study area

Yendi is located between latitude 9° 26′33.79 North and 0° 00′35.68 East. The municipality shares boundary with six districts: Saboba to the East, Chereponi and Zabzugu to the South, Nanumba to the North, Gushegu and Mion Districts to the West. The district stretches over an area of 1,446.3 sq. km. (GSS, 2010). The district experiences a mean annual rainfall of about 1,125mm during the peak rainy season of March to September. The daily temperature ranges from 21°C to 36°C. The vegetation is savanna vegetation which is characterised by short to medium trees. The main economic activities are farming and animal rearing. The soil comprises sedimentary rocks of voltaic sandstone shales and mudstone. The soil is predominantly laterites, ochrosols, sand and clay. In terms of administration, the Municipality has three town councils: Yendi zonal council, Malzeri zonal council, and Gbungbaliga zonal council. There are 268 communities in the Municipality (GSS, 2014).

2.2. Sample selection

A purposive non-probability sampling technique was used to select 6 out of 21 farming communities with technical assistance from the Yendi District Assistant Director of the Ministry of Food and Agriculture (MOFA). The six study communities are Dabganjado, Sukaani, Bagbani, Kpaatia, Kulkpanga and Tindang (Table 1). Data were obtained from farmers through face-to-face interviews using a questionnaire to collect information on farmers' observations and perceptions on climate change, levels of awareness on climate change, causes of climate change, adaptation strategies, and barriers to climate change adaptation. Two hundred and forty (240) farmers were randomly selected for an interview with assistance from agricultural extension officers working under the Ministry of Food and Agriculture.

Focus group discussions (FGDs) were held for local people known to be experts in weather prediction. The FGD participants and key informants were purposively selected from seven (7) communities to understand the climate information needs of farmers and also find out the extent to which indigenous knowledge has been helpful to predict rainfall. Processing of data was done using descriptive statistics shown in tables, graphs, and charts.

3. Results

The general perception among farmers in Yendi is a view of rapid changes occurring in climate over decades which is the source of harsh climatic conditions that negatively affect farming. Study results show the majority of the farmers (86.3%) noticed the climate is changing, while (9.5%) said the climate is not changing. A few (3.5%) were not sure about changes in the climate despite the annual variations in the pattern

Table 1: Study communities

Community	Population	Sample Size	Number of People in Focus Group
Dagbanjado	1,548	34	4
Sukaani	1,057	23	5
Bagbani	643	19	4
Kpaatia	1,154	21	5
Kulkpanga	1,650	46	8
Tindang	1,502	38	7
Yendi	51, 335	59	12
Total	**58,889**	**240**	**45**

of rainfall characterised by a decline in precipitation even in months when rain is expected, a situation that has resulted in a much drier Northern Savannah zone. When the farmers were asked about specific observations on the frequency and amount of precipitation in a year, 64.1% mentioned a decrease in precipitation in the past 30 years. Still, a few of them 2.8%, said rainfall rather increased. Those who did not notice any change in rainfall and said the rainfall pattern is somehow irregular were 11.4% 1.2%, respectively. Please refer to Figure 1.

As far as change in temperature is concerned (Figure 2), 58.3% of the farmers said the temperature is rising, and 2.6% perceived a decrease in temperature. Those who said there is no variation in temperature were 14.6%, and 20.4% of the farmers perceived fluctuations in monthly and daily temperatures.

3.1. Awareness of climate change

When farmers were asked about the sources of information available to them on radio and television, 50% of them rated their source of information from media as a 'medium' level of awareness on climate change. Their explanation of what a medium level of awareness means is getting information at least once every six months from a media source. The response of farmers to awareness of climate change is shown in Figure 3.

Those with a low level of awareness constitute 29.6%, and they obtain information at least twice a year on climate change. A few of them, 20.4%, had a high level of awareness of climate change as a result of the occasional visit of agricultural extension officers who educated them on what to do to cope with climate change.

3.2 .Causes of climate change

The farmers mentioned multiple causes for climate change, including superstitious beliefs, seasonal changes, farming practices, and the destruction of trees. Destruction of trees is perceived to be the most common cause of climate change, according to 47.5% of the farmers. The farmers have observed that the absence of trees prevents cloud formation, a requirement for rainfall. Others believed there are supernatural forces such as local gods that can stop the rain from falling whenever the iniquities of communities become unbearable, as mentioned by 22.5% of the farmers (Figure 4).

Those who claimed they do not know the causes of climate change were 12.5% of the respondents. Poor farming practices were mentioned by 10% of the farmers as the cause of climate change, and change in wind direction was mentioned by 5% of the farmers as the cause of climate change. Farmers believe that unfavourable wind directions do not enhance the formation of rain-bearing clouds that cause rain to fall. Others (2.5%) believe that change of seasons from wet to dry naturally causes dry, hot conditions, which is a natural event that cannot be attributed to climate change.

3.3. Adaptation strategies by farmers

Farmers in Yendi Municipality, like many other small-scale farmers in the world, have been adapting to cli-

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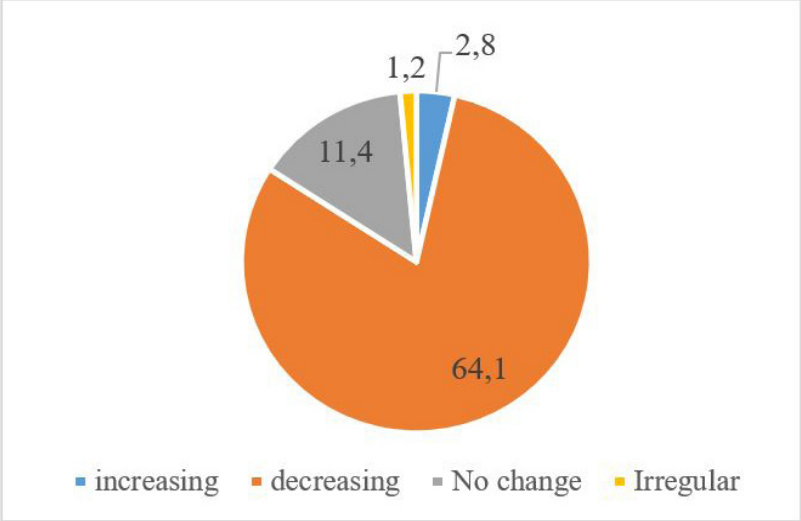

Figure 1. Farmers' perception on precipitation

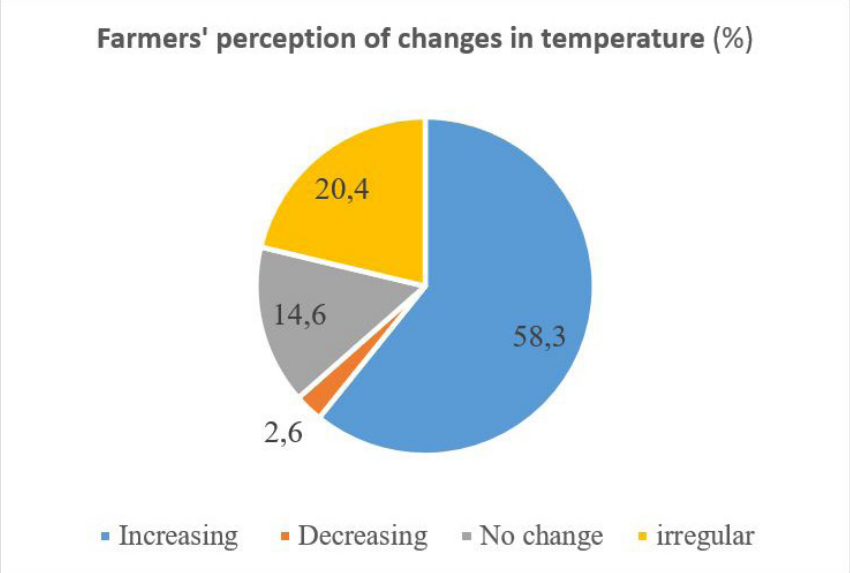

Figure 2: Farmer's perception of change in temperature

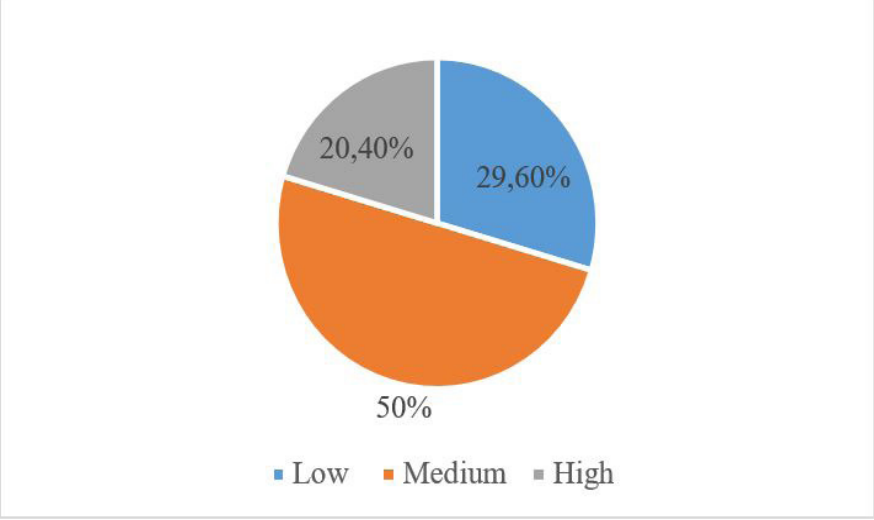

Figure 3: Farmer's awareness about climate change

mate change for many years through improved farming practices. The data shows a majority of farmers affirm they take some actions to cope with climate change. In all, about 92% said they take measures to adapt to climate change, while 8% of the respondents said they take no adaptive measures to cope with climate change.

In a follow-up question to find out what specific adaptation initiatives are implemented, different measures were mentioned, such as the use of chemical fertilisers and a shift from crop cultivation to animal rearing (Figure 5). The most common adaptation measure to climate change is a move away from cultivating crop varieties that cannot cope with water stress to drought-resistant crop varieties that mature in a short rainy season, as mentioned by 42.08% of the farmers. Examples of drought-tolerant crops mentioned are special millet varieties and the cultivation of more vegetables than cereals such as pepper that can be harvested in few months before droughts become severe. Other farmers (20.83%) adapt to climate change by timing themselves to take advantage of the rainfall to plant their crops. The planting dates are critical because a misjudgement will amount to the loss of seedlings. Expansion of agricultural lands is another adaptation strategy meant to cope with climate change, as 12.91% of the respondents believe extending or changing land cultivated from infertile lands to more fertile forest soils will help increase farm yields.

When it is impossible to expand farm sizes due to the absence of forest and woodlands, farmers apply chemical fertilisers to increase their yield, which was mentioned by 7.91% of them. When situations become unbearable due to climate change, most farmers migrate to cities to find menial jobs (Yaro et al, 2015). The construction of dams to irrigate farms is an adaptation method applied by 4.41% of the farmers. Rearing of animals instead of crop cultivation and diversification of livestock from high grass-eating ruminants to less grass-consuming animals amid drought conditions is an adaptation measure practised by 4.16% of the respondents.

3.4. Barriers to climate change adaptation strategies

Even though much effort is put into adaptation to cli-

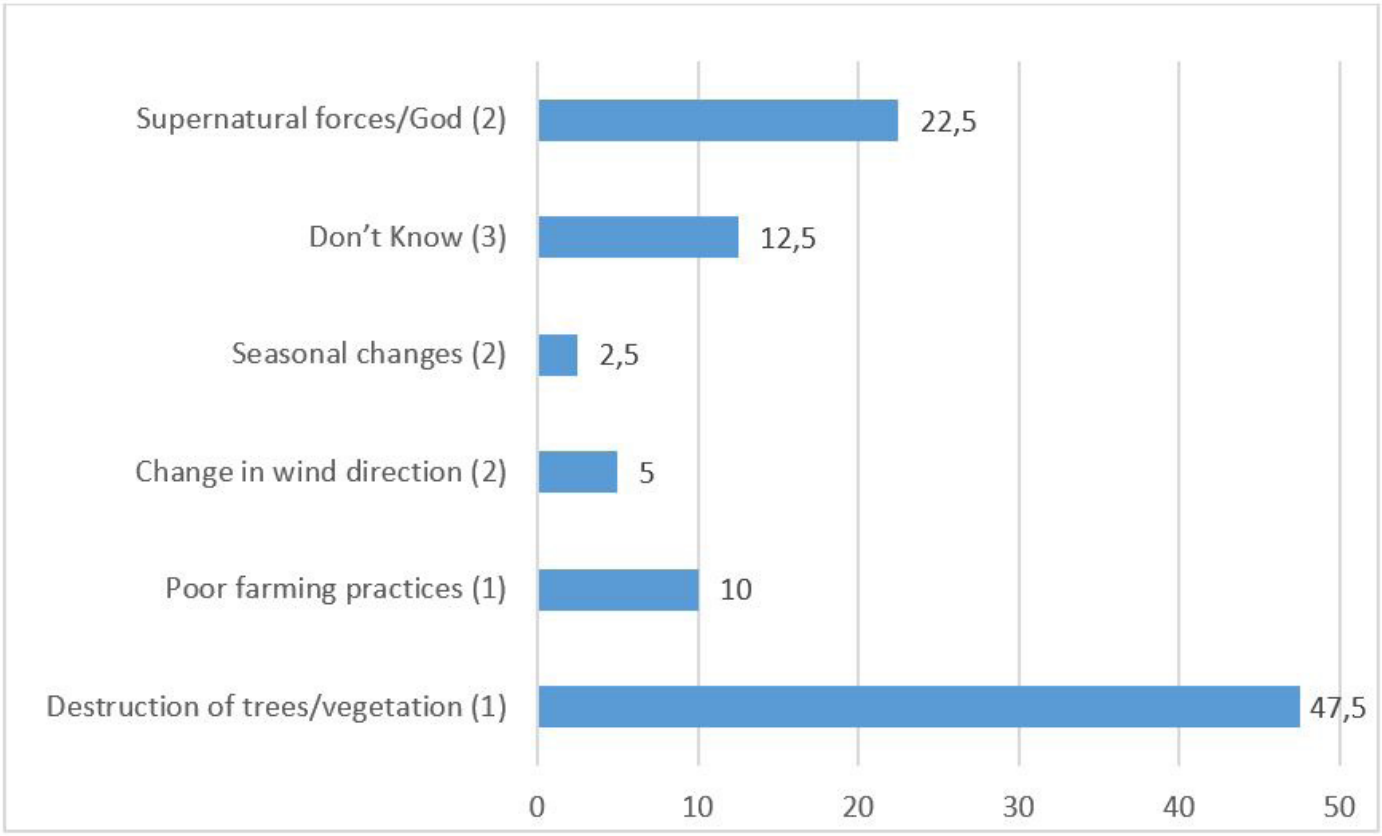

Figure 4: Perceived causes of climate change

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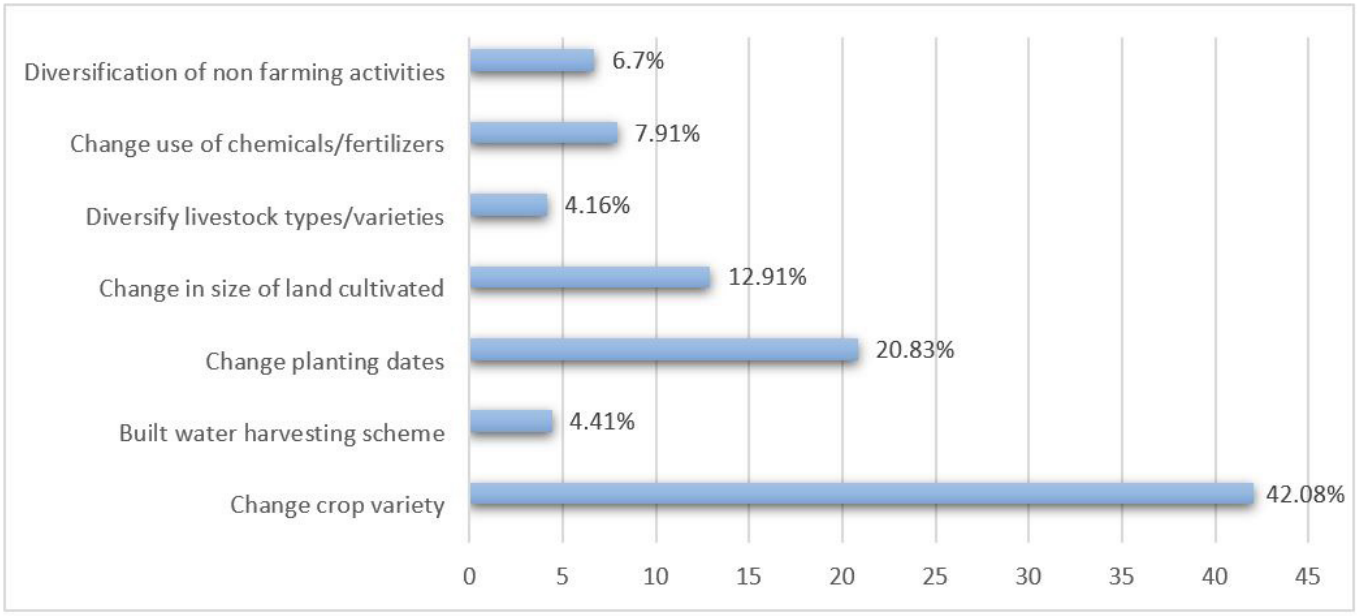

Figure 5: Types of adaptation practices of farmers in Yendi

mate change, there are some barriers to adaptation, such as lack of sufficient information on adaptation technologies and access to credit resources (Figure 6). The majority of farmers (51.9%) cited financial constraints as the main hindrance to climate change adaptation. Other challenges are lack of information (21.6%), inadequate access to irrigation facilities (9.5%), inadequate extension officers (9.4%), and insufficient access to infrastructure and inputs (7.6%). Information from a focus group discussion revealed a lack of access to weather forecast information as set back to climate change as farmers have no information to decide on the type of crop varieties to plant and the methods for planting as effective adaptation measures.

Agricultural extension officers who visit farmers to advise them on their farms are too few, given the ratio of extension officers to farmers in the Municipality (1: 200). Inadequate logistics and the lack of existing farmer co-operatives are seen as limiting adaptation to climate change.

While institutions are key to capacity building which helps farmers adapt better to climate change, they are not well resourced to build the capacity of farmers. When farmers were asked to suggest solutions to the challenges of adaptation to climate change 53.6% of the farmers cited financial assistance from the government. In comparison 10.2% said construction of irrigation facilities and recruitment of more extension officers was mentioned by 8.3% of them. Access to climate information was mentioned by (20.8%), and subsidising the price of farm inputs was suggested by 7.1% of the farmers.

3.5. Policies and incentives for climate change adaptation

Farmers made various suggestions on sustainable adaptation policies and incentives that will make them adapt better. Farmers believe formulation of a comprehensive adaptation framework for the Yendi Municipality, when well-coordinated, will serve the interest of farmers. A coordinated policy will ensure that farmers are assisted in producing and linked to the right markets for their products to be purchased. Government assistance to establish efficient irrigation systems will facilitate crop production during drought periods. The promise made by the ruling New Patriotic Party government to construct dams in every village in Ghana, if indeed implemented, would have helped farmers a great deal.

3.6. Ministry of food and agriculture's support for adaptations

The Ministry of Food and Agriculture (MOFA), whose responsibility is it to support farmers, has not been very successful in helping farmers as it is not

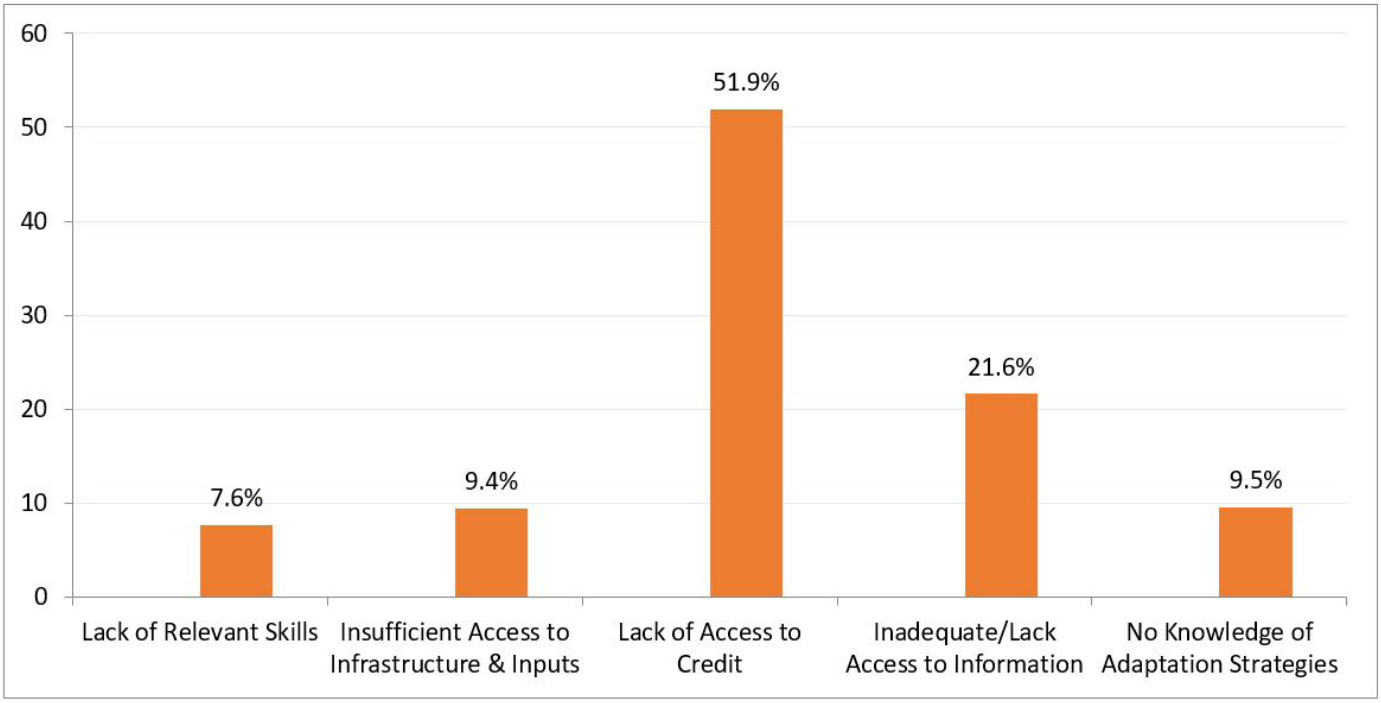

Figure 6: Barriers to climate change adaptation strategies

well resourced. The Ghana national adaptation plan was published in 2018, meaning it is very new and yet to be implemented. A focus group discussion held for farmers showed they have had support from MOFA in terms of technical support, which usually comes as educating farmers on best farm practices and supplying agro-chemicals. The education given to farmers includes bush fire prevention and correctly mixing and applying agro-chemicals on food crops, particularly maize and rice. Even though some credit facilities exist, they have so far not received any benefits. According to the agriculture extension agent for Kpaatia, farmers have not benefited from the credit scheme because they failed to form an association that gives farmers financial assistance as financial institutions find it is easier to recover loans from associations than individuals.

When farmers were asked to rank the kinds of support they preferred from the government, majority of them ranked financial support first (52.5%), followed by material support (35%) in terms of tools and agro-chemicals. Others mentioned technical support, which is the government's main support to increase farmers' output and adapt to climate change, as the least response. About 52.5% of farmers in favour of financial support believe this kind of assistance would help them mechanise their farms, purchase fertilisers, and improve seeds. Those who want material support favour the distribution of free seeds, pesticides, and fertilisers. Only 2.5% preferred technical support such as training to learn best farm practices which will equip them with the knowledge to improve their farming methods to cope with climate change adaptation.

4. Discussions

The general perception of farmers about climate change in the Yendi Municipality is that of a drier savannah zone where the soil moisture is either very limited or absent depending on the month of the year making it difficult or impossible to grow crops. It is also reported that the frequency of rainfall has declined, and temperature is increasing, a perception confirmed by the Ghana Meteorological Agency in 15 years (1997 - 2011). Similar studies in the Western Region of Ghana show farmers' perception of climate change focuses on a reduced frequency of rainfall and an increase in temperature (Acquah & Onumah, 2011). In other parts of the world, climate change is perceived as variability in rainfall and temperature

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(Jolly et al., 2002; Dhaka, Chayal & Poonia 2010).

Even though farmers are aware the climate has changed, there are many viewpoints regarding the causes, some of which can be based on science, such as destruction of trees/vegetation and poor farming practices that accelerate climate change, while others are based on superstition. Adaptation efforts of farmers to climate change in the Municipality are crop and animal diversification, expansion of farmlands, use of chemical fertilisers and agrochemicals to increase farm yields. Studies elsewhere show farmers resort to livelihood diversification, water harvesting schemes, crop diversification, planting of drought-tolerant crops, migration, and adjustment in planting dates as measures of adapting to climate change (Batterbury, 2004; Khan et al., 2009; Simbarashe, 2013; Nyantakyi-Frimpong, 2013; Liu et al., 2013). The vulnerability of farmers to climate change can be improved further when their capacity is built on climate change adaptation in addition to eliminating social, environmental, and cultural obstacles that hinder climate change adaptation (Sand, 2012; Raghuvanshi & Ansari, 2016).

As mentioned by 51.9% of the farmers in Yendi municipality, providing financial support and subsidies to farmers to buy fertilisers and agrochemicals is another way to adapt to climate change. The District municipal officer of MoFA explained that farmers need to organise themselves to take advantage of credit facilities since financial constraint is seen as a major setback to farmers and institutions who intend to adapt to climate change (Batterbury, 2004).

Lack of irrigation facilities has worsened the plight of farmers as they struggle to cope with climate change. The government's assistance can relieve farmers from the hardship of climate variability and enable them to cope with climate change when irrigation facilities are provided (Vidal, 2009). Government and private sector interventions are vital for farmers to be effective in adapting to climate change. It is projected that the impact of climate change will become severe such that traditional coping/adaptation mechanisms may not be sufficient to deal with these impacts (Rai, 2008).

Limited access to climate information has been a challenge to farmers when it comes to deciding on the type of crops to plant and crop cultivation methods. The availability and access to climate information would aid farmers to make informed decisions concerning their farm operations, but such information is often not available to them (Challinor et al., 2003: Kandji et al., 2006). According to Golnaraghi & Kaul (1995), in the case of Brazil, grain production in 1992 fell by 18% when the average precipitation also decreased significantly by 73%. This can be contrasted with grain production, which fell by 85% in 1987 with about 70% of average precipitation when climate forecasts were not applied.

5. Conclusions

This study concludes that farmers believe the climate has changed in the Yendi municipality with indicators of high temperature and irregular or decreasing precipitation, resulting in changes in the amount of crops produced that will affect food security in the near future. The main causes of climate change identified by the farmers in the study area are negative farming practices of cutting down trees, burning the bush during the dry season and belief in supernatural forces. Adaptation measures to climate change include diversification of crops and animal species. Farmers are ready to adapt their farming methods to cope with the changing trends they have observed but cannot do so due to barriers to adaptation to climate change, such as financial constraints and lack of access to weather information. The difficulty in adapting to climate change affects food supply and food security in Africa and Ghana in particular. Finally, the government of Ghana should put in operation the national climate adaptation plan document that was launched in 2018 to assist farmers to adapt to climate change.

Conflict of Interests

The authors hereby declare that there are no conflicts of interest in the gathering of data and preparation of this paper.

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Research Paper

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Application of check-all-that-apply (CATA) in sensory profile assessment of arabica dark roast and black pepper mixed coffee

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black pepper coffee; consumer profiling; brewing; rapid analysis

Black pepper coffee is one of the innovations in Bangka Belitung Province, Indonesia, with a warm characteristic due to the naturally occurring piperine compounds. This study aimed to assess black pepper coffee's sensory profile using the CATA (check-all-that-apply) rapid analysis method and to find the formula and brewing technique liked most by consumers. The study consisted of two stages: determining the sensory attributes of black pepper coffee and obtaining sensory data from coffee-consumers with different coffee and black pepper powder ratios (98:2; 96:4; and 94:6) and brewing methods (cold brew, drip V60 brew, and tubruk). The analysis used in this CATA included the Cochran's Q test, correspondence analysis, principal coordinate analysis (PCoA), and penalty analysis using the XLSTAT 2019 software. The results showed a total of 14 sensory attributes, including bitterness, acidity, sweetness, spiciness, caramel, black tea, dark chocolate, smokiness, hints of black pepper, hints of cinnamon, hints of ginger, hints of lemongrass, brown sugar, and body/mouthfeel. Statistical analysis showed that the addition of black pepper and type of brewing had a significant effect (5% level) on the sensory attributes of black pepper coffee, except for bitterness, spiciness, and hints of black pepper based on the Cochran's test. According to the panellists, the ideal black pepper coffee had acidity, sweetness, body/mouthfeel, spiciness, hints of black pepper, and bitterness, and the attributes of acidity, sweetness, and hints of black pepper were included as must-have attributes. Based on the overall analysis, cold brew coffee with 4% black pepper was close to the ideal black pepper coffee.

1. Introduction

Indonesia is the fourth largest coffee producer and exporter globally. Indonesian coffee production, such as arabica and Robusta, is expected to increase from 2019-2023, with an average growth of 1.43% per year (Widaningsih, 2019). Arabica coffee is a coffee type that has a strong aroma that is higher in acidity, sweetness, and commercial value, which makes Arabica coffee of superior sensory quality compared to other types of coffee (Dias & Benassi, 2015; Vignoli et al., 2014). Coffee beans are generally processed into coffee powder through roasting, where degrees of roasting affect the composition and amount of volatile compounds in the coffee beans responsible for a more robust aroma and taste (Somporn et al., 2011). The higher the roasting temperature, the lower caffeine and phenolic compounds such as chlorogenic acid (Fuller & Rao, 2017; Somporn et al., 2011; Vignoli et al., 2014). Apart from roasting, brewing methods such as decoction, infusion, and pressure methods are also essential factors that affect coffee's sensory

quality (Lopez-Galilea et al., 2007; Moroney et al., 2015; Ludwig et al., 2012). Alan (2015) reported that the drip brew method resulted in higher intensity for coffee flavour. Also, Asiah et al. (2017) explained that the decoction method is an authentic Indonesian dish and used as a standard in assessing the taste of coffee internationally by several coffee experts.

One of the innovations in ground coffee processing products is adding black pepper powder, such as the Kola-N brand by a producer of Nibung Jaya Abadi in Bangka Belitong Province. As one of the bioactive compounds in black pepper, the piperine content produces coffee with a characteristic warm taste. This black pepper coffee product has been marketed in Bangka Belitung Province, Indonesia, and has become one of Bangka Belitung's signature products. This Province is a top source for pepper production; in 2019, production reached 33,810 tonnes (Dirjen Perkebunan, 2020). However, there is no information or documentation regarding the black pepper coffee products' sensory quality characteristics. Research on consumer profiling on coffee needs to be conducted to produce ground black pepper coffee and a serving method to approach consumer preferences.

Consumer-based sensory evaluation methods widely used today are free-choice profiling, projective mapping, flash profiling, sorting, and check-all-that-apply (CATA). The CATA method is a fast and simple method of collecting information about the sensory profile of a food product based on consumer perceptions by providing a checklist for the presence of the sensory attributes in question (Ares et al., 2010). Several studies have used this method to assess the sensory value of coffee products, such as Espitia-López et al. (2019), Heo et al. (2019), Khairunnisa (2019), and Marusiva (2019). Several others have assessed the sensory profile of various food products using the CATA method, including Belusso et al. (2016) on processed fish products, Adawiyah & Yasa (2017) on commercial sweeteners, Ares et al. (2010) on chocolate milk dessert, Dooley et al. (2010) on vanilla ice cream products, Jorge et al. (2015) on processed meat products, Adawiyah et al. (2019) on green tea, Pramudya & Seo (2018) on cooked rice, Alencar et al. (2019) on wine, and Gordon (2019) on Mexican sauce. Apart from food products, the CATA method was also used in cosmetic products (Parente et al., 2014). This study aims to obtain a sensory analysis through rapid consumer profiling using the CATA method (check-all-that-apply) and a selected coffee blend through this CATA profiling method with several specified parameters for dark roast Arabica and black pepper mixed coffee *tubruk*.

2. Materials and Methods

The main ingredients used in this study were dark roasted Arabica beans from Gunung Halu (West Bandung, West Java) and Bangka's black pepper powder. The treatments included a combination of the ratio of arabica coffee and black pepper powder (98:2 (A1); 96:4 (A2); and 94:6 (A3)) and the brewing method (cold brew (B1), drip V60 brew (B2), and *tubruk* (B3)) (modification of Fauzi et al., 2019). Dark roasted Arabica coffee beans were ground with a fine fineness. For brewing, the ratio of coffee used was 1:15, where 10 grams of coffee were brewed in 150 mL of water at 92 °C (Asiah et al., 2017).

Cold brew coffee was made as follows: ground black pepper coffee was poured into the container, followed by water. The mixture was covered tightly and stored at 10°C for 12 hours. The extract was filtered into another container using Hario VCF size 02 coffee filter paper and a glass funnel.

For drip brew coffee, ground black pepper coffee was put into coated V60 with a glass filter. Hot water at 92 ° C was poured in a circular motion to stir the coffee perfectly. The brewing time was 2-3 minutes.
And *tubruk* coffee was made by brewing hot water at 92 °C directly on the coffee grounds in a glass cup. After 4 minutes, the mixture was stirred evenly.

2.1. CATA (Check-All-That-Apply) method for sensory profiling

2.1.1. Determination of sensory attributes

The attributes determination used in the questionnaire list of the CATA method can be obtained by Focus Group Discussion (FGD) (Dooley et al., 2010). The FGD consisted of eight coffee baristas (five certified and three non-certified baristas) active in coffee cupping events with more than one year of experience, plus one moderator. The moderator only oversaw the discussion, acted as a facilitator, and prepared all the

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panellists' needs such as samples, mineral water, test sheets, and other necessities. All baristas tested the samples and used SCAA (2015) as a reference to set the attributes of the coffee. They performed organoleptic testing twice, and all the results were collected, then the obtained results were discussed again to determine the most likely attribute.

2.1.2. Data retrieval

The panellists used were 50 black pepper coffee-consumers(Moskowitz, 1997). In this study, some of the panellists did have training on sensory evaluations; therefore, there was a description of sensory attributes to facilitate the panellists' understanding of sensory testing. Before tasting the sample, the panellists were asked to check the sensory attributes that best described their perception of the ideal black pepper coffee's sensory profile. Then the panellists tasted the samples and rated the coffee samples' likeness intensity scores on a 9-point Likert scale (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like or dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely). After that, the panellists tasted the sample once more and assessed sensory attributes in the coffee sample by placing a checkmark on the questionnaire. During testing, panellists were welcome to rest if needed and were not given a time limit.

2.2. Data Analysis

XLSTAT 2019 software with CATA analysis tools and preference mapping was used for data analysis in the CATA (Check-All-That-Apply) method. The resulting data analysis was in Cochran's Q test, correspondence analysis, Principal Coordinate Analysis (PCoA), and penalty analysis. The preference mapping tools in XLSTAT 2019 were used to obtain complementary data.

3. Results

3.1. Determination of sensory attributes in focus group discussion (FGD)

The FGD method is one of the most useful qualitative methods to obtain a sensory description of a food product. In this study, panellists determined the sensory attribute terminology to equate perceptions of the concept of sensory attributes between one another (Kemp et al., 2009). The decisions or discussion results were taken directly by the panellists, namely eight coffee baristas, without any intervention from the moderator, as shown in Table 1.

Table 1. Sensory attributes based on the results of the Focus Group Discussion

No	Sensory attribute	Description
1	Bitter	The bitter taste of coffee
2	Acidity	The sour taste of coffee
3	Sweetness	The pleasant sweetness of coffee
4	Spicy	Spicy taste that tends to be warm
5	Caramel	The taste and aroma is like caramel from the caramelization process
6	Black Tea	The taste and aroma of black tea
7	Dark Chocolate	The taste and aroma of bitter chocolate
8	Smoky	The taste and smell are similar to those found in baked goods, such as the smell of smoke produced when burning wood.
9	Hints of Blackpepper	The taste and aroma sensation of black pepper
10	Hints of Cinnamon	The taste and aroma sensation of Cinnamon
11	Hints of Ginger	The taste and aroma sensation of Ginger
12	Hints of Lemongrass	The taste and aroma sensation of lemongrass
13	Brown Sugar	The aroma of brown sugar
14	Body/Mouthfeel	Thick or full sensation in the mouth

3.1. Panellist profile in data retrieval

The panellist profile in this research can be seen in Figure 1. Fifty consumer panellists were included in this study, with a 60% male and 40% female ratio. According to Moskowitz (1997), at least 40-50 panellists are required to reduce bias in the obtained data in the sensory test. The panellists' were between 21 to 55 years old, with educations levels ranging from high school to master degree, with the majority possessing a bachelor education.

3.3. Sensory profile of black pepper coffee

The Cochran's Q test with Marascuilo multiple pairwise comparisons compares each sensory attribute in each sample with a test level of 5% (Meyners et al., 2013). This result is described in Table 2.

The Cochran's Q test with Marascuilo multiple pairwise comparisons is used to construct a correspondence analysis. The correspondence analysis represents the ideal black pepper coffee and black pepper coffee samples profile in a biplot map according to their sensory attributes (Meyners et al., 2013). This analysis can be seen in Figure 2.

Preference mapping is a technique that links acceptance data (hedonic data) with sensory characteristics of products (descriptive data) to determine product characteristics that affect consumer preferences (Martínez et al., 2002). Preference mapping data analysis in Figure 3 depicts the percentage of panellists who give preference values above average. The contour plot shows the regions corresponding to the various preference consensus levels on a chart with the same axes as the preference map. The preference level is expressed as a percentage (%), and each colour has a different percentage (Manik et al., 2016). In the regions with cold colours (blue), a low proportion of models give high preferences. The regions with hot colours (red) indicate a high proportion of models with high preferences.

The Principal Coordinate Analysis (PCoA) graph illustrates the correlation between the sensory attributes and the panellists' preferences for black pepper coffee samples. This analysis can be seen in Figure 4.

Penalty analysis on the CATA method can only be done if preferred data are available (Meyners et al., 2013). Based on the penalty analysis results on XLSTAT software, there are five sensory attributes: must-have, nice to have, must not have, does not harm, and does not influence. A sensory attribute has the potential to become a must-have sensory attribute if the sensory attribute has a condition P (No) | (Yes) of more than 20% and a positive mean drops value. The analysis curve of the must-have attributes can be seen in Figure 5.

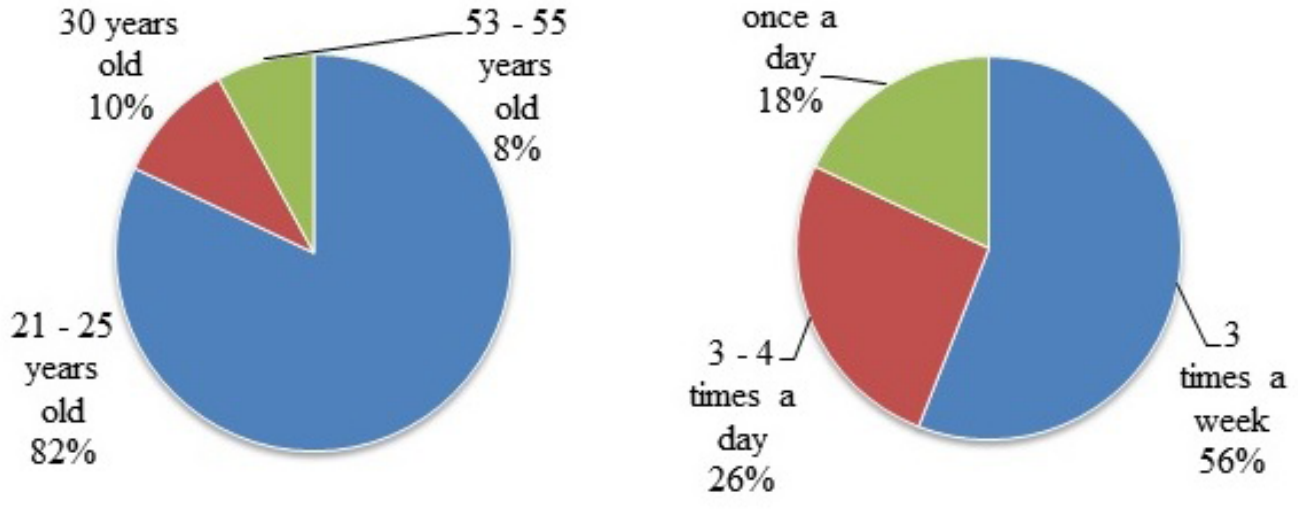

Figure 1. Profile of coffee-consumers based on (a) the panellists' age, and (b) frequency of coffee consumption

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Table 2. The Cochran's Q test with Marascuilo multiple pairwise comparisons

Attributes	A1B1	A2B1	A3B1	A1B2	A2B2	A3B2	A1B3	A2B3	A3B3
Bitter	0.920^{a}	0.960^{a}	0.960^{a}	1^{a}	1^{a}	1^{a}	1^{a}	1^{a}	1^{a}
Acidity	0.38^{ab}	1^{d}	1^{d}	0.540^{bc}	0.360^{ab}	0.180^{a}	0.780^{cd}	0.680^{bc}	0.160^{a}
Sweetness	0.500^{abcd}	0.920^{e}	0.740^{cde}	0.800^{de}	0.560^{bcd}	0.360^{ab}	0.480^{abc}	0.380^{ab}	0.180^{a}
Spicy	0.780^{a}	0.940^{a}	1^{a}	0.800^{a}	1^{a}	0.960^{a}	1^{a}	0.960^{a}	0.960^{a}
Caramel	0^{a}	0^{a}	0^{a}	0.800^{d}	0.740^{cd}	0.560^{bcd}	0.380^{b}	0.620^{bcd}	0.460^{bc}
Black tea	0.400^{abc}	0.180^{a}	0.880^{d}	0.680^{cd}	0.240^{a}	0.280^{ab}	0.840^{d}	0.640^{bcd}	0.740^{d}
Dark chocolate	0.100^{a}	0.200^{a}	0.460^{b}	0.700^{bc}	1^{d}	1^{d}	0.880^{cd}	1^{d}	0.860^{cd}
Smoky	0^{a}	0^{a}	0^{a}	0.440^{b}	0.660^{b}	0.760^{b}	0.760^{b}	0.840^{b}	0.500^{b}
Hints of black pepper	0.820^{a}	1^{a}	1^{a}	1^{a}	1^{a}	1^{a}	1^{a}	1^{a}	1^{a}
Hints of cinnamon	0.820^{d}	0.920^{e}	0.980^{e}	0.340^{ab}	0.500^{b}	0.220^{a}	0.140^{a}	0.140^{a}	0.100^{a}
Hints of ginger	0.520^{b}	0.180^{a}	0.560^{bc}	0.900^{d}	0.900^{d}	0.760^{bcd}	0.840^{bcd}	0.860^{cd}	0.620^{bcd}
Hints of lemongrass	0.540^{bc}	0.220^{a}	0.860^{cd}	0.480^{ab}	0.320^{ab}	0.240^{ab}	0.800^{cd}	0.860^{d}	0.540^{bc}
Brown sugar	0.680^{cde}	0.080^{a}	0.480^{bcd}	0.100^{a}	0.780^{e}	0.760^{de}	0.100^{a}	0.300^{abc}	0.200^{ab}
Body/Mouthfeel	0.140^{a}	0.620^{b}	0.940^{cd}	0.640^{bc}	0.580^{b}	0.940^{cd}	1^{d}	1^{d}	1^{d}

Note: A1B1: different letter in a line shows significant difference at 5% level
Arabica and black pepper ratio of 98:2 with cold brew method
A1B2: Arabica and black pepper ratio of 98:2 with drip V60 brew method
A1B3: Arabica and black pepper ratio of 98:2 with tubruk method
A2B1: Arabica and black pepper ratio of 98:4 with cold brew method
A2B2: Arabica and black pepper ratio of 98:4 with drip V60 brew method
A2B3: Arabica and black pepper ratio of 98:4 with tubruk method
A3B1: Arabica and black pepper ratio of 98:6 with cold brew method
A3B2: Arabica and black pepper ratio of 98:6 with drip V60 method
A3B3: Arabica and black pepper ratio of 98:6 with tubruk method

Meanwhile, a sensory attribute has the potential to become a nice-to-have or must-not-have sensory attribute if the sensory attribute has a condition P (Yes) | (No) of more than 20%, where positive mean drops are categorised as a nice-to-have sensory attribute, and negative mean drops is a must-not-have attribute. This curve analysis is described in Figure 6.

4. Discussion

Cochran's Q test results in Table 2 show that each sample's sensory attributes are significantly different at the 5% level, except for bitter, spiciness, and hints of black pepper attributes. Various brewing techniques and the addition of black pepper concentrations in coffee cause differences in each coffee brew's sensory characteristics. Pratama (2017) reported that black pepper, diluted at 1: 200000, still left a distinctive piperine flavour. Piperine has stable properties (Hamrapurkar et al., 2011) so that all black pepper coffee samples with the treatment combination left the attributes of spiciness and hints of black pepper. The darker the coffee roasting profile, the greater the bitter taste character produced; therefore, all treatment combinations still leave a bitter taste in dark roast Arabica coffee.

According to panellists, perceptions regarding the sensory profile of ideal black pepper coffee are illustrated by the correspondence analysis map in Figure 2. Ideal black pepper coffee in quadrant 1 has acidity, sweetness, spiciness, hints of black pepper and bitterness. The closest sample to the ideal black pepper coffee product is cold brew coffee with 4% and 6% black pepper concentrations. While cold brew coffee with 2% black pepper in quadrant 4 has dominant hints of a cinnamon attribute. *Tubruk* black pepper coffee with black pepper of 2%, 4%, and 6% and V60 coffee with 2% black pepper in quadrant 2 have dominant black tea, hints of lemongrass, dark chocolate, and body/

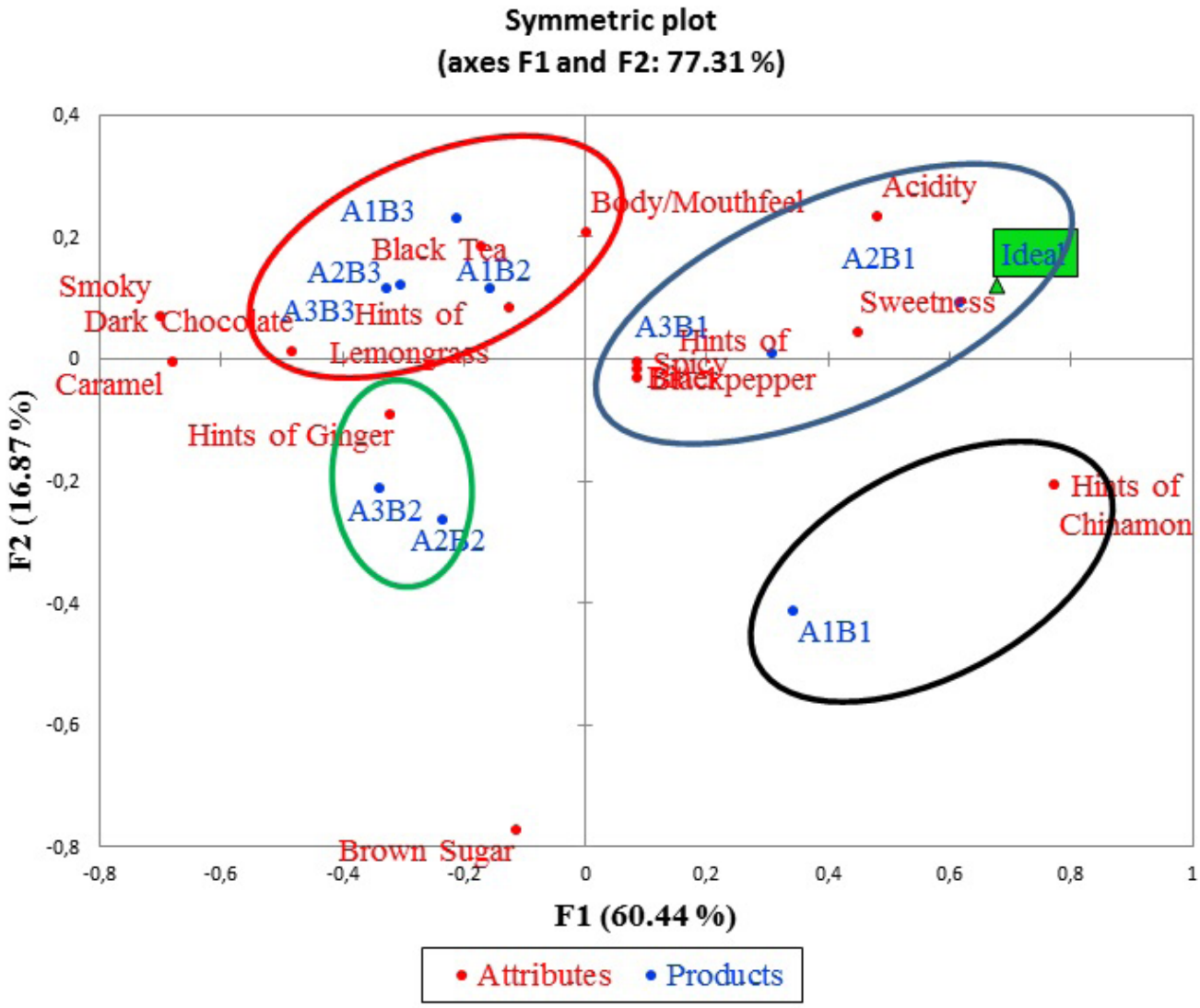

Figure 2. Representation of the ideal black pepper coffee sensory profile

Note: A1B1: Arabica and black pepper ratio of 98:2 with cold brew method
A1B2: Arabica and black pepper ratio of 98:2 with drip V60 brew method
A1B3: Arabica and black pepper ratio of 98:2 with tubruk method
A2B1: Arabica and black pepper ratio of 98:4 with cold brew method
A2B2: Arabica and black pepper ratio of 98:4 with drip V60 brew method
A2B3: Arabica and black pepper ratio of 98:4 with tubruk method
A3B1: Arabica and black pepper ratio of 98:6 with cold brew method
A3B2: Arabica and black pepper ratio of 98:6 with drip V60 method
A3B3: Arabica and black pepper ratio of 98:6 with tubruk method

mouthfeel attributes. V60 black pepper coffee with 4% and 6% black pepper in quadrant 3 have the dominant hints of a ginger attribute. Brown sugar, smokiness, and caramel are the minor attributes based on Figure 2. In addition, the quality of the analysis is sufficient (almost 80% of explained total inertia on the first two dimensions).

Figure 3 shows that many models (80% - 100%) give preference values above the average for cold brew black pepper coffee with black pepper concentrations of 2% in quadrant III and 4% and 6% in quadrant II. For black pepper coffee prepared in V60 and *tubruk* brewing techniques with a black pepper concentration of 2%, 4%, and 6%, a low proportion of models

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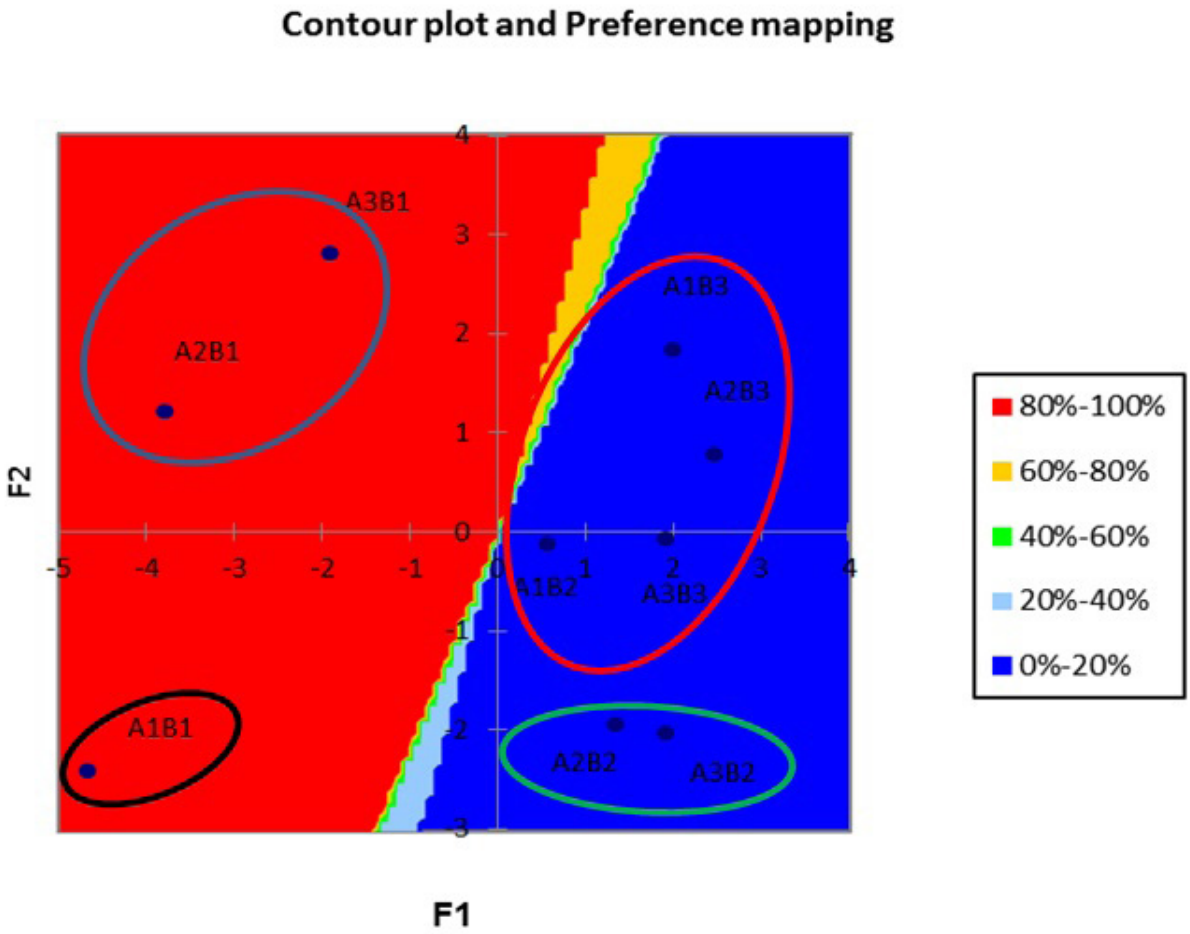

Figure 3. Panellists' preference map of black pepper coffee samples

Note: A1B1: Arabica and black pepper ratio of 98:2 with cold brew method
A1B2: Arabica and black pepper ratio of 98:2 with drip V60 brew method
A1B3: Arabica and black pepper ratio of 98:2 with tubruk method
A2B1: Arabica and black pepper ratio of 98:4 with cold brew method
A2B2: Arabica and black pepper ratio of 98:4 with drip V60 brew method
A2B3: Arabica and black pepper ratio of 98:4 with tubruk method
A3B1: Arabica and black pepper ratio of 98:6 with cold brew method
A3B2: Arabica and black pepper ratio of 98:6 with drip V60 method
A3B3: Arabica and black pepper ratio of 98:6 with tubruk method

(0% - 20%) give a preference value above average, where these coffees are in the blue areas in quadrants I and IV. This mapping analysis strengthens the correspondence analysis that the panellists prefer cold brew coffees with 4% and 6% black peppers. These coffees are the closest to the ideal black pepper coffee with the attributes of sweetness, acidity, spiciness, and hints of black pepper. Angeloni et al. (2019) reported that coffee's sensory characteristics with different extraction methods (drip, cold brewing, and French press) were different, and the extraction process and temperature influenced these different characteristics.

Based on the previous PCoA and the correspondence analysis, which is strengthened by contour plot and preference mapping, only the acidity, sweetness, and spiciness attributes have similarities to the ideal and affect the panellists' preferences. According to Figure 2 in the correspondence analysis results, the sample that closely matches the dominant attribute is cold brew coffee with 4% black pepper. Temperature is a factor in the brewing method that affects a suitable coffee extraction. Coffee, brewed at a low temperature, will tend to under-extract, so the resulting coffee has a bland to sour taste (Lingle, 2011). Also,

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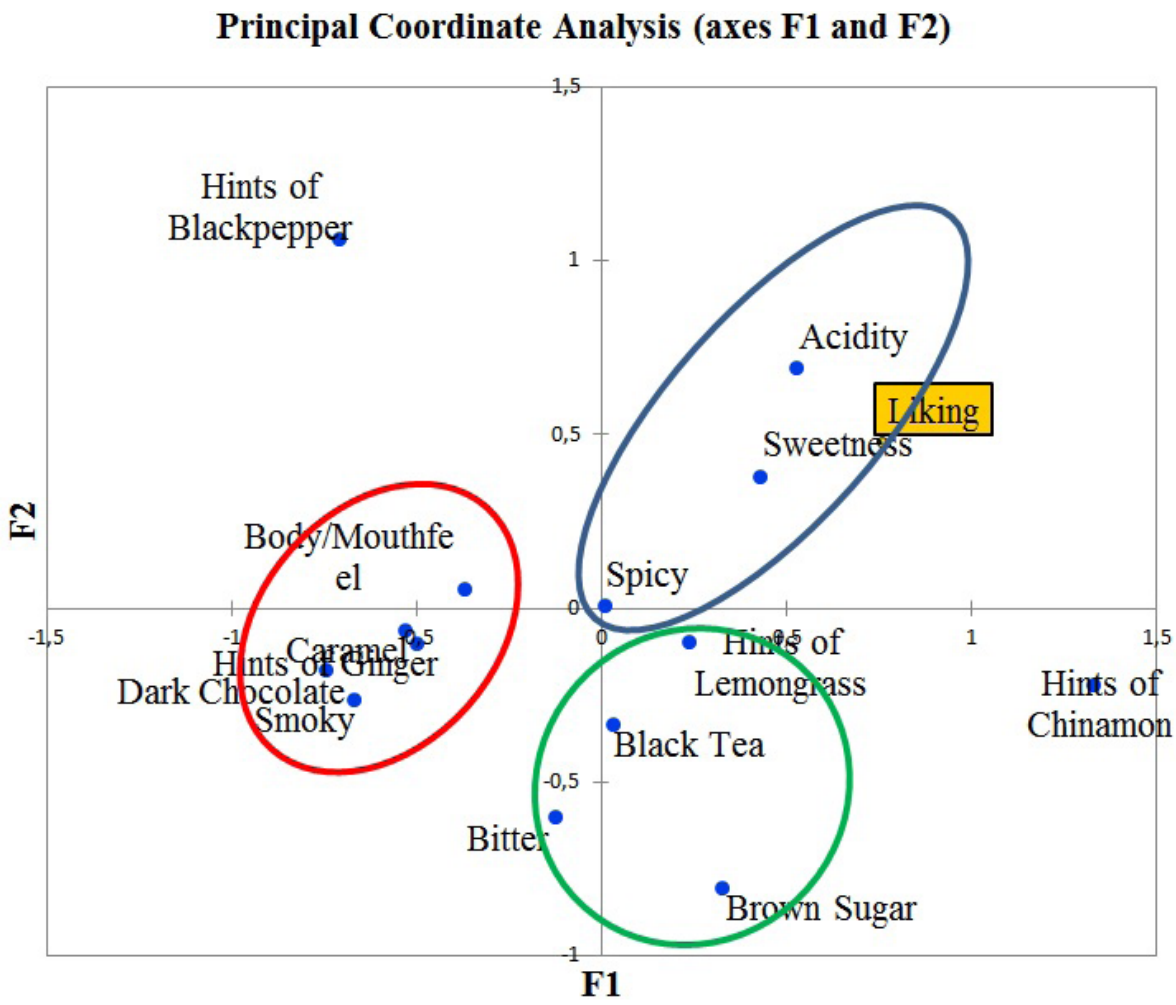

Figure 4.. Correlation plot of attributes and liking

cold-brew coffee has low acid and bitter characteristics (Baumann et al., 2012). The lower level of acidity in coffee with the cold brew method will result in a sweeter taste (Fuller & Rao, 2017; Angeloni et al., 2019). The addition of 4-6% black pepper makes for the right taste of spiciness.

Figure 5 shows three attributes are grouped as must-haves, namely the attributes acidity, sweetness, and hints of black pepper. According to the panellists, the attributes in this category must be contained in black pepper coffee products and have a positive impact on preferences. The must-have attribute is a sensory attribute that was not found in real market products, even though these sensory attributes were desired by panellists in ideal products (Meyners et al., 2013).

Figure 6 shows that the attributes of caramel, black tea, dark chocolate, smokiness, hints of ginger, hints of lemongrass, and brown sugar are classified as must-not-have; however, none of the attributes is classified as nice-to-have. The must-not-have attribute is undesirable in the development and has a negative impact on the Likert value.

Cochran's Q test, correspondence, and preference mapping analysis show an apparent relationship in black pepper coffee. It is a relationship that produces a selected black pepper coffee of 4% cold brew black pepper coffee with attributes of acidity, sweetness, and hints of black pepper.

5. Conclusion

Based on the research results, the differences in the concentration of black pepper and the brewing method significantly affected all sensory characteristics of black pepper coffee at the 5% level, except for the attributes of bitter, spiciness, and hints of black pepper. According to the panellists, the ideal black pepper coffee perception before tasting the sample was black

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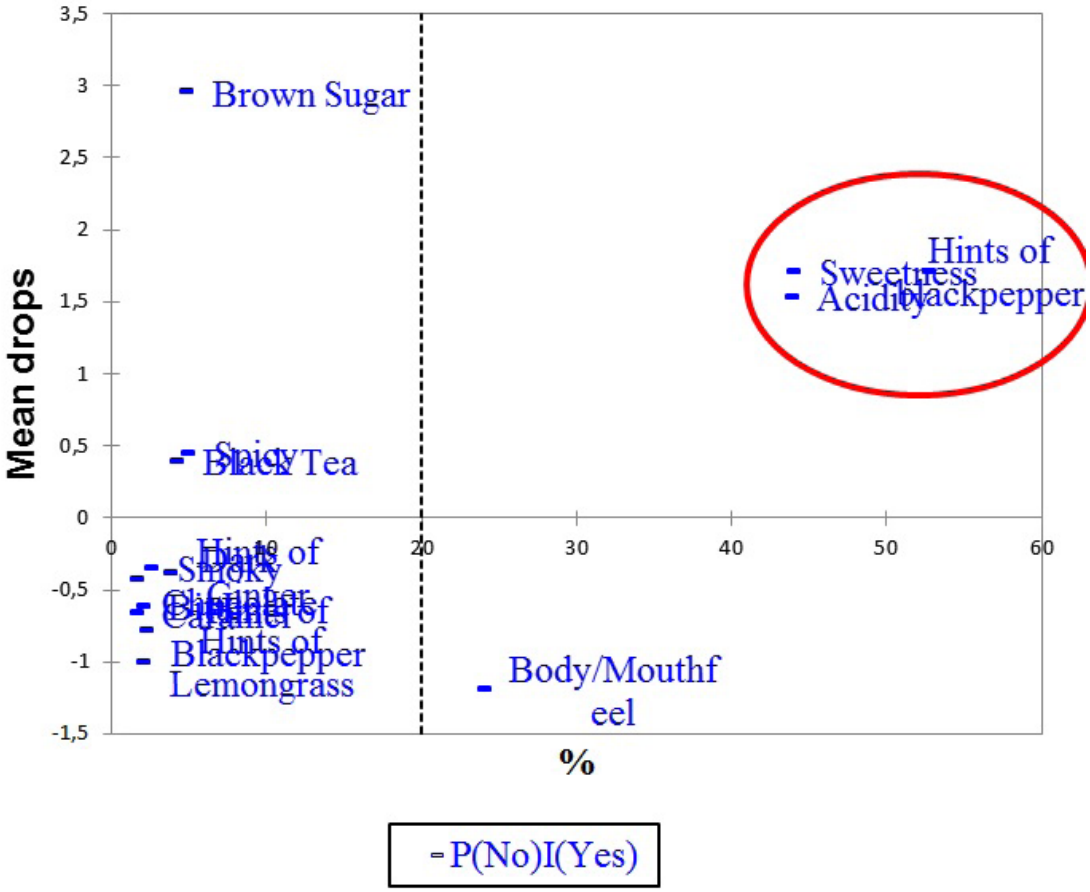

Figure 5. Analysis curve for must-have attribute

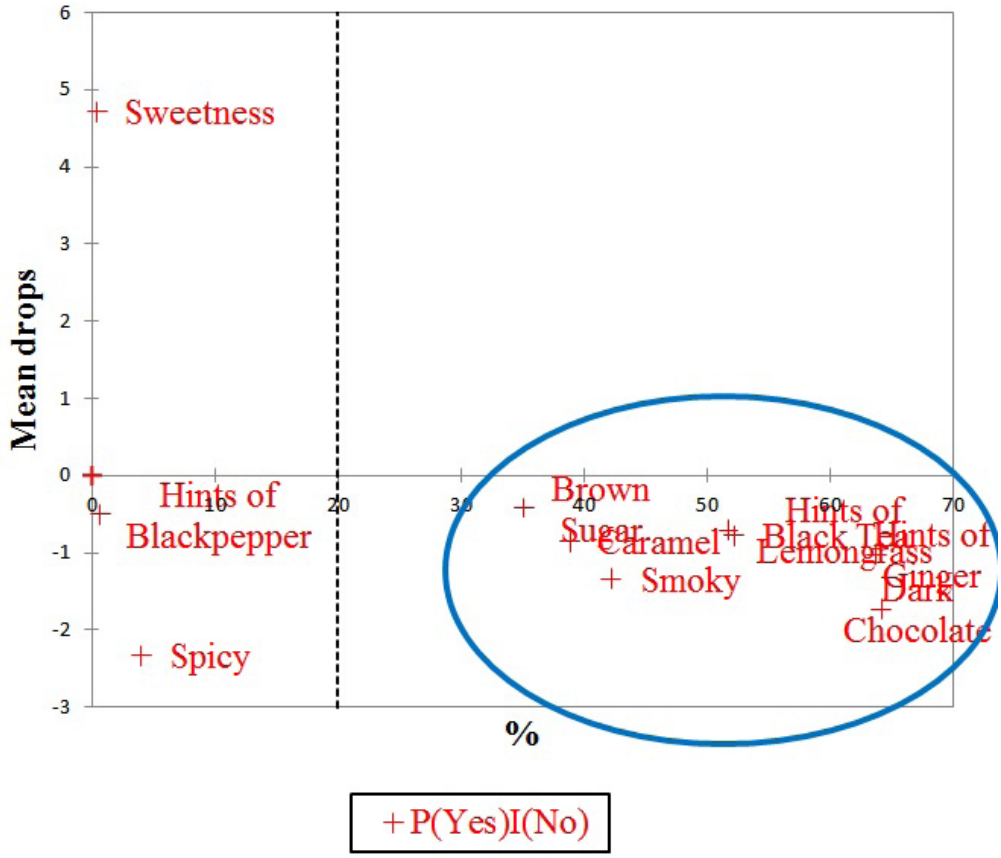

Figure 6. Analysis curve for nice-to-have and must-not-have attributes

pepper coffee with acidity, sweetness, body/mouth-feel, spiciness, hints of black pepper, and bitterness. The attributes that affected preference after tasting the sample were acidity, sweetness, and spiciness. Based on penalty analysis, the attributes of acidity, sweetness, and hints of black pepper were in the must-have category. The sample close to the ideal attribute and favourite was cold brew coffee with 4% black pepper.

Conflict of interest

The authors declare no conflict of interest.
The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Plant breeding and sustainable farming

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Sustainable agriculture is based on various animal and plant production practices that guarantee nutritious human food, enhance environmental quality, and conserve natural resources. However, producing food for the growing population has been a severe challenge since the beginning of farming 10000 years ago. The overuse of chemical fertilizers and pesticides during the Green Revolution (the 1960s and 1970s) helped increase crop yield. It almost ended hunger in many countries even though the disastrous effects of the chemicals on the environment and the scarcity of water and arable lands increased the hunger in the insanely increasing human population.

Plant breeding is a real hope that improves new varieties with higher yields, disease resistance, lower use of chemicals, better adapting to climate stress, reduced postharvest losses, and more healthy, nutritious, and fiber-rich food (Bailey-Serres et al. 2019). Conventional plant breeding is performed using several methods, including pure line selection, mass selection, and controlled mating. These methods have been valuable tools for plant breeders, but they are expensive, time-consuming, and most importantly, they have had limited success in improving complex polygenic traits. The average time to get superior lines for starting the selection is 3 to 7 years, depending on the crop and used strategy, and it usually takes 10 to 15 years of continuous work to start releasing the developed cultivars (Acquaah G. 2015). The main goal for the majority of the conventional breeding programs is essentially producing varieties of high performance under high-input farming systems, and these varieties do not yield high under low-input conditions. That causes excessive unresponsible use of these inputs, posing severe threats to humans, animals, the environment, soil, and groundwater.

Modern plant breeding, also known as molecular plant breeding, was started during the 1980s. The development of a plethora of plant molecular markers, new molecular methods, sophisticated statistical procedures, and computer software allowed the detection and use of specific molecular markers associated with quantitative trait loci (QTL) for complex traits. These advanced molecular techniques helped to improve the genetic architecture of crops. Marker-assisted selection (MAS) is one of the widely used methods in molecular breeding, and it uses phenotypical and DNA markers as selection criteria for selecting important traits in plant breeding. This process improves the efficiency of breeding programs and significantly reduces the time to produce the final varieties because it allows breeders to select the candidate plants that have the trait of interest, even when they are seeds. Genomic selection (GS) is another method of molecular plant breeding that predicts the genomic estimated breeding value (GEBV) of plant candidates from high-density markers positioned throughout the genome (Crossa et al., 2011). Unlike MAS, the GEBV is based on all markers, including minor and significant marker effects, and may capture more of the genetic variation for the particular trait and increase genetic gain.

Scientists have developed modern molecular tech-

nologies to help find new markers or genotype a high number of samples at a low cost and in a short time, such as Kompetitive allele-specific PCR (KASP) and Diversity Array Technology (DArT). New precision and high-throughput phenotyping tools are also being developed to lower the cost of assessing variety traits which will lead to improving the breeding schemes and eventually producing superior varieties that enhance the sustainability of agriculture farming.

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Can global warming liability turn into a profitable food security solution

Greenhouse emissions are considered the main driver of global warming. Among plenty of gases, the main two responsible for the greenhouse effect include carbon dioxide and methane.
Although carbon dioxide is highly emitted in the atmosphere, methane's effect on global warming is about 85 times as great over 20 years. The negative impact of methane extends beyond that to threaten the air quality and cause an estimated 1 million premature deaths annually worldwide due to respiratory illnesses. The concentration levels of methane have grown twice as fast as the concentrations of carbon dioxide since the beginning of the industrial revolution.

New hope on the horizon for converting the harmful greenhouse gas into a food security solution. A new promising innovative process can capture and transform methane, into protein-rich feed for farmed fish.
A first-of-its-kind analysis published by Stanford University explored how bacteria that are fed on captured methane grow into protein-rich fishmeal. A methane-consuming bacteria called methanotrophs can be grown in a chilled, water-filled bioreactor and can be fed pressurized methane, oxygen and nutrients such as nitrogen, phosphorus and trace metals. The resulting protein-rich biomass can be used as fishmeal in aquaculture feed.

Moreover, the researchers analyzed the economic part of the innovative solution. Fishmeal produced involving methane costs lower than the market price for traditional fishmeal. Therefore, this solution could be a profitable solution considering the increased demand for aquatic animals since 1960.
This study was funded by the Stanford Center for Innovation in Global Health and the Stanford Natural Gas Initiative.

Reference
Stanford University. (2021, November 22). Researchers reveal how to turn a global warming liability into a profitable food security solution. ScienceDaily. Retrieved November 28, 2021 from www.sciencedaily.com/releases/2021/11/211122135318.htm

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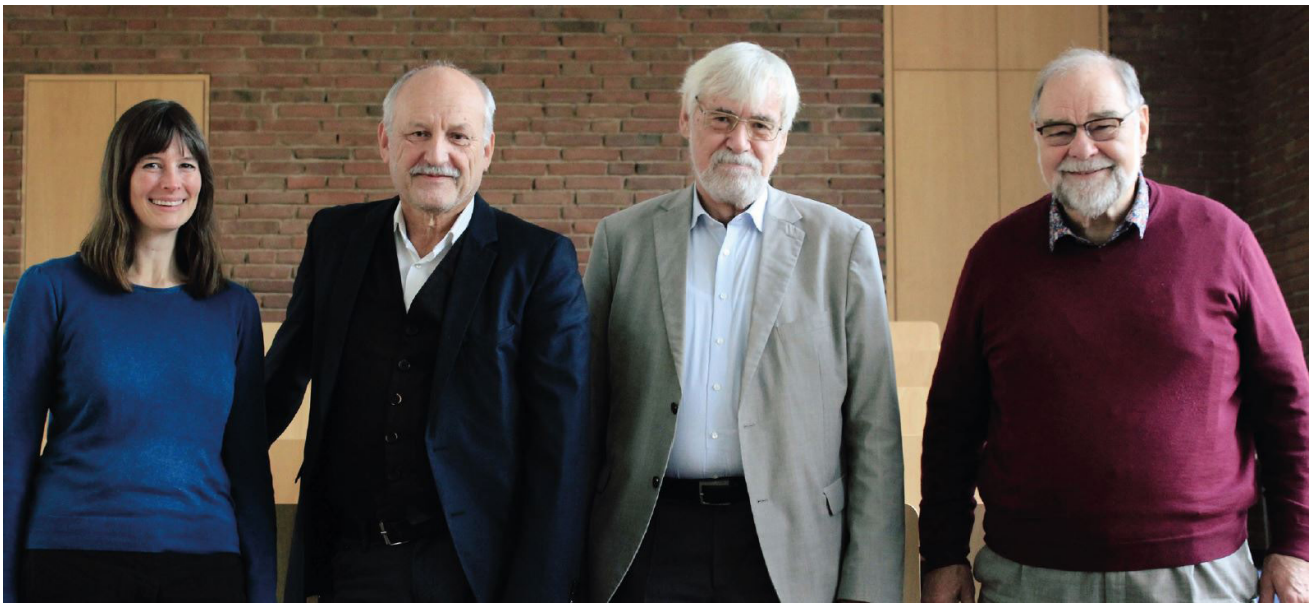
40 years of organic farming at the University of Kassel

Photo : Ines Reinisch



From left to right: Prof. Dr. Miriam Athmann, Prof. Dr. Jürgen Heß, Prof. Dr. Peter von Fragstein und Niemsdorff und Prof. Dr. Hartmut Vogtmann.

With the world's first professorship for organic agriculture, Hardy Vogtmann laid the foundation of four decades of teaching and research in organic farming at the University of Kassel in 1981. Today, about 1200 students are studying at the Faculty of Organic Agricultural Sciences at the University of Kassel, Witzenhausen.
Last October, the fortieth-anniversary of the Faculty of Organic Agricultural Sciences took place in Witzenhausen with well-known speakers who covered everything from the foundation to the present day.
The chairwoman of the host association, Prof. Dr. Angelika Ploeger, together with the dean of the faculty, Prof. Dr. Maria Finckh, welcomed around 120 guests who came to Werra from all over Germany. After the video greeting from the Hessian Agriculture Minister, Priska Hinz, three former students shared their experience of what it was like back then to fight for a chair for organic agriculture as an 'eco-freak'. After that, Prof. Dr. Ernst-Ulrich von Weizsäcker, who was president of the then comprehensive university 40 years ago, entertainingly presented the initial resistance in his opening lecture.
Prof. Dr. Hardy Vogtmann, the 'organic pope', gained at that time international fame as the holder of the first professorship for organic agriculture. "In order to further develop organic farming, transdisciplinary research that looks for sustainable solutions for agricultural problems is required", says Vogtmann.

The event was full of opportunities to meet and connect with other people and hold lively discussions not only during the breaks but also at the organic market, where a variety of regional organic products were presented.
The anniversary congress was organized by the Association for the promotion of a natural and socially compatible food and landscape culture with the cooperation of the Department of the Organic Agricultural Sciences, University Association and the North Hesse eco-model.
Recordings of the congress lectures can be found here:

https://www.youtube.com/channel/UC-3JUXAGW6DZxBPjjAC-4pw

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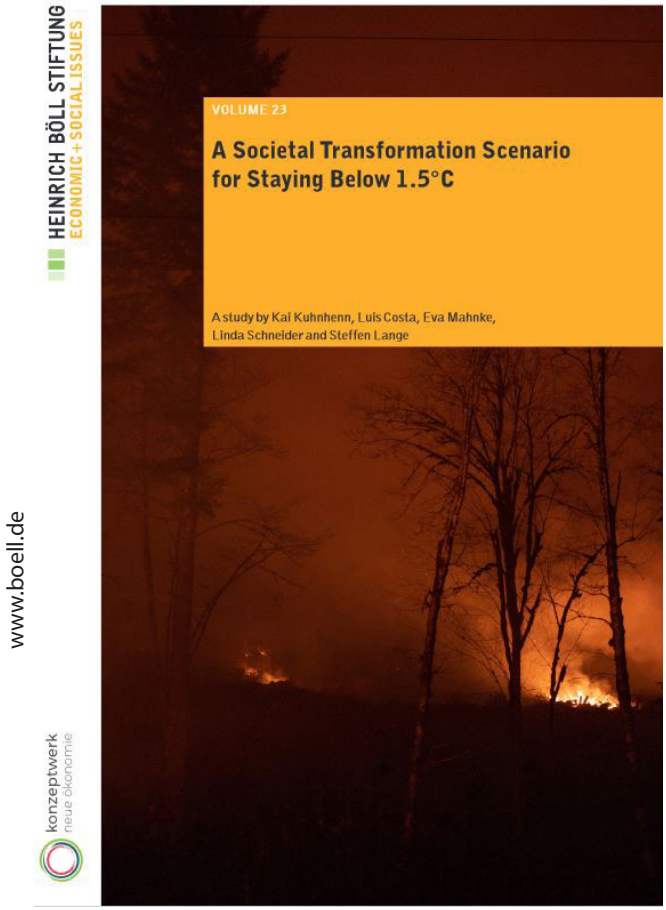
A Societal Transformation Scenario for Staying Below 1.5°C



The Societal Transfomation Scenario is a global 1.5°C mitigation scenario that challenges the notion of continued global economic growth and its compatibility with ambitious climate targets such as the 1.5°C limit. It shows how we can stay below 1.5°C by reducing production and consumption in the global North without resorting to risky technologies such as CCS, geoengineering and nuclear. There is an increasing urgency to develop global emission reduction scenarios that explore a broader societal transformation - including limiting production and consumption in key high-emitting sectors in the Global North.

A summary of the long version of the scenario is now available that brings together all the key points.

The long version can be found here:
https://www.boell.de/sites/default/files/2020-12/A%20Societal%20Transformation%20Scenario%20for%20Staying%20Below%201.5C.pdf?dimension1=division_iup

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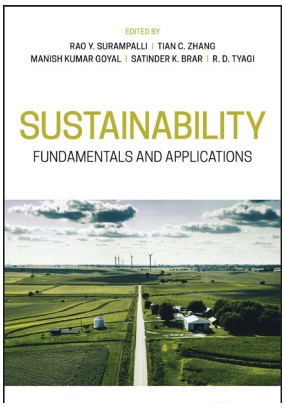

Sustainability Fundamentals and Applications

A review by Nayram Ama Doe

Authors (Eds.): Rao Y. Surampalli, Tian C. Zhang, Manish Kumar Goyal, Satinder K. Brar and R.D. Tyagi
Publisher: John Wiley & Sons Ltd
Published year: 2020
Language: English
ISBN: 978-1-119-43396-5
Length: 696 pages

In today's global world, global issues are given much attention of which sustainability falls in this category. This vital issue has increasingly become prominent both in education and practice. However, huge problems have emerged from our contemporary and modern-day practices, such as heightened exploitation of non-renewable energy sources and uncontrolled waste generation in different ways, which affect the concept of sustainable development. This book highlights topics regarding sustainability, such as basic concepts and issues of sustainability, challenges and solutions to sustainability and global forward steps to achieving sustainability.

This book is divided into three main chapters constituting diverse sub-topics for each chapter. Chapter one introduces sustainability and sustainable development, discussing important concepts and issues of sustainability. The sustainability concept is described as a "people-centred and conservation-based concept, that implies the development of the standard of human life by respecting nature's capacity to afford life-support facilities and resources".

Additionally, this sustainable concept is described as a normative one, exemplifying the standard for making decisions and actions which will be respected as the community and society endeavours to satisfy its needs of survival. Furthermore, some sustainability issues discussed in this chapter include ecological balance, climate change, health and safety of individuals and the environment and CO2 emissions. Some key actions discussed in dealing with these issues were stabilizing the ecosystem and enriching biodiversity to solve ecological balance issues. Also, minimising and reducing the pollution load in the environment by adopting green technology. In concluding this chapter, a specific definition cannot be assigned to the sustainable development concept due to its dynamic nature.

The second chapter of this book highlights the need, role and significance of sustainability. It specifically discusses the various approaches to achieving sustainability by taking into consideration the three main pillars of sustainability which are social, economic and environmental which form the foundation in dealing with crucial issues faced globally. Also, this chapter confers methods in creating and maintaining development without harming the mutually dependent pillars of sustainability. One interesting topic discussed by the author was a to-do list that emerged from the Sustainable Development Goals(SDGs) some of which include promotion of healthcare services, good sanitation, complete elimination of hunger and poverty, achieving gender equality and maintaining better standards of living.

The final and concluding chapter focuses on dimensions, intersections and knowledge platforms of sustainable development. This chapter aims at conferring an overall understanding and interpretation of sustainability. The focus of this chapter is to give a new stance, specifically one that will discover the deep conceptualizations of sustainable development. Also, this chapter examines briefly the social, economic, and environmental aspects of sustainability. In addition, the chapter underlines indicators of sustainable development jointly discussing the three main aspects and dimensions of sustainability. The final part of this chapter discourses the existing knowledge schemes for achieving sustainability and future avenues of the same.

Essentially, this book was precise, insightful and educative as it reveals and informs readers on the concept of sustainability and its important associated issues. It gives a comprehensive knowledge of the significance of sustainability as well

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as the role it plays on the road to achieving developmental goals. This book is recommended as a helpful resource in understanding the nuances of sustainable development.

About the author:

Nayram Ama Doe is a master's student at the University of Kassel and Fulda University of Applied Sciences, Germany, studying International Food Business and Consumer Studies. Her research focuses on food sustainability, international food legislation, agriculture, and food systems, and she is very passionate about food security and food supply chain issues.

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