VOLUME 10 NUMBER 1
WINTER 2022

ISSN-INTERNET: 2197-411X
OCLC-NR.:862804632

FOFJ

THE FUTURE OF FOOD JOURNAL

JOURNAL ON FOOD, AGRICULTURE & SOCIETY

Publisher

VDW VEREINIGUNG DEUTSCHER WISSENSCHAFTLER

UNIKASSEL VERSITÄT | ORGANIC AGRICULTURAL SCIENCES

SFS Sustainable Food Systems & Food Sovereignty

Future of Food: Journal on Food, Agriculture and Society

Volume 10, Nr. 1
February 2022

Published 25 February 2022

ISSN Internet	**2197 411X**
OCLC Number	**862804632**
ZDB ID	**27354544**

open access

Address
Future of Food: Journal on Food, Agriculture and Society
Specialized Partnerships in Sustainable Food Systems and Food Sovereignty,
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University of Kassel,
Nordbahnhofstrasse 1a,
D- 37213 Witzenhausen,
Germany.

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Official web page of the journal
www.thefutureoffoodjournal.com

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UniKassel & VDW, Germany-February 2022

Editorial

An eye on the status of food security in The Middle East and North Africa (MENA)

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Countries of the Middle East and North African region (MENA) share many features that impinge on food security. Their environments are primarily dry, and it originates from transboundary sources where surface water is available. Many have a limited natural capacity for agriculture and persistent gaps in government investment in agriculture. The MENA remain net food importers. Most rely on the global markets to provide at least 50% of people's food calories. The MENA are vulnerable to sudden global market conditions and geopolitical pressures such as embargos and sanctions mainly due to food import dependency. Negative impacts of climate change, such as reduced rainfall and temperature increases, further threaten local agricultural production annually.

Socio-economic realities vary across MENA and alter the ability of households and individuals to secure food. Their population is mainly young and rapidly urbanizing, pushing for income diversification and enhanced livelihoods outside of rural areas. Some unemployment rates are alarming among the highest globally – economic, social and resource inequality levels are outstanding. Moreover, the MENA collectively house the most significant number of internally displaced people and refugees worldwide. Internal or external conflicts, war, occupation, or profound economic and social crises were present before the onset of Covid-19. Conflict and economic crises have affected food security outcomes largely and deepened inter-country inequalities. Besides, there are significant intra-country variations in the levels of wellbeing and quality of life across the MENA. For instance, the Gulf countries are among the largest per capita GDP in the

ISSN-Internet 2197-411x OLCL 862804632

UniKassel & VDW, Germany-February 2022

world, while Yemen, Somalia, and Djibouti are among the poorest nations worldwide. These differences help to account for some of the variations in food and nutrition security status across and within the Middle East and North Africa.

Furthermore, the majority of the MENA share common weak outcomes of their food systems. Food security is the most critical outcome recorded among the economic, social, and environmental outcomes. The population of these regions suffer from the triple burden of malnutrition – the coincidence of undernutrition, overweight/obesity, and micronutrient deficiencies – and show some of the highest rates of obesity (27% of the regions are obese, double the global average), child stunting (22.5%), and anemia (35%) in the world (FAO et al., 2021).

As global food prices started to rise sharply, the concerns about food security in the MENA were triggered. While the Covid-19 pandemic has been causing perturbations that dwindle the poor food security status, many countries started to be aware of the need for transformation of food systems. The call for food sovereignty and the right to food came back to motion in many countries such as Lebanon (massive local initiatives) and Jordan (launching the National Food Security Strategy 2021-2030). More attention was put into food sovereignty as a potential answer for the crisis of unstable prices that could lead to a severe food security status.

Finally, yet importantly, the UN World Food Systems Summit (FSS) held in 2021 brought major ideas and actions: promoting initiatives aimed and overcoming difficulties and achieving healthier, more sustainable, and inclusive food systems, as well as delivering progress across all of the vastly delayed Sustainable Development Goals (SDGs). The food system's gendered and youth-oriented transformation is essential to ensure inclusivity and equity. Improving incomes on the basis of just and benefit-sharing is an important means of enhancing the affordability of healthy diets and leads to food security for all.

Reference:

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ISSN-Internet 2197-411x OLCL 862804632

Research Paper

Future of Food: Journal on Food, Agriculture and Society
10 (1) February 2022

Innovative formulation of oleogels using bioactive compounds and sal starch and characterization of their products

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Data of the article

First received : 15 September 2020 | Last revision received : 27 December 2021
Accepted : 15 January 2022 | Published online :15 February 2022
DOI : 10.17170/kobra-202110144899

Keywords

Sal Meal; Oleogel; Rice Bran Oil; Sesame Oil; Stability Studies

There is a focus on oleogels nowadays with low saturated fatty acids and zero trans fatty acids to substitute solid fats in various food formulations. The other advantage of using oleogels is that it can retain the individual oils' health benefits, especially the micronutrients as the processing does not involve high temperature. The present study used a blend of rice bran oil and sesame oil. Both the oils are rich in micronutrients, together with starch obtained from sal meal and lecithin as a gelling agent to produce oleogels. The novelty of the study includes using naturally derived starch moiety from sal meal as a gelling agent, which remains unutilized instead of commercially available starch. The gelator concentration was varied from 3-12%, and the six oleogels thus produced were characterized for their suitability as solid fats. Microscopic characteristics test for gelation, degree of hardness, XRD analysis, and storage stability studies were carried out. Results showed that oleogels prepared with 8 and 10% gelator displayed the most desirable properties compared to other oleogels. The gels were kept for three months to study the physical stability also. The retention of micronutrients was also studied. Therefore, it could be concluded that a novel oleogel can be formulated with two micronutrient-rich edible oils and gelling agents like sal starch and lecithin.

1. Introduction

In view of improving the nutritional and other quality characteristics of food products, fats and oils are widely used in food formulations. Fats and oils are indispensable parts of our diet for their energy source, bioactive components, vitamins, precursors, and flavour carriers. Scientists have been busy modifying the physical properties of oils to resemble those of fats (Vaclavik and Christian, 2014). Hydrogenation, interesterification, and fractionation processes lead to the formation of solid fats, which are mainly used in food formulations (Mills et al., 2017). Solid fats offer the disadvantage of carrying higher amounts of saturated fatty acids and trans fatty acids. Associated with these fatty acids is one of the biggest societal challenges in the twenty-first century that is obesity and its related impaired health conditions (Wang et al., 2011).

This problem is increasing in India. To omit this huge economic and health concern of saturated fatty acids novel technologies need to be implemented to curb the associated epidemics and address the resulting gigantic food manufacturing problem. To fulfil these requirements, the food industry is trying to structure the triacylglycerol and reformulate food using these structured triacylglycerols. These fabricated solid fats are typically used in bakeries, breakfast spreads, mar-

garines, chocolates, and chocolate-derived products generally related to high saturated fat content.

Oleogels have been proposed to structure oil in food formulations (Marangoni and Garti, 2011). This can be achieved due to the addition of a gelator, a structuring agent, to the liquid oil phase. Literature review suggests that the quality characteristics of already prepared oleogels have been found at acceptable limits. Oleogel is required to eliminate the quality defects such as preventing or decreasing fat migration substantial for fat bloom and reducing saturated fatty acid content of the corresponding products (Hughes et al., 2009). The phase behaviour of oleogels depends on the type of oil used in the formation of gels indicating the molecular interaction and crystallization property. Oil type is an important factor affecting the rheological, texture property, thermal property of the oleogels, and oleogelator type and concentration.

A blend of rice bran oil and sesame oil is well known for their unsaturated fatty acids and high antioxidant content. The blend has also been reported to depict significant anti-hypertensive and lipid-lowering action and produce an additive effect along with anti-hypertensive medication (Devarajan et al., 2016).

In our study, the blend of rice bran oil and sesame oil was used as the liquid oil in oleogelator preparation. The liquid oil was structured to form 3-D networks by dispersing the oleogelator molecules into the oil phase by using appropriate processing methods like heating, stirring, and cooling (Almdal et al. 1993; Co and Marangoni, 2012; Flory 1953). Oleogelators are chosen because they are soluble in the oil and form a network during gelation. Starch derivatives like ethylcellulose are a common oleogelator used in today's world. Sal fat is well known as a minor oil-bearing material of tree origins commercially used as a cocoa butter substitute. After oil extraction, the deoiled cake of sal has limited commercial value and is either thrown away or stacked for years. Thus, starch extracted from the deoiled cake can serve as a low-cost oleogelator. Lecithin is also a well-known food-grade oleogelator which itself has a role in cognition, regulation of blood lipid levels, and essential component of the cell membrane (Perez-Monterroza et al. 2014).

Oleogels and its emerging technology are the main focus of many research areas geared towards catalyzing the decrease in occurrence of obesity and cardiovascular disease. In this connection it is necessary to discover a food-grade gelator system possessing the functional properties required by most food items. By using food-grade gelators, many food components can be made available together in the form of gel. The aim of my present study is to formulate oleogel using a mixture of rice bran oil and sesame oil as the liquid oil and a combination of sal starch and lecithin as the oleogelator. Polyphenol was used in the formulation to increase the gel's antioxidative property and increase its stability and shelf life. The oleogel thus produced was characterized to evaluate its physicochemical properties.

2. Materials and Methods

2.1. Preparation of blended oil

A blend of rice bran oil and sesame oil was obtained by mixing both the oils in the ratio of 1:1 and then determining the fatty acid composition of the blended oil.

2.2. Determination of the fatty acid composition of blended oil

Fatty acid composition of the blended oil was analyzed by GC. Fatty acid ethyl esters (FAME) were prepared by the method described by Metcalfe and the compositions were determined by GC analysis. The GC (make: Agilent, model: 6890 N) instrument used was equipped with an FID detector and capillary DB-Wax column (30mL, 0.32mm I.D, 0.25µm FT). N2, H2 and airflow rate were maintained at 1ml/min, 30 ml/min, and 300ml/min, respectively. Inlet & detector temperature was kept at 250˚C, and the oven temperature was programmed as 150-190-230˚C with an increased rate of 15˚C/min and 5 min hold up to 150 ˚C and 4˚C/min with 10 min hold up to 230˚C. The percentage proportions of fatty acids were calculated.

2.3. Extraction of Sal Starch from Sal De-oiled Cake

Sal Deoiled Cake (Sal DOC) was steeped with four volumes of 1.25% sodium hydroxide (NaOH) solution at room temperature for 90 minutes. After that, the steeped solution was centrifuged at 5000rpm for 15 minutes. The solid matter thus obtained consisting of mainly starch and fibre was washed further with water and centrifuged. The solid matter was steeped in water, wet ground, and filtered after water washing

ISSN-Internet 2197-411x OLCL 862804632

(at least 4 washings) to obtain an aqueous suspension. This suspension was centrifuged, and starch was obtained as residue. The crude starch thus obtained was washed successively with 0.1N HCl and 5% NaOH solution and water repeatedly. The starch obtained thereafter was bleached with sodium hypochlorite solution till there was a satisfactory decolourization. The bleached starch was washed with water till the chlorine odour was removed. Starch was finally dried at about 50-60°C under vacuum over a tray drier.

2.4. Extraction of tea polyphenol by microwave-assisted method

Polyphenol extraction from tea leaves was performed using a microwave-assisted extraction (MAE) process using a domestic microwave (Electrolux EM17MS80WH) i.e., the experimental setup was done using a closed vessel system. It was employed at a power supply of 200W. A total of 10 grams of tea leaves were weighed and crushed and then placed in a microwave-proof glass container of a capacity of 500 mL. Then solvent (methanol) was added where the solvent-to-material ratio was 1:40, and polyphenol was extracted under MAE conditions (Ghasemzadeh-mohammadi et al., 2017). Total polyphenol content was assessed thereafter using Folin–Ciocalteu's reagent (Ghasemzadeh-mohammadi et al., 2017).

2.5. Oleogel Preparation

Oleogels with two organogelators (Starch and Lecithin) were prepared at different addition levels (3-12% w/w). The decision of the selected levels was based on pre-experiments to determine the most suitable oleogels as spreadable products. Two types of oleogels were prepared by blending the blended oil with food-grade gelators like starch and lecithin. Polyphenol was added (1% w/w) to the prepared oleogel. Total 6 sets of oleogels (Sample 1: 3%; Sample 2:5%; Sample 3:6%; Sample 4:8%; Sample 5:10%; Sample 6: 12%) were prepared in the study. Different sets of gels were prepared using different concentrations of gelators and blended oil. All samples were prepared with continuous stirring at 300rpm and cooled immediately at -20°C, and stored at 4°C. After overnight setting at room temperature, the oleogels were completely formed and then analyzed.

2.6. Characterization of Oleogels

2.6.1. Test for gelation:

The completely formed oleogels are taken in 10ml vials, and pictures of the overturned vials are taken to observe the efficacy of gel formation (Maroto-Conteno et al., 2015).

2.6.2. Hardness Evaluation:

Hardness or consistency of the samples was determined in terms of penetration yield value (g/cm2) using a penetrometer with a 40° angle. The penetrometer is a fast and empirical method that is used in the determination of texture. The cone used for penetration was placed just above the sample before the cone was released. The penetration time was 5s, and depth was read directly from the instrument in 0.1mm units. Yield values were calculated with the help of the equation given below:

a. Yield value (g/cm^2)= $KW/P^{1.6}$
b. Where K=constant (5840 for 40 cone angle); W=-weight of the cone assembly (79.03); P=mean of penetration depth from three replicates (cm) (Kouzounis et al., 2017).

2.6.3. Microstructural Analysis:

Microstructural observation of lipid samples was conducted with a polarized light microscope attached to a digital camera. The oleogel samples (10µl) were placed on a micro slide after melting the sample at 80°C, and then the samples were covered with coverslips. The microstructure analysis was performed of the samples, which were stored at 4°C (Patel and Dewettinck, 2015).

2.6.4. XRD analysis:

The polymorphic crystal forms were determined using an X-Ray Diffractometer. X-ray diffraction (XRD) patterns of the oleogels were taken with a P.W 3040/60 model X-Ray Diffractometer (PA Nalytical, Netherland). Angular scans from 2.0 to 70° (2θ) were performed at a 2°/min scan rate with a Cu source X-ray tube (Jendrzejewska et al., 2020).

2.6.5. Physical stability of oleogel formulations:

Each oleogel formulation was kept in glass and plas-

tic containers with tight lids. Then, all of them were stored in different storage conditions: 4°C and 25°C and observed for 0, 1, 2, and 3 months. For accelerated stability studies using centrifugation test, 5g of each oleogel was freshly prepared, and during the cool-down process, each oleogel was dispensed to 15ml tubes. These tubes were kept at room temperature for a week to maintain their gelation properties before they were centrifuged at 2500 rpm for 30 minutes with REMI centrifuge (Goupale and Rajkapoor, 2011).

2.6.6. Storage stability of the oleogels:

To evaluate the storage stability of oleogels, peroxide value was determined using AOCS official methods (AOCS Official Method Cd8b-90). The peroxide value determines the milli-equivalent of peroxide per kg of a sample that oxidizes potassium iodide under the test conditions.

2.7. Statistical Analysis

All the data were expressed as mean ± S.E.M. Two ways ANNOVA was used to test the differences between control and experimental subjects.

3. Results and Discussion

3.1. Fatty acid composition of blended oil

Analysis of the lipids in the diet showed that blended oil contained 43.65% linoleic acid ($C_{18:1}$) and 32.75% linolenic acid ($C_{18:2}$). The fatty acid composition of the blended oil is given in Table 1.

3.2. Polyphenol Content of tea leaves

The polyphenol content of the tea leaves used as an antioxidant in the study was 18.20 ± 0.32 of Gallic acid equivalent.

3.3. Oleogel Characterization

The oleogel prepared in this study has a smooth structure and good spreadability. Even though all the oleogels have a homogeneous texture, the oleogels produced by low concentrations of oleogelators, i.e., 3% and 5%, do not exhibit significant stiffness, and the flow property is more or less like that of a liquid. On the other hand, by increasing the concentration of oleogelators, the oleogel formed exhibited considerable amount of stiffness. Fig. 1a shows the pictures of the oleogels produced, which exhibited the physicochemical properties of oleogels. It was also shown from the study that the oleogels formed with 12% oleogelators exhibited a considerable amount of stiffness and greasiness. Undesirable amount of greasiness, oiliness, grittiness, tackiness, stiffness, or stickiness attributes an uneasy feeling and limits the oleogels to be released inside the body. The study depicts that C, D, E have a good appearance compared to A, B, and F oleogels. Moreover, the A and B oleogels showed liquid behaviour indicating that these formulations were not very stable.

3.4. Microstructure characteristic of oleogel formulation

Aggregation processes of oleogel forming materials through self-assembly and crystallization are the important properties of oleogel formation. Fig. 1b depicts the microstructures of the oleogels formed. From the figure, it is evident that all the oleogels showed the formation of crystal aggregates i.e. a network of fat crystals as shown by their microstructures

Table 1. Fatty acid composition of blended oil

Fatty acid / Sample	**Fatty Acid (% w/w)**			
	$C_{16:0}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$
Blended Oil	19.48±0.11	4.12±0.09	43.65±0.19	32.75±0.22

Values are Mean±SEM

ISSN-Internet 2197-411x OLCL 862804632

where the crystal appears as dark spots. All the figures showed the formation of small crystal aggregates in the starch oleogel network except Fig 1b. All the figures do not show a self-assembly network. Only the oleogels formed with a high concentration of starch as oleogelators showed the presence of self-assembly structures in their crystal networks. These aggregates are identified as sphere-shaped structures called spherulites.

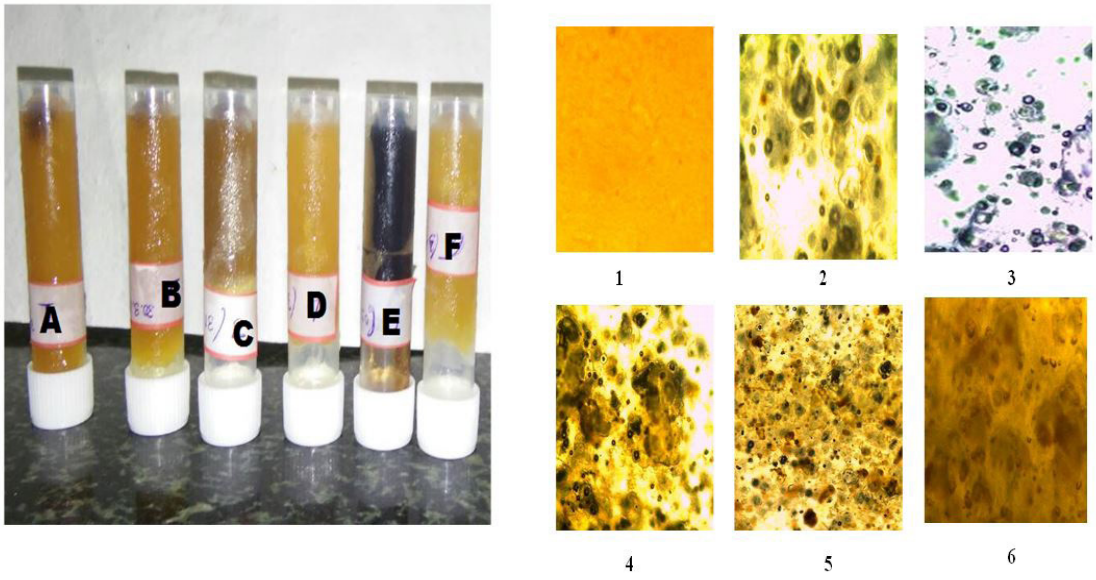
3.5. Changes in XRD

In order to determine the polymorphic nature and sub-cell type of crystals, the XRD pattern of the different oleogel samples was analyzed. The results are provided in Table 2. In order to present the patterns graphically, the oleogel curves are shown in Fig 2. The XRD data of sample 1 shows wide-diffraction peaks of 3.05Å. The XRD data of sample 2 shows wide-diffraction peaks of 4.52 Å and 3.75 Å. In the other four samples, there was a single diffraction peak between 4.36-4.56 Å observed. This observation suggested that samples 3-6 possessed finely developed crystals and caused clear diffraction intensity. On the other hand, no small peaks were observed. The short spacing spectra at around 4 Å observed in the case of the samples were characteristic of orthorhombic packing, which was similar to ß packing of triacylglycerols

The XRD data of oleogel samples 3-6 confirmed the presence of ß crystal form of the triacylglycerols in oleogel structures. This, in turn, facilitated the formation of a smooth and creamy texture of the prepared oleogel samples.

3.6. Effect of samples on the hardness

The hardness of oleogels, in general, is a contributory factor of oleogel characteristics such as appearance, workability, spreadability, and oil exudation. The hardness of oleogels usually increases due to the aggregation of the fat crystal network. The yield values of the oleogel samples are indicated in Table 2. The table indicates that product hardness increases with an increase in oleogelator concentration. The highest



1a 1b

Figure 1a. Pictographs of Oleogels formed by Olegelators (3-12%)
A: 3%; B:5%; C:6%; D:8%; E:10%; F: 12%

Figure 1b. Pictographs showing microstructure of oleogels
1: 3%; 2:5%; 3:6%; 4:8%; 5:10%; 6: 12% oleogelator concentration

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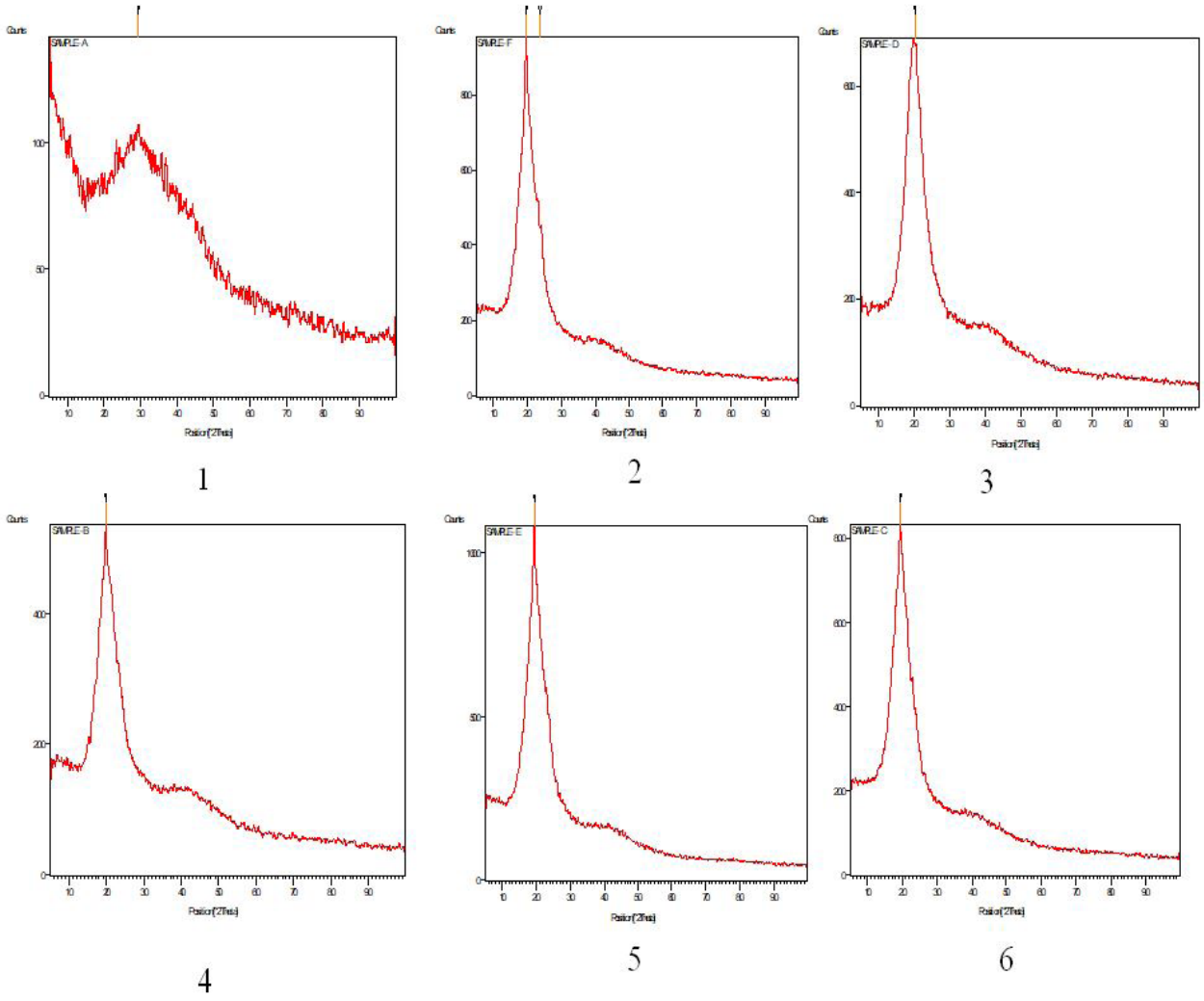

Figure 2. XRD pictographs of the oleogel samples. 1: 3%; 2:5%; 3:6%; 4:8%; 5:10%; 6: 12% oleogelator concentration

yield value belonged to sample 6, which contains the maximum amount of oleogelator compared to the other samples.

3.7. Changes in Physical Stability

Syneresis of the oleogel, observable by the separation of liquid from the gel, depicts an unstable formulation. Syneresis is also thought to be more likely in gels comprising larger aggregates due to the fibres or crystal structure in the gelation network sticking to the thick bundles. It is evident from the stability data that the physical stability of oleogels is highly dependent on the composition of oleogels. The physical stability data is depicted in Table 3. The table showed that samples 4, 5, and 6 were able to maintain their gal formation when kept in plastic containers.

3.8. Changes in Peroxide Value (PV)

The changes in the peroxide values of selected oleogels during storage are seen in Table 4. PV of oleogels (3, 4, 5, and 6) stored for 3 months registered a no significant increase with the storage period. The not much change in the PV indicates that there was not much oxidation caused by the formation of hydroperoxides during fat oxidation. It was observed that the change in PV of control was between 0.32 meq/kg and 2.09 meq/kg during the 3 months of storage. However, in oleogel 1 and 2, there was a slight change in the PV indicating oxidation caused by the formation of hydroperoxides during fat oxidation. The nutritional contribution of the tea polyphenols may have conferred this greater oxidative stability of the oleogel samples.

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Table 2. d spacing and the yield value (g/cm^2) of different oleogel samples

Sl. No.	Sample No.	Yield Value (g/cm^2)	d spacing (Å)
1	1	62.8±1.3	3.05
2	2	76.2±1.0	3.75 and 4.32
3	3	98.1±1.6	4.36
4	4	100.6±0.5	4.56
5	5	100.9±1.2	4.56
6	6	259.8±3.5	4.49

1: 3%; **2**:5%; **3**:6%; **4**:8%; **5**:10%; **6**: 12% oleogelator concentration

Table 3. Physical Stability of Oleogel Formulations : G=gel, L=liquid, GL=mixture of gel phase and liquid phase (partial syneresis)

Formulations	**Stability 0 months**	**Stability 1 month**	**Stability 2 months**	**Stability 3 months**
1	GL	L	L	L
2	GL	GL	L	L
3	G	G	GL	L
4	G	G	G	G
5	G	G	G	G
6	G	G	G	G

Table 4. Changes in Peroxide Value (PV) during storage

Sample No.	Initial (meq/kg)	1 month storage (meq/kg)	2 month storage (meq/kg)	3 month storage (meq/kg)
1	0.47	0.52	1.56	1.95
2	0.50	0.56	2.04	2.09
3	0.32	0.50	0.59	0.72
4	0.42	0.53	0.65	1.04
5	0.50	0.52	0.55	0.55
6	0.50	0.59	0.68	0.72

4. Conclusion

This study proved that successful oleogels could be produced with the help of Sal Starch as an oleogelator. The gels formed with 8 and 10% oleogelators showed the best properties in terms of spreadability, the test of gelation, microscopic structure, XRD studies, physical stability, and hardness. The storage stability data depicted that the samples with a low concentration of oleogelator showed high peroxide value after 3 months of storage, while with a high concentration of oleogelator, the storage stability of the oleogel was improved. Thus, a blend of rice bran oil and sesame oil can be successfully transformed into spreadable oleogels using Sal starch as oleogelator and can be used in the manufacture of bakery products.

Acknowledgement

Authors gratefully acknowledge the grant received from Indian Council of Medical Research (ICMR) for carrying out the above work.

Conflict of Interest

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

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Research Paper

Future of Food: Journal on Food, Agriculture and Society
10 (1) February 2022

Evaluating the role of climate-smart agriculture towards sustainable livelihoods in Mutare district, Zimbabwe

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Data of the article

First received : 28 February 2021 | Last revision received : 22 December 2021
Accepted : 17 January 2022| Published online :15 February 2022
DOI : 10.17170/kobra-202110144900

Keywords

climate smart agriculture; conservation agriculture; livelihood strategies; adaptation; productivity; resilience

Increasing climate variability continues to threaten livelihoods in Southern Africa, where communities face the challenges of addressing context-specific complexities associated with rain-fed agriculture. Zimbabwe is equally vulnerable, but the country is going through a transformation in agriculture by implementing climate-smart agriculture practices that endeavour to enhance adaptation, resilience, and increase productivity. The study was undertaken in Mutare district, Zimbabwe to explore the role of climate-smart agriculture practices applied to construct sustainable livelihoods. The study employed qualitative data collection techniques that involved households and key informant interviews. Descriptive statistics and exploratory research design were applied to give a meaningful narrative of the data. The results revealed traditional and innovative agriculture production methods based on least soil disturbance, preservation of ground cover, and crop diversification. Small livestock farming was lauded as a basic strategy that ameliorates immediate family needs, whilst large livestock farming was revealed as a symbol of status and source of funds to mitigate important family events such as deaths or weddings of a close relative. Forestry farming was established as a reliable source of income that is earned from the sale of timber, woodcrafts, and fodder for livestock, among others. The paper further established that changes in climatic conditions resulting in droughts, thunderstorms, leaching of crops, and infestation of pests are the major challenges that reduce the implementation of climate-smart agriculture practices that support robust, sustainable livelihoods. The paper recommends continued financial and technical support from government and non-governmental organizations to promote climate-smart agriculture practices that support sustainable livelihood outcomes and mitigate the detrimental effects of climate variability and change.

1. Introduction

Climatic trends in Southern Africa indicate that climate variability and change will increase with increased intensity of extreme weather conditions such as droughts, floods, mean temperature, and altered patterns of precipitation (Makate, Wang, Makate, & Mango, 2016; Mubaya, Njuki, Mutsvangwa, Mugabe, & Nanja, 2012; Nhemachena & Hassan, 2007). Climate variability is described as short-term fundamental features of the climate that manifests clearly in changes over months, seasons, and years (Lamsal, Kumar, & Atreya, 2017). Although Southern Africa is vulnerable to climate risks due to reliance on rain-fed traditional agricultural production systems, agriculture continues to be vital for economic growth, poverty allevia-

tion, and food security (Adele & Todd, 2011). Zimbabwe is equally exposed to the devastating vagaries of climate variability and change (Zinyemba, Archer, & Rother, 2018). The country is especially vulnerable because the livelihoods of the majority of the population depend on rain-fed agriculture, which employs about 70% of the population (Muzari, Nyamushamba, & Soropa, 2016; Nhemachena & Mano, 2007).

The reliance on agriculture calls for capacity building through sound technical assistance that focuses on improving established and new agriculture practices and technologies that ensure the construction of sustainable livelihoods. Sustainable livelihoods refer to "the ability of a livelihood to cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base"(-Chambers & Conway, 1992).

Climate variability and change studies in agriculture have established that climate-smart agriculture (CSA) is among the various agriculture systems that developed as promising ways of securing food and ensuring sustainable livelihoods for the increasing world population that is faced with climate change scenarios (Manda et al., 2016). The practice involves integrated agriculture development programmes that aim at improving environmental stewardship, productivity, and sustainable livelihoods (Rosenstock et al., 2016).

The Food and Agriculture Organisation (FAO) of the United Nations first conceived CSA as agriculture that seeks to increase sustainable productivity, strengthen farmers' resilience, reduce agriculture's greenhouse gas emissions, increase carbon sequestration, strengthen food security, and deliver environmental benefits (McCarthy, Lipper, & Zilberman, 2018).

Manda, Alene, Gardebroek, Kassie, and Tembo (2016) posit that CSA is among the best viable agriculture strategies that can combat the impacts of climate variability and change and ensure sustainable livelihood outcomes in rural and urban communities. CSA incorporates principles that include: (a) adaptation - having technologies that suit the specific areas in which they are practiced; (b) productivity-increasing agriculture productivity and livelihood benefits; and (c) mitigation – alleviating greenhouse gas emissions (Kpadonou et al., 2017; Rosenstock et al., 2016). There is a need for micro-level study of these principles' influence in supporting the construction of sustainable livelihoods. This paper focuses on agriculture production technologies that sustain the livelihoods of rural and urban households. Most specifically, the study evaluates traditional and innovative production technologies that are applied to address context-specific complexities in agriculture production systems that support sustainable livelihood outcomes. Knowledge developed from this study aims to contribute to the location-specific data bank that enhances understanding of the role of CSA that ensures sustainable livelihoods. The structure of the manuscript includes a discussion of materials and methods, presentation of results, discussion, and conclusion

2. Materials and methods

2.1 Description of the study area and population

The study was undertaken in the Mutare district in eastern Zimbabwe. The district is about 265 km east of Harare, the capital city of Zimbabwe. Mutare district is surrounded by Chimanimani, Buhera, Makoni, and Mutasa districts and shares a border with Mozambique on the east, as shown in Figure 1. The topography is distinguished by large and rugged mountains, steep slopes, valleys, and a network of streams and rivers. Zimbabwe is classified into five natural regions (NR) that are determined by rainfall regime, soil quality, and vegetation, among other factors (Mugandani, Wuta, Makarau, & Chipindu, 2012; Ndebele-Murisa & Mubaya, 2015). The study area is situated in both NR I and II, which are the most agriculture productive regions in Zimbabwe (Mugandani et al., 2012; Nyamadzawo, Wuta, Nyamangara, & Gumbo, 2013).

Mutare district includes rural and urban communities. Mutare urban is located near Vumba Mountain and Murahwa Hill and is accessed through the Christmas pass tunnel. The latitude is18°58'0" and longitude is 32°40'0" (Mapira, 2011). The Sakubva River and its tributary Nyaphumbi pass through Mutare urban.

In 2012 the population of Mutare District was approximately 449 745 and was composed of 262 124 in Mutare rural and 187 621 in Mutare urban (Zimstat, 2015). The composition of households was 58 400 in Mutare rural and 48 258 in Mutare urban (Zimstat, 2015). The population was predominately African

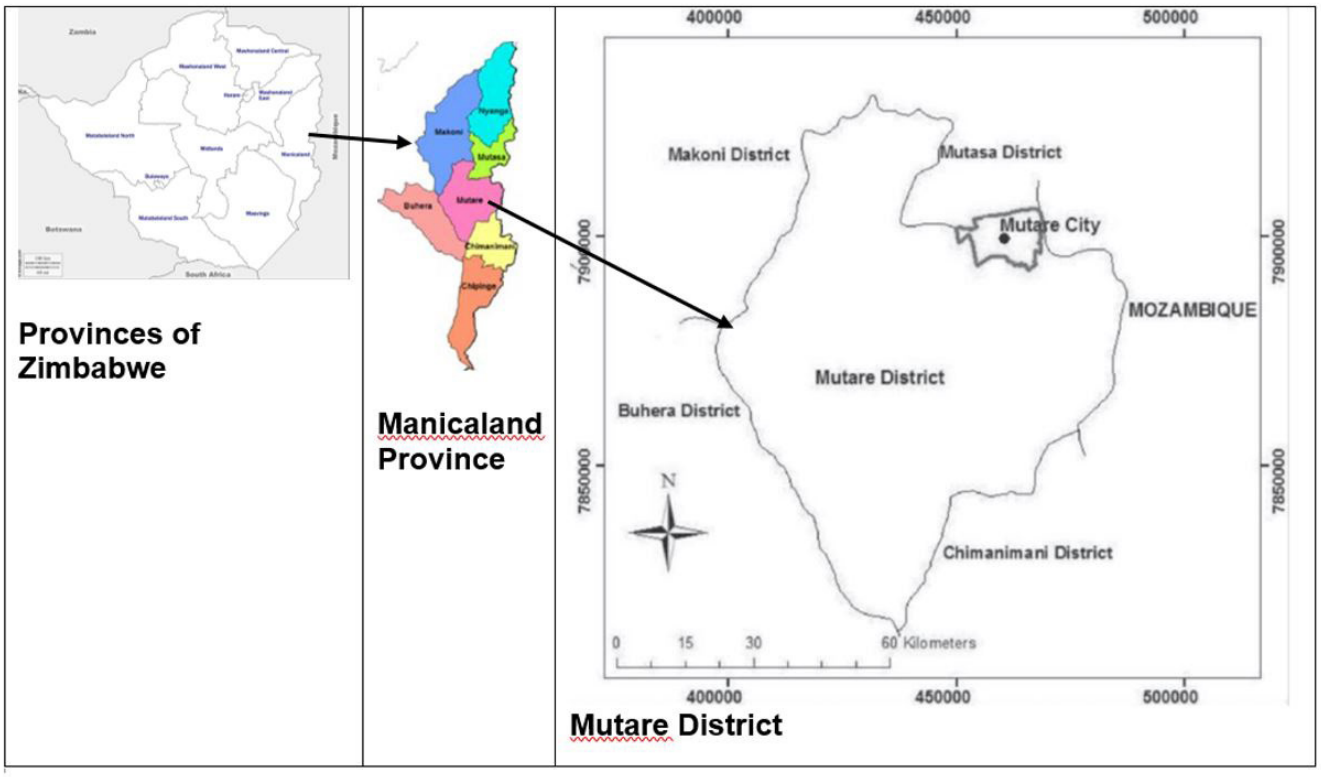

Figure 1. Map showing Zimbabwe, Manicaland Province, and Mutare District, adapted from Mabaso et al. (2015)

ethnic origin with less than 1% European, Asiatic and mixed origin.

2.2 Strategy of Inquiry

The study applied qualitative research enlightened by descriptive statistics and exploratory research designs. The qualitative inquiry collected participants' perceptions and experiences of the study phenomenon. Tenny, Brannan, Brannan, and Sharts-Hopko (2017) posit that qualitative research can explain processes and patterns of people's experiences and behaviours that are carried out through interviews but are difficult to quantify. Mwongera et al. (2017) postulate that interviews are carried out individually with those knowledgeable about the phenomenon under study.

Descriptive statistics was chosen because it gives an in-depth summary of the sample under study (Kaliyadan & Kulkarni, 2019). The descriptive statistical method applied was the survey method. Exploratory research was employed because it lacks a formal structure and a high degree of flexibility (Swedberg, 2020). Descriptive statistics and exploratory inquiry allowed the researchers to dwell deeper into the participants' perceptions and experiences of the role of CSA that ensure their livelihoods.

2.3 Data collection and analysis

Purposive sampling was applied to gather data during the field research between January and March 2020. This involved interviews with purposively selected 266 households (144 rural and 122 urban), 4 traditional leaders, 5 ward councillors, 4 focus group discussions (FGDs), 4 state and local government level extension services officials, and 2 NGO officials. The FGDs were structured as 3 mixed gender rural smallholder farmers and 1 mixed gender urban smallholder farmer. The sample size was decided upon following the principle of saturation – the survey was stopped when the interviews brought no more new data different from responses already collected (Saunders et al., 2018). The inclusion for household participation was pegged at a minimum of 10 years of continuous stay in their communities. Open-ended questions that could be changed to match the participants' level of comprehension and intelligence were employed to allow the participants to explain their experience, feeling, and thinking about the role of CSA in influ-

ISSN-Internet 2197-411x OLCL 862804632

encing their livelihood outcomes. Households who were not comfortable articulating their experiences in English were interviewed in their local dialect of the Shona language. Interviews were supplemented with field observations. Adequately trained 10 research assistants undertook transect walks with note-taking and were constantly interacted with the principal researchers. Content analysis was employed to examine the results of the qualitative research. Content analysis is a systematic coding and categorizing approach that is employed to examine a large amount of data and break it into manageable units, determine trends and patterns of words used, their relationships, frequency, and decide what needs to be divulged to others (Ayres, 2007; Grbich, 2012).

3. Results

3.1 Inquiry into participant's comprehension of CSA practices

Interviews were conducted between January and March 2020. A question was asked to probe participants' understanding of CSA. The feedback in Figure 2, where 'n' represents the number of participants in rural and urban communities, demonstrates that the largest number of participants indicated 'partial understanding' followed by 'never heard of it' and 'good understanding.' The participants who indicated that they have a good understanding were mainly from Mutare urban, where they engage in more technical and labour-intensive CSA based on horticulture. In contrast, participants who indicated that they had never heard of it were mainly rural households who rely on subsistence farming to mitigate food insecurity.

3.2 Conservation agriculture practice

The participants were further probed on their understanding of one of the techniques of CSA. They were asked a related question, 'Have you heard about conservation agriculture (CA), and the responses were a dichotomous 'yes' or 'no.' The dispersion of responses was 'yes' 93% and 'no' 7%. However, the overwhelming yes response illustrates a lack of understanding that CA is one of the hundreds of technologies, practices, and approaches that fall under CSA (Makate et al., 2016). This assertion is substantiated because participants who rated their knowledge of CSA as never heard of it were among the 93% who overwhelmingly reported that they had heard of CA. CA is based on the concurrent implementation of three principles: minimum mechanical soil disturbance, maintenance of ground cover with organic matter, and diversification of crop species grown in rotation or sequence (Kassam, Friedrich, Shaxson, & Pretty, 2009). The practice is strengthened through improved comprehensive participatory agriculture extension services, technical and financial support. Participants pointed out that when they practice CA, they can often sell surplus yields to support other livelihood outcomes that save lives through the enhancement of natural resources management.

3.3 Forms of conservation agriculture practices in the study area

Further questions associated with CA were asked to comprehend rural communities' perception of CSA agricultural practices. The participants were probed by asking the question, 'What is the most productive CA practice on your farm?' Participants were expected to indicate what they perceived to be their most productive CA based on their lived experience of their communities. The pie chart Figure 3, where 'n' represents the number of rural households interviewed, reveals that planting basins is the most practiced CA technique.

3.3.1 Planting basins

The practice of planting basins has its advantages and disadvantages. The advantages that were highlighted include solving the problems of inadequate draughts power that usually delay planting, which inadvertently affects crop yields. Besides, participants pointed out that planting basins gives them the advantage of preparing their fields during the dry season ahead of the rain season. This reduces the pressure for labour demands during the onset of the rain season. Participants highlighted that the major disadvantage is that the technique is labour intensive. This assertion concurs with the findings of other researchers who observe that conservation tillage requires a lot of labour during the first year but becomes less labour intensive during subsequent years since the same ripper furrows or planting basins will be used (Wagstaff &

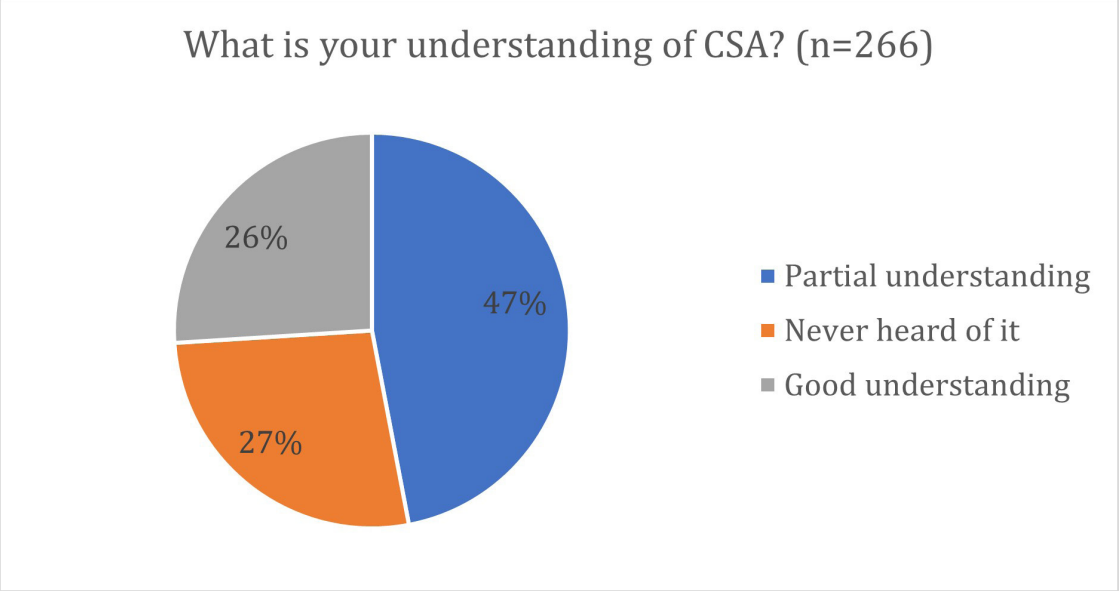

Figure 2. Participants' understanding of CSA (Fieldwork January – March, 2020)

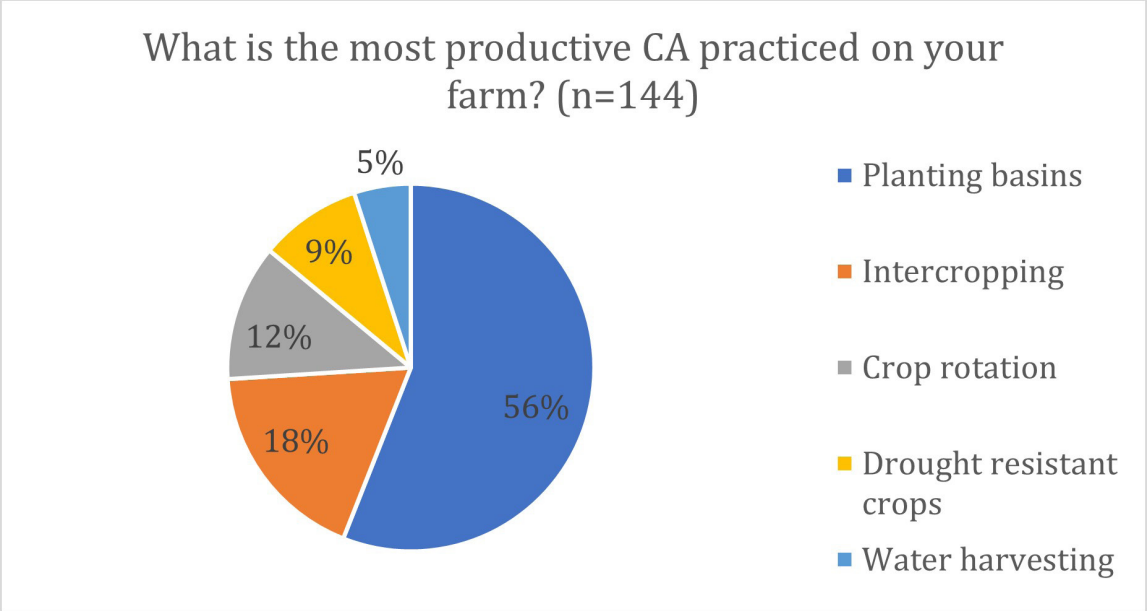

Figure 3. CA practice on farms (Fieldwork January – March, 2020)

Harty, 2010). Participants alluded that while planting basins is the most productive farming practice, they generally apply it with other practices.

3.3.2 Intercropping

Interview participants concurred that intercropping is the second most practiced strategy. Intercropping is the method of farming that involves concurrent planting of more than one variety of crops on the same field (Makate et al., 2016). The crops may belong to the same or different species, and this is done as basic ecological principles that include diversity, competition, and facilitation (Hauggaard-Nielsen et al., 2016). Intercropping efficiently makes use of light, land water, and nutrients while stabilizing the agroecosystem (Ning et al., 2017). Participants elaborated their comprehension of intercropping when one farmer ex-

ISSN-Internet 2197-411x OLCL 862804632

plained that:

For the past 10 years, my banana and coffee yields have continued to improve since the method of planting the two in the same field was introduced on my farm. I now know the importance of combining crops as a moisture retention practice since bananas have large leaves that have a positive influence on moisture retention through the provision of shade. In addition, I practice intercropping maize with leguminous crops such as beans, pumpkins, watermelons, and cucumbers. (Female, 52-year-old farmer)

Further narratives from FGDs concluded that many households are now mixing leguminous crops such as cowpea and red speckled sugar beans with maize production. FGDs agreed that intercropping of leguminous crops with cereals enhances the soil's facilitation of nutrients. They further reveal that the practice has improved livelihood outcomes, including improved food security, nutrition, and income. Additionally, participants argued that they practice intercropping to reduce the impact of extreme events driven by crop failure because different crop types have specific climatic adaptability.

3.3.3 Crop rotation

There was a consensus among interview participants that many households in the Mutare district are practicing crop rotation. Crop rotation is defined as the routine of growing a sequence of plant species on the same field (Dury, Schaller, Garcia, Reynaud, & Bergez, 2012). The participants stated that they alternate legumes such as soybeans and cowpea with maize crops to improve soil fertility and control diseases and pests, thereby reducing agrochemicals. Participants indicated that crop rotation reduces weeds, insects, need for nitrogen fertilizers, soil erosion but increases soil fertility and yields per hectare. However, a key informant observed that some farmers still prefer to grow maize without crop rotation because maize generates more cash. This observation is in line with studies in Zambia, which reveal that households usually favour cultivating maize even in areas suitable for proper rotation with other crops (Nolin & Von Essen, 2005).

3.3.4 Cultivation of drought-resistant crops

It emerged in this study that farming systems located in the marginal environments of the district are characterized by a shift to growing drought-tolerant crops such as small grains. Participants expressed that they are cultivating drought-resistant crop varieties to improve food security and as a mechanism for constructing sustainable livelihood outcomes. However, a key informant from the Zimbabwe Farmer's union regretted that some smallholder farmers are still biased towards the production of cash crops which are highly susceptible to extreme weather events. The key informant recommends that farmers need a mindset change to start to think of re-energizing small grain products such as millet, finger millet, and sorghum that are drought resistant. Regarding staple crops such as maize, the informant recommended that smallholder farmers ought to opt for hybrid varieties that take a shorter period to mature than the traditional ones.

3.3.5 Rainwater harvesting practice (n=167)

A question relating to rainwater harvesting was asked to comprehend how households apply the technology. Rainwater harvesting is described as a technology applied to gather and store water from land surfaces using methods such as artificial ponds and reservoirs (Helmreich & Horn, 2009). Other technologies involve collecting rainwater from rooftops and storing it in tanks or cisterns mounted on elevated platforms. Rainwater harvesting is an adaptation strategy that ensures the organized use of rainfall to boost agriculture productivity (Rioux et al., 2016; Wambugu, Franzel, & Rioux, 2014). Participants were asked the question 'What is the rainwater harvesting practice on your farm,' and in response, they highlighted the following options: (a) external water harvesting, which involves collecting run-off from rainfall over a surface; (b) domestic rainwater harvesting which is collecting rainwater from rooftops; and (c) in situ rainwater harvesting which is collecting rainfall on the surface where it falls and stores it in the soil. The number of participants who responded was 107 in rural communities, and 60 were urban dwellers. The distribution of responses was: (a) domestic rainwater harvesting – 78%, (b) in situ rainwater harvesting – 15%, and (c) external water harvesting - 7%.

The participants explained that they harvest rainwater

from rooftops, store it in polyethylene tanks, and use it for market gardening and domestic and livestock water supply. Rainwater harvesting has the advantage of providing water which is a vital part of the natural capital required to ensure sustainable livelihoods (Kahinda, Taigbenu, & Boroto, 2007). External water harvesting is practiced mainly in commercial farming communities that are endowed with rivers, streams, waterfalls, and valleys that can be converted to large water reservoirs. On the other hand, in-situ rainwater harvesting is practiced in rural communities where shallow wells are dug to collect rain and surface water used for domestic and market gardening.

3.3.6 Challenges that impede the adoption of CA

Interview participants expressed that one of their biggest challenges is changes in climatic conditions. Results from the FGDs and interviews with the elders indicated that rainfall comes sporadically, and when it does, it comes with a lot of thunderstorms that destroy crops. Thunderstorms were specifically identified as major challenges that cause leaching and waterlogging. Waterlogging results in crops turning yellow, compelling farmers to apply stronger fertilizer (urea) instead of ammonium nitrate, which is applied as a topdressing. In addition, the participants indicated that changes in the climatic condition are causing infestation of pests that include diamondback moth (*Plutella xylostella*) (cabbage moth) that force them to use more pesticides, adding to the high cost of inputs. Besides, the participants added that they are faced with the challenge of an unfavourable political landscape where government-supplied agriculture inputs are distributed on partisan grounds. The study established that although CSA is not entirely a new concept, the challenge is that it is a practice that requires refinement and intensification through technical and financial support without patriotism to political affiliations.

3.4 Livestock farming

3.4.1 Small livestock farming

Interview participants agreed that a variety of livestock farming alongside crop production ensures sustainable livelihood outcomes. The participants explained that basic small livestock strategies like fowls, piggery, sheep, and goats give them safety nets. Livestock farming is valuable as they meet immediate family needs, especially small livestock, including poultry and goats (Baudron, Mwanza, Triomphe, & Bwalya, 2007). Small livestock such as indigenous chicken breeds were highlighted as a valuable source of instant cash instead of large livestock, that are sold to fund major events. This is what one of the interview participants had to say:

I rear chicken (popularly known as road runners) as opposed to broilers which are expensive and exhausting to manage. My breed survives on anything including small grains, vegetables, and insects. My preferred breed is Rhode Island. I improve my turnover through strategies such as preventing the chickens from brooding and as a result, they start to lay again within 21 days. Chickens are easy to sell and I combine poultry production with other on-farm activities such as using chicken manure as fertilizer for vegetable gardening. (Male, 57-year-old livestock farmer)

The general sentiments from this narrative were shared by most smallholder farmers who were unanimous that chicken farming leads to positive livelihood outcomes in their communities. The researchers were shown a variety of livestock projects and agreed that poultry that included breeds such as Rhode Island, Black Australorp, and Potchefstroom Koekoek was the dominant occupation in rural households, whereas urban households tend to raise broilers for meat and hybrid hens that lay lots of eggs.

3.4.2 Traditional climate-smart livestock farming strategies

The study additionally sought to understand the perspective of sampled village elders' traditional climate-smart livestock farming strategies that have sustained livelihood outcomes in Mutare district over the years. One of the 4 interviewed elders narrated that:

We had our hard mashona cattle, goats, and chicken breeds that were resistant to droughts and common diseases. The breeds started to disappear after the introduction of breeds that were bigger making them more valuable on the market. However, these breeds were/are expensive to maintain and tend to struggle during extreme events. (Male, 78-year village elder)

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A key informant spoke of the advantages of reverting to livestock farming of indigenous breeds resistant to drought. The informant recommended that livestock farmers in Mutare district, as is the case with the rest of Zimbabwe, should adapt to small animal breeds such as the Boran cattle breeds that are hardy, drought-resistant, and can survive most common diseases. The informant further recommended the rearing of goats as they are adaptive to cold or hot climatic conditions, and the quality of their manure is good for gardening. The researchers agreed with the key informant's recommendations because interview participants contended that they are turning to rear goats for meat and, to a lesser extent, milk sources.

3.4.3 Cattle pen fattening and dairy farming

Smallholder farmers expressed the view that intensive cattle farming is a strategy that they use as a symbol of status, source of protein, manure, draughts power, and most importantly, funding important events. The participants pointed out that apart from the thriving dairy industry, they are cattle fattening before selling them to abattoirs. The participants further narrated that they grow fodder for feeding dairy cows and beef livestock. The smallholder farmers indicated that they preserve fodder for use when livestock feed is scarce during the dry season. Additionally, they buy maize and wheat straws from other farmers after harvest and preserve them for their animals during the dry season.

Smallholder livestock farmers highlighted tick-borne disease as the main challenge they face due to the non-availability of dipping facilities. As a result, the participants are forced to spray dip chemicals. Some participants said they have no choice but to buy medicines for their sick animals as the veterinary department struggles to treat them. The participants bemoaned that medicines are very expensive, so it is not always possible to recover costs when they sell their livestock. Lastly, the smallholder farmers pointed out that cattle rustling was becoming a major challenge to achieving sustainable livelihoods.

3.5 Urban Agriculture

The study sought to ascertain the reason behind the proliferation of urban farming activities, consistent with the general trend across Zimbabwe. Urban agriculture is not a recent phenomenon as it has always been the mainstay of many households (Chaminuka & Dube, 2017). Urban participants indicated that they practice some form of agriculture for different reasons. The participants were asked a specific question: 'What benefits do you derive from urban agriculture?'The responses included: 'food supplement,' 'employment creation,' 'community development,' 'access to land,' and 'social bonding.' The pie chart Figure 4 where 'n' presents the number of urban households interviewed shows the distribution of responses. A majority (78%) indicated that they practice urban agriculture as a coping strategy that mitigates the ever-increasing food prices. The participants argued that urban farming reduces their dependence on maize meal from shops and open markets such as Sakubva Musika (Vendor market) in Mutare.

Participants in FGDs further added that they are actively engaged in urban CSA with technical and financial assistance from Caritas Mutare, the development arm of the Catholic Church, Mutare diocese. According to Gwetsayi, Dube, and Mashapa (2016), households in Mutare engage in horticulture as strategies that sustain livelihoods. Participants revealed that they practice precision agriculture techniques in their backyard gardens to supplement their income. The practice entails more precise and controlled cultivation of crops (Belder, Rohrbach, Twomlow, & Senzanje, 2007). Participants revealed that they are practicing horticulture, where they apply techniques such as drip irrigation. They further stated that they use hybrid seeds to grow maize, tomatoes, cabbages, carrots, broccoli, cauliflower, onions, and sweet peppers and have recorded increased yields. On the other hand, urban poverty and high unemployment influence the increase of urban farming. Besides supplementing food requirements, 13% of households indicated urban agriculture as a source of employment. Many urban agriculture projects are run by women who engage youth and invariably provide them much needed skills training.

3.6 Agroforestry and related activities

The participants revealed that sustainable forestry creates many benefits, including timber, wood fuel, wood crafts products, and livestock fodder. They also showed that sustainable forestry could provide a re-

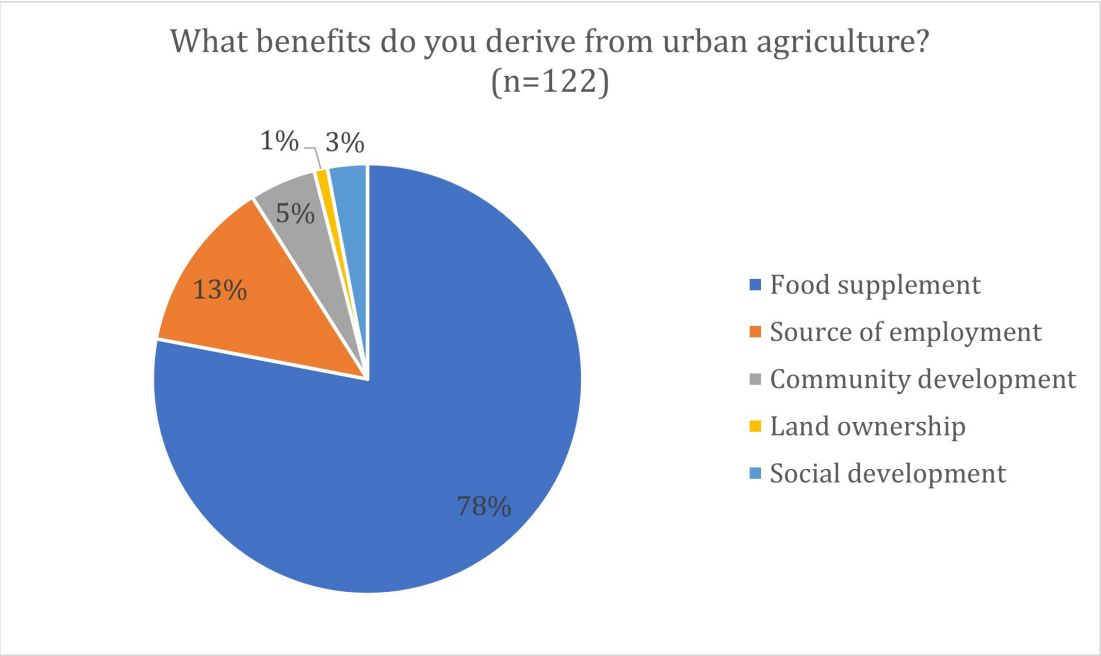

Figure 4. Benefits derived from urban agriculture practice (Fieldwork January - March 2020)

liable source of income through the supply of timber and other wood crafts products (Cavatassi, 2005). Some participants said tree species, shrubs, and grass are extremely valuable to livestock during droughts that cause a moisture loss. By grazing on these native plants, livestock produces better beef and milk. Others said that draft animals benefit from the tree vegetation. In the study area, there are many miombo woodlands, which supports a variety of livelihood outcomes. Participants argue that they use wood fuel for cooking, heating, and lighting their houses. (Lawrence, Tapiwa, Lovemore, & Michael, 2020). Trees that provide a source of energy and fruits included a mixture of *Brachystegia spiciformis, Jubenardia globorora, Brachystegia boehmii, B. tamarinodoide, and Uapaca kirkianaand* (Kujinga, Chingarande, Proisca, & Nyelele, 2012). The researchers established that forestry farmers grow mostly *eucalyptus globulus* and *pinaceae* for commercial purposes

Challenges forestry farmers face are that people in Mutare district are turning to commercial timber poaching for survival due to socio-economic practices that harm sustainable forestry. Forestry farmers regret the practices that harm sustainable forestry. In addition, fires such as those used when hunting, or wood fuel, are damaging their woodlands. Also, with the unavailability of electricity in rural communities, and the unreliability of electric power, forestry farmers stated that their woodlands are being pressed.

4. Discussion

Mutare district in eastern Zimbabwe is transforming agriculture through models that seek to continually improve productivity, environmental stewardship and ensure sustainable livelihoods (Muzorewa & Chitakira, 2020). A combination of results of the participants who indicated partial and good understanding (73%) of CSA is in line with the findings of Huyer and Nyasimi (2017), who submit that while the CSA approach is new and still developing, most of the practices already exist worldwide and are currently used by farmers to cope with various production risks. It is the finding of this study that through the practice of CA, households improve their long-term food requirements and very often in the short-term as well.

Steenwerth et al. (2014) concurred that CA increases the capacity for farmers to adapt to climate variability and change by reducing vulnerability to extreme events. Most importantly, CA increases synergies among resources conservation, food production, and sustainable livelihoods. The study results are consist-

ISSN-Internet 2197-411x OLCL 862804632
UniKassel & VDW, Germany-February 2022

ent with the findings of other scholars who pointed out that planting basins are the most popular CA alternative that is practiced in Zimbabwe (Twomlow et al., 2006). The technique is locally known as conservation tillage, differentiating from other CA practices. Conservation tillage comprises different soil management practices that involve inverting the soil using either a plough or handheld tool (Baudron et al., 2007; Marongwe et al., 2011). This mechanical manipulation of the soil does not affect the soil characteristic, including temperature, soil, water, conservation, evaporation , and infiltration (Busari, Kukal, Kaur, Bhatt, & Dulazi, 2015).

The unreliability of rainfall patterns and increasing temperatures forces farmers to shift to growing drought-resistant crop varieties that include finger millet, sorghum, beans, and sunflowers (Rusinga, Chapungu, Moyo, & Stigter, 2014). On the other hand, small livestock farming supports households by providing important livelihood benefits. According to Mutibvu, Maburutse, Mbiriri, and Kashangura (2012), apart from being an important source of protein, small livestock such as goats, sheep, and fowls are a source of income as they are easily disposable when the need arises, unlike large livestock. Chickens, in particular, offer a fast off-take that plays an important role in the lives of resource-poor households, whereas small livestock such as goats provide a vital source of meat and milk (Muchadeyi, 2007). Researchers elsewhere in Zimbabwe acknowledge this view when they state that livestock is kept for different uses that include meat, milk, draughts power, and different cultural uses (Mavedzenge, Mahenehene, Murimbarimba, Scoones, & Wolmer, 2006; Mutibvu et al., 2012; Ndebele et al., 2007; Svotwa, Hamudikuwanda, & Makarau, 2007).

5. Conclusion

The study established that households in Mutare district, Zimbabwe employ various CSA practices that include crop, livestock, and forestry farming as advocated for in Zimbabwe. CSA has increased synergies among food production systems that have significantly produced surplus quantities sold to support the construction of sustainable livelihood outcomes. The agriculture revolution is achieved through practices such as CA that include minimum soil disturbance through planting in basins, intercropping, crop rotation, cultivation of drought-resistant crops, and rainwater harvesting. Key informants included elders who submitted that CSA is not entirely a new agriculture strategy but is a practice that requires refinement and intensification through technical and financial support. The study recommends more research on livelihoods of resource-poor households to guide policy initiatives and development programmes that enhance livelihood adaptation strategies, thereby creating desired livelihood outcomes. There is a need for a level social, economic, and political playing field to remove impediments that lead to agriculture inputs being distributed on partisan grounds to improve food security.

Acknowledgement

The authors would like to thank the reviewers who provided valuable comments on the earlier versions of this manuscript

Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the study's design, 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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ISSN-Internet 2197-411x OLCL 862804632

Future of Food: Journal on Food, Agriculture and Society
10 (1) February 2022

Impact of organic manuring on soil carbon sequestration under monoculture and perennial systems in tropical rainforest of Nigeria

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Data of the article

First received : 18 May 2021 | Last revision received : 25 December 2021
Accepted : 20 January 2022| Published online :15 February 2022
DOI : 10.17170/kobra-202110144901

Keywords

croplands; mulching; plant residues; tillage; regenerative agriculture

Organic carbon is a vital indicator of soil health, which can contribute to a sustainable agroecosystem. In Africa, mismanagement of agricultural soils has depleted the organic carbon pool. The decline in soil organic carbon has important implications for food security and environmental sustainability. This study examined the impact of monoculture and perennial systems on soil carbon sequestration after fifteen years of cropping in a tropical rainforest of Nigeria. Agronomic management in the monocultures of maize and cassava included farmyard manuring, mineral fertilizers, and tillage practices, while the leaf litters from the avocado and plantain trees remained as soil mulch in the perennial systems. A total of 640 soil samples obtained in the first 15 cm depth from the monoculture and perennial systems were analyzed for particle size distribution, bulk density, and soil organic carbon. Results indicated that clay particles in soil increased significantly ($P \leq 0.05$) in the perennial systems than those of monocultures, whereas the bulk density decreased significantly ($P \leq 0.05$) under perennial systems (averaged 1.31 Mg m^{-3}) compared to monocultures (averaged 1.60 Mg m^{-3}). The soil carbon content (averaged 1.47 %) and carbon stock (28.77 Mg C ha^{-1}) of the perennials was significantly higher ($P \leq 0.05$) than those in the monocultures (averaged 0.87 % and 20.86 Mg C ha^{-1}, respectively). We conclude that permanent soil mulching with plant litters under perennial systems can increase carbon sequestration. The seasonal cropping and tillage under the monoculture system can decrease the soil carbon stock. Organic mulching is a regenerative practice that can restore the carbon pool while improving soil health and crop productivity in agroecosystems across Africa.

1. Introduction

Soil carbon sequestration through croplands has stimulated global interest in the last three decades (Minasny et al., 2017). Soil carbon sequestration is one of the mechanisms where carbon storage is enhanced, thereby reducing the rate of atmospheric CO_2 concentration (Dignac et al., 2017). Soil is a large pool of highly active humus containing twice as much carbon as vegetation and atmosphere pools (Wang et al., 2017), and thus, cropland soils are important sinks for carbon storage (Poeplau & Don, 2015). However, agricultural systems across Africa contribute to the carbon footprint in soil and the atmosphere, increasing CO_2 production. Poor soil and crop management practices such as continuous tillage, monocultures, and removal of organic residues increase CO_2 emissions (Bationo & Buerkert, 2011). Regenerative agricultural practices such as permanent soil covering with organic residues or cover crops, minimum or

conservative tillage, and crop diversification can contribute to soil carbon sequestration and mitigation of CO_2 emissions (Oyeogbe et al., 2017).

The amount of carbon sequestered in the soil is a function of the long-term input of organic materials such as leaf litters, plant and harvest residues, and animal manures (Poeplau & Don, 2015). For example, organic residues from plants and animals under mixed farming systems in West Africa increased the soil organic carbon content (Bationo & Buerkert, 2011). Also, a long-term soil fertility experiment in Nigeria demonstrated that the combination of organic manures and mineral fertilizers was more effective in increasing the soil organic carbon than mineral fertilization alone (Raji & Ogunwole, 2006). Moreover, soil carbon concentration can be affected by the processes of decomposition and erosion (Poeplau & Don, 2015). In tropical Africa, the prevailing high temperature and rainfall also increase the rate of soil carbon decomposition and erosion loss (Igwe et al., 2000).

Restoring the carbon in the soil is not only about mitigating climate change but also enhancing agroecosystem services such as improving air and water quality, reducing soil disturbance and erosion, and ensuring food security. Increased soil organic carbon is a significant indicator of agroecosystem sustainability and is a climate-resilient strategy for alleviating the hidden hunger affecting billions of people while protecting the environment (Rosenberg & Izaurralde 2001). Lal et al. (2006) reported that the accumulation of one-ton carbon in soil per hectare in a year would increase food production to the tune of 30-50 metric tons per year, particularly in Africa.

Thus, the relevance of carbon sequestration in cropland soils is crucial for enhanced soil fertility and crop productivity. However, studies on soil carbon sequestration in diversified cropland systems across Africa are scarce. Our study focuses on soil carbon sequestration in the monocultures and perennial systems under different management practices in the tropical rainforest of Nigeria. We hypothesized that the soil carbon sequestered in the perennials of avocado and plantain would be greater than animal manures and mineral fertilizers in the monocultures of maize and cassava due to the regeneration of carbon material via leaf litter mulching.

2. Material and Methods

2.1. Description of the experimental site and cropping history

The location of the experimental site is in Sapele, Niger Delta of Nigeria, 5o 51' N, 5o 44' E; 10 m above sea level. The average temperature and rainfall conditions in the period (2018) under investigation were 26.6 ° C and 2406 mm, respectively. The pH of the soil ranges between 5.6- 6.2. And is classified as Ultisols according to the USDA soil taxonomy. The cropping history of the field includes monoculture systems of maize and cassava and perennial systems of plantain and avocado orchard. Both cropping systems have been under cultivation for the past fifteen years. Agronomic management practices in the monocultures included the application of farmyard manure, mineral fertilizers, and conventional tillage, whereas, in the perennials, mineral fertilizers were applied only in the first three years of crop establishment, and the leaf falls from avocado and plantain remained as permanent soil mulch.

The cropping area under investigation of monocultures (maize and cassava) and perennials (avocado and plantain) was 6400 m^2, delineated into four blocks of the experimental unit. Each block (20 × 20 m^2) of the experimental units was treated as a cropping system of maize, cassava, avocado, and plantain and replicated four times. Thus, the experiment design was a 4 × 4 treatment combination under randomized complete block design.

2.2. Soil analyses

From each block of 400 m^2 cultivated area, soils were obtained in every 10 m^2 from the 0-15 cm depth. Thus, a total of 640 soil samples was obtained, made of 40 each from the maize, cassava, avocado, and plantain systems. The soil samples were air-dried and sieved with a 2 mm sieve for particle size distribution and a 0.5 mm sieve for organic carbon analyses. The soil particle size distribution was measured with a hydrometer (Bouyoucos 1936) and organic carbon by the wet oxidation method (Walkley & Black, 1934). Also, undisturbed soil was obtained in quadruplicate for bulk density determination (Blake & Hartge, 1986). The soil organic matter content was derived using the van Bemmelen conversion factor of 1.724 (organic carbon

content in % multiplied by 1.724), and carbon stocks in soil (Mg C ha^{-1}) in a fixed depth of 0-15 cm was estimated using the following equation 1, from Oyeogbe et al., (2018).

$$\text{SOC stock} = \frac{\text{SOCconc}(\%) \times \text{bd}\left(\text{Mg m}^{-3}\right) \times \text{soil depth (m)} \times 10^4\ \text{m}^2\ \text{ha}^{-1}}{100} \quad (1)$$

Where SOC is soil organic carbon stock in Mg C ha^{-1}; SOCconc is soil organic carbon concentration; bd is bulk density of soil; m is metres of the soil depth thickness.

2.3. Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) for the randomised complete block design using the SAS package 9.1 where treatment effects were significant at $P \leq 0.05$, the least significant difference (LSD) test was used to compare the means of each treatment combination.

3. Results

3.1. Particle Size Distribution

The distribution of sand, silt, and clay particles differed among the monocultures and perennials (Table 1). Clay particles increased significantly ($P \leq 0.05$) in the perennial systems (avocado and plantain) compared to the monocultures (maize and cassava), while sand and silt particles remained the same.

3.2. Bulk density

The bulk density was significantly different ($P \leq 0.05$) among the monoculture and perennial systems (Table 2). Soil bulk density decreased in the perennials of avocado (1.29 Mg m^{-3}) and plantain (1.33 Mg m^{-3}) compared to the monocultures of maize (1.59 Mg m^{-3}) and cassava (1.61 Mg m^{-3}).

Table 1. Particle size distribution

Cropland systems		Sand	Silt	Clay
		%		
Monoculture	Maize	95.72±0.26a	1.78±0.17a	2.50±0.25b
	Cassava	96.28±0.28a	1.71±0.20a	2.01±0.28b
Perennial	Avocado	92.53±0.24a	2.25±0.18a	5.22±0.17a
	Plantain	92.88±0.25a	2.48±0.16a	4.64±0.16a
P-value (0.05)		4.21	1.54	1.98

Different letters in the same column mean significant differences. ±=standard deviation, n=40.

Table 2. Soil bulk density and organic carbon content

Cropland systems		Bulk density (Mg m^{-3})	Organic carbon (%)
Monoculture	Maize	1.59±0.09b	0.89±0.19b
	Cassava	1.61±0.07b	0.85±0.18b
Perennial	Avocado	1.29±0.03a	1.53±0.12a
	Plantain	1.33±0.04a	1.40±0.13a
P-value (0.05)		0.21	0.38

Different letters in the same column mean significant differences. ±=standard deviation, n=40.

ISSN-Internet 2197-411x OLCL 862804632

3.3. Soil organic carbon content and stocks

The soil organic carbon content and stocks (Table 2, Fig. 2) were significantly different ($P \leq 0.05$) among the monoculture and perennial systems. Organic carbon in soil and the associated carbon stock increased under the perennial cropping of avocado (1.53 % and 29.7 mg C ha^{-1}, respectively) and plantain (1.40 % and 27.9 mg C ha^{-1}, respectively) compared to monocultures under maize (0.89 % and 21.2 mg C ha^{-1}, respectively) and cassava (0.85 % and 20.5 mg C ha^{-1}, respectively).

4. Discussion

4.1. Particle Size Distribution

An increase in the clay content under the perennial systems than those of monocultures could be related to the leaf litters, which contributed to organic matter decomposition and carbon turnover in soil. Sinoga et al. (2012) and Rodriguez-Lado (2017) showed that leaf litter decomposition regulates the clay content and carbon storage in soil. The clay fraction in the soil is generally highly associated with organic carbon storage (Matus et al., 2016). Sausen et al. (2014) reported that high clay particles increased the soil carbon storage in highly weathered soil in Brazil. In the soils under study, the permanent mulching with leaf litters in perennials may reduce raindrop and erosion impact on the clay fractions and organic carbon loss; whereas, seasonal tillage in the monoculture systems exposed the clay fractions and organic carbon to erosion loss. Furthermore, the high concentration of sand and clay fractions than silt could be due to the soil formation process, caused by the underlying sand particles and the clay sequence of the parent rock material (Akpokodje, 1989).

4.2. Bulk density

The decrease in soil bulk density in the perennials of avocado and plantain is closely related to the organic carbon inputs from the leaf litter decomposition. The permanent soil mulching with leaf litters in the perennials of avocado and plantain can contribute to soil carbon storage while reducing carbon loss from the damaging effects of high temperature (Buchkowski et al., 2019). A decrease in the soil bulk density is associated with high organic carbon and stable structural aggregates (Arunrat et al., 2020). The soil bulk density indicates structural stability, which depends on the organic carbon constituents. The structural stability of soil to form and retain stable aggregates is dependent on the binding force of organic matter stabilization (Paul, 2016). Leaf litter decomposition can reinforce the structural aggregates and associated organic carbon storage in soil (Sausen et al., 2014; Capellesso et

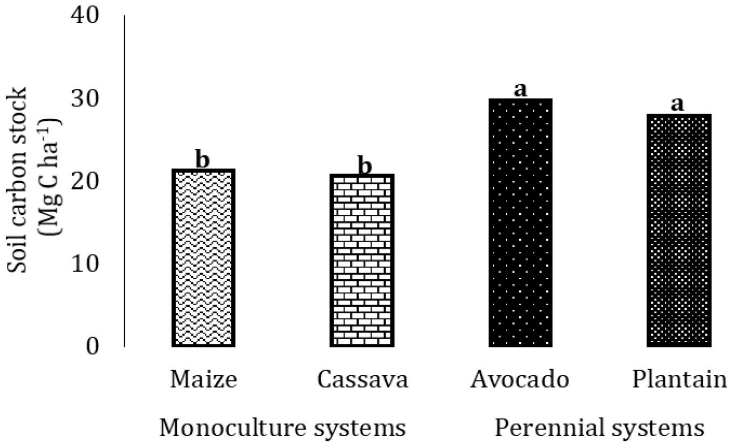

Figure 1. Soil carbon stocks under monoculture and perennial systems. Different letters represent significant difference at $P \leq 0.05$

Figure 1. Soil carbon stocks under monoculture and perennial systems. Different letters represent significant differences at $P \leq 0.05$

al., 2016), while monocultures disintegrate soil aggregates (Zhou et al., 2020). Increased soil bulk density in the monocultures of maize and cassava may be due to continuous tillage, which may have exposed the organic carbon to rapid decomposition and loss. Don et al. (2011) reported that soil tillage contributes to carbon loss of up to 30-40% compared to semi-natural vegetation such as the perennial system. Increased soil bulk density by the seasonal tillage in monocultures affects the accumulation of organic carbon responsible for forming stable soil aggregates (Zhou et al., 2020).

4.3. Soil organic carbon content and stocks

Increased soil carbon stock in the perennial systems is due to the accumulated organic matter from leaf litters decomposition in the last 10-15 years. Litter contribution to soil organic carbon increased up to 40% compared to soils without litter addition after 120 years of abandonment (Novara et al., 2015). Leaf fall and litter decomposition can reinforce carbon cycling and turnover in soil (Sausen et al., 2014; Capellesso et al., 2016). On the contrary, seasonal tillage in the monocultures decreased the soil carbon stock and associated carbon sequestration. Haddaway et al. (2017) reported that conventional tillage reduces the capacity of soil to sequester organic carbon by exposing the soil surface to erosion and high-temperature effects. More importantly, organic carbon stabilization in cropland soils can positively affect biomass productivity and environmental sustainability. In this study, the perennials of avocado and plantain increase the stability of soil carbon from the uninterrupted conversion of organic residues into humus and the associated sequestration of carbon.

5. Conclusions

Monocultures and perennials are diversified agroecosystems in Nigeria. The sustainability of these cropland systems depends on the soil ecosystem services, particularly the soil organic carbon content. Restoring the soil carbon pool through organic mulching can improve soil health and crop productivity while mitigating the adverse effects of climate change. Permanent soil mulching via leaf litter in the perennials of avocado and plantain contributed to the efficiency of soil carbon sequestration, while seasonal tillage in the monocultures of maize and cassava decreased the carbon sequestration potential. Soils under diversified agroecosystems have the potential to minimize atmospheric CO_2 emissions through carbon sequestration.

Conflict of interest

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

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ISSN-Internet 2197-411x OLCL 862804632

Future of Food: Journal on Food, Agriculture and Society
10 (1) February 2022

Social assistance and food security during covid-19 pandemic lock-down: insights from Nigeria

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Data of the article

First received : 18 May 2021 | Last revision received : 20 November 2021
Accepted : 15 January 2022| Published online: 15 February 2022
DOI : 10.17170/kobra-202110144902

Keywords

Covid 19 pandemic; social assistance; household food insecurity; food security; Nigeria

Nigeria, a fast-growing country, has been food insecure prior to the Covid-19 pandemic. Local agricultural production cannot satisfy it's ever-growing population's food and nutrition needs. This state was aggravated by the Covid-19 pandemic lockdown which the government adopted to stem the spread of the virus. To cushion the effects of the lockdown, social assistance of diverse forms from varying sources were supplied. This study assesses the effect of the lockdown order on household food security level, and the coping strategies that were adopted. Also, it examines the kinds of social assistance received and how such mitigated food insecurity status among households that benefitted. The study uses used a secondary dataset from the Nigeria COVID-19 National Longitudinal Phone Survey. The National Bureau of Statistics collected the data in March, June, and July, targeting periods before, during, and when the lockdown was gradually eased, respectively. The results revealed that most households experienced different forms of shock during the lockdown, notably increases in food prices and disruption of farm activities. Furthermore, only a few households received social assistance, main from state governments and religious bodies. The assistance received had a positive effect on household food security during the lockdown period.

1. Introduction

Social assistance in times of crises

In most times of crises, such as violence, poverty, war, natural disasters and pandemic, the populace is disproportionally affected, with the poor, disabled and the politically marginalised mostly affected. Thus, underscoring the significance of social safety nets (SSN). Social assistance (SA) or SSN describes intervention programs that are non-contributory and primarily put in place to support poor or vulnerable people and families to survive a period of scarcity, deprivation, hunger, and susceptibility (HLPE 2012; World Bank 2018). SA has been emphasized and provided by governments and non-government organizations at various national, regional, and international levels. Food and Agriculture Organization of the United Nations (2016) extensively discussed the organisation's engagement and support for different countries in times of crisis. Another example of such intervention is the Supplemental Nutrition Assistance Program (SNAP) of the United States government, described as the most important anti-hunger program. According

to the U.S. Agriculture Department, the programme assisted about 40 million low-income Americans in affording a nutritionally adequate diet[1]. Similarly, the cash transfer and grant system programs of the Government of South Africa, especially amid the Covid-19 pandemic was laudably appraised. In a recent report by the World Bank, the government reportedly spent over 3 percent of the GDP and above 15 percent of total government spending to provide sizeable benefits to the poorest households during the Covid-19 pandemic. In the same vein, during natural disasters, aids have been provided to victims to provide immediate succor. For instance, a few hours after the 2003 major earthquake that struck the city of Bam, Kerman Province in south-eastern Iran, the Iranian Red Crescent Society (IRCS) swung into action. The IRCS deployed search and rescue teams, provided temporary shelter, distributed food and non-food items, and supplied emergency water and medical services to victims (Ghafory-Ashtiany and Hosseini, 2008).

1.1 Food insecurity and associated issues

Nowadays, food insecurity is one of the critical concerns for the increasing global population. According to the USAID (1992), food security occurs "when all people at all times have both physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life." A family is said to be food secured when every member has access to adequate food for an active and healthy daily life and when the household occupants do not experience starvation or food scarcity (Otaha 2013).

Food insecurity, especially at the household level, is a major cause of increased vulnerability to poverty and hunger, affecting many families around the world. This makes untold households go to bed hungry on a daily basis (Jessup-Varnum 2018). This could result from several factors leading to food crises including stresses of unstable prices of food, climatic changes and drought, limited natural resources, and intermittent emergencies such as pandemic/epidemic that result in food shortage, either acute or long term.

The consequential effects of food insecurity are enormous, including poverty, malnutrition, undernutrition, hunger, and food shortage/insecurity. These unwholesome conditions kill millions of people worldwide annually and have been described as the root causes of human insecurity and factors besetting sustainable development (FAOUN 2016). Food insecurity is more pronounced in the sub-Saharan Africa region, with the largest percentage of hunger and undernourishment globally (Jessup-Varnum 2018). It, therefore, constitutes a major challenge for most African governments.

1.2 Food insecurity in Nigeria

In Nigeria, prior to the pandemic, food insecurity was a serious issue due to several factors impeding the growth and productivity of the agricultural sector. The latter was the mainstay of the economy at independence when it contributed about 63.49 percent to the Gross Domestic Product (GDP) in 1960 (CBN 1980; Nwankpa 2017). However, the table was turned when crude oil was discovered leading to the neglect of other sectors including agriculture. From 2013 to 2019, the contribution of agriculture to Nigeria's GDP did not exceed 26% at any time (PwC 2020), notwithstanding the sector's potential. Other challenges besetting the sector include climate change, gender inequality, cattle rustling in the North, continued insurgency in many parts of the country, conflicts (constant farmer-herdsmen, religious, tribal, etc.), among others (Otaha 2013; World Bank 2019).

These issues have negatively impacted food availability, accessibility, affordability and hence food security in the past decades. Consequently, Nigeria has not performed well in various food security indices at national and international arenas. For instance, The Global Food Security Index (GFSI) of the Economist Intelligence Unit (2019)[2], rated Nigeria 86 amidst 107 nations in 2013 and 94 out of 113 countries in 2019. Similarly, the general household survey conducted in 2015 by the NBS reported that the estimated value of moderate and severe food insecurity in the country were 26.4 and 19.6 percent, respectively.

Much recently, in 2019, the government ordered par-

[1] https://www.fns.usda.gov/pd/supplemental-nutrition-assistance-program-snap.
[2] Global Food Security Index 2019 Strengthening food systems and the environment through innovation and investment. Available online: https://foodsecurityindex.eiu.com/index. Accessed 20/12/2020

ISSN-Internet 2197-411x OLCL 862804632

tial (August) and later full (October) closure of all land borders in the country. This heightened the prices of some common food commodities, including rice. This became obvious as the food inflation increased from 13.2% in August 2019 to 14.7% in December 2019 and rose to 15% in April 2020.

1.3 COVID-19 pandemic

COVID-19, an infectious disease caused by coronavirus has become a global pandemic, adversely impacting and causing socio-economic "downturn" in over 200 countries with millions of individuals and families affected and over two million fatalities (World Health Organization 2020). The adverse impacts of COVID-19 have been enormous on the socio-economic outlook of human lives coupled with its attendant challenges on all sectors of the global economy, including agriculture, manufacturing, tourism, health, education, and service.

The impacts and challenges of the pandemic among African countries are enormous and far-reaching. This is apparent in the affected countries' needs for foreign aids from better-positioned economies in terms of fiscal and supply of medical equipment (testing kits, vaccines, protective kits, etc).

Nigeria recorded its first case of COVID-19 on February 27th, 2020, and has since experienced a steady increase in the number of cases across the states of the country. As part of measures to curtail the spread of this highly infectious disease, the Nigerian government, through the Presidential Taskforce (PTF) set up to manage the COVID-19 pandemic, came up with some guidelines for the country (NCDC 2020). Notable among the guidelines was the strict lockdown order which was enforced between the periods of March and August 2020. However, different stages of lockdown easing were experienced across different states of the country between the periods depending on the level of assessed risk of transmission. Normalcy gradually returned to businesses and agricultural activities during the mid of lockdown period. Other measures enforced were compulsory use of face masks, closure of businesses except those offering essential services, schools, and markets.

The associated challenges of the pandemic have been reported to include job losses, declined/stopped business revenue, slashed income, disruption of agricultural and farming activities, hike in food prices, increased poverty, hunger, and malnutrition. These occurrences were sudden and unexpected, resulting in difficulty and lack of capacity of households and individuals to afford basic living needs. This has been suggested to further aggravate the situation of malnutrition and food shortages in Nigeria. During the period of the lockdown order, two things were of utmost priority to all classes of people - good health and food. To cushion the effects of the lockdown period on individuals and households, monetary aids in the form of safety nets and palliatives (majorly food items) were provided to indigent individuals from various sources. The federal and state governments as well as non-governmental organizations (NGOs), religious bodies and well-meaning individuals provided funds for social welfare and palliatives to lessen the burden associated with the pandemic. As laudable as the measures and steps taken, the system and mechanism of distribution and the actual impacts of the initiatives are pivotal to be documented, especially within the months of lockdown period.

1.4 COVID-19 and food insecurity in Nigeria

Among the most grievous challenges associated with the COVID-19 pandemic is its negative effect on food security. The lockdown and movement restrictions order during the pandemic affected nearly all stages of the food value chain (Andam et al. 2020). These resulted into reduced agricultural activities, unavailability, inaccessibility, and unaffordability of many food commodities due to sharp hikes in food prices, and of course, panic buying in many parts of the country. There was also reduced income flow to many households, given that a vast majority (about 80%) of Nigerians work in the informal sector (e.g., road peddlers, transporters, petty traders, and artisans, private firms). This resulted to a decrease in family income, increase indigence, and higher possibility of long-term brunt, including greater levels of hunger (Human Rights Watch, 2020). In all, restrictions in movement due to the pandemic engendered substantial economic costs that, in turn, threatened lives, jeopardized livelihoods, and deepened poverty (Alani and Olanrewaju 2020).

As a result, many households who ordinarily are not considered poor and already vulnerable ones experienced transitory food insecurity, facing the risk of

hunger and poverty.

Consequently, Nigeria was one of the 44 countries that FAO globally recognized to require external food assistance in March 2020[3], and food inflation rose to an average of 15% in April 2020. Most of the northern states of the country, particularly Borno, Yobe, and Adamawa states which have been raged with terrorism and banditry, were most affected. During the pandemic, FAO reported that a majority of Nigeria's population could not afford food from local markets due to a lack of income coupled with a hike in food prices. Another gruesome effect of COVID-19 disease on Nigerian food security includes disruption of 2020 farming season, unbalanced food distribution and supply chain, depletion of food reserves, and decreased farmers' income, amongst others (PwC 2020). Globally, one of the immediate public policy responses of countries to the Covid 19 pandemic is the creation or expansion of social assistance schemes (CGAP 2020; World bank 2020).

1.5 Social assistance during Covid-19

Worldwide, state-led social assistance disbursements during the pandemic were estimated to have benefited nearly 2 billion people, including over a billion new social assistance payment recipients (CGAP 2020; Gentilini et al. 2020). In India, APU (2020) reported that among the 5,000 respondents interviewed, 74% of vulnerable households received at least one round of relief package, while about 50% received cash disbursement. Additionally, about 33% of the respondents obtained loans to meet with their expenses during the same period. According to CGAP (2020), social assistance was better administered to intended recipients in climes with already established humanitarian services and cash transfers.

In response to the pandemic, the Federal government of Nigeria launched the COVID-19 Fiscal Stimulus to support the economy[4] and deployed three major social interventions. First, three months' interest holidays were rolled out to about two million small-scale business owners on Tradermoni, Marketmoni, and Farmermoni [5]. These loans were distributed by the Bank of Industry, Bank of Agriculture, and the Nigeria Export and Import Bank. The second was to increase the number of beneficiaries in the national food and cash transfer scheme from 2.6 to 3.6 million households during the pandemic lockdown (Eranga 2020). The scheme was an already established social assistance payment program that targeted the country's poor and vulnerable households. In addition, the amount paid to recipients was increased from ₦5,000 monthly to ₦20,000. The third measure was the donation of foodstuffs to states' governments and the Federal Capital Territory, Abuja, for distribution to low-income families in their respective states. Food from the national grain reserve was also distributed to citizens. Additionally, the private business organizations collaborated with the Central Bank of Nigeria to establish CACOVID (Coalition Against COVID-19) towards the end of the first quarter of 2020. Cash donations from this group are kept by the CBN as COVID-19 Support Account (CBN 2020). Coalition Against COVID-19 donated above ₦30.1 billion ($72 million) at the end of June 2020 (Ejiogu et al. 2020).

Even though these social assistances have benefited some people, there were allegations of irregularities, lopsidedness, corruption, lack of transparency, and poor accountability in their distributions (Ejiogu et al. 2020; Eranga 2020). The beneficiaries were mainly poor and vulnerable in the country and were determined/selected by the Ministry of Humanitarian Affairs, Disaster Management, Social Development, and states governments. There were no comprehensive, all-inclusive parameters for determining the beneficiaries, especially such that would capture those who became poor and food insecure as a result of the pandemic. Andam et al. (2020) found that additional

[3] http://www.fao.org/giew/country-analysis/external-assistance/en/

[4] Ministry of Finance (2020) https://statehouse.gov.ng/wp-content/ uploads/2020/04/HMFBNP-Final-Press-Statement-on-Responding-to-the-COVID-19-06.04.2020-v.7.docx-1.pdf

[5] Tradermoni, Marketmoni and Farmermoni are three arms of the Government Enterprise and Empowerment Programme (GEEP) initiated by the Federal Government of Nigeria on the platform of its National Social Investment Programme. They were created to provide zero-collateral soft loans to traders/artisans, market women and farmers respectively.

ISSN-Internet 2197-411x OLCL 862804632

measures than what was provided were needed specifically for people residing in urban areas with very low income and rural families with non-agricultural trades, for instance, those who lost their jobs or income.

This study sets out to examine and analyze the impacts of the lockdown order on food (in)security and other variables listed as food prices, location of household, sources, and frequency of assistance and palliatives shocks experienced during the period and the various coping strategies adopted by households using differential trend analysis method. The specific objectives are:

(1) Assess how households were affected and social assistance received during the lock-down period.

(2) Examine the level of food (in)security during the pandemic in terms of food accessibility, food affordability, and feeding pattern of Nigerians.

(3) Assess the effect of social assistance obtained on food security during the lock-down period.

2. Methodology

2.1 Research design

This study uses a secondary dataset from the Nigeria COVID-19 National Longitudinal Phone Survey (COVID-19 NLPS) involving a nationally representative sample of 1,950 households. The data was collected by National Bureau of Statistics with the support of the World Bank. The households sampled in this survey were drawn from the sample of households interviewed in Wave 4 2018/2019 of the General Household Survey Panel.

2.2 Variables of study

The study investigates the effect of the lockdown period on the lives of Nigerians by analyzing the relationship between the outcome variable and the explanatory variables.

In the survey, the shock was measured by asking respondents of each household if they have been affected by shock(s), in terms of job losses, non-farm business closure, theft/looting of cash and other property, disruption of farming, livelihood, fishing activities, increases or fall in prices of agricultural or business inputs, food insecurity, increases in prices of main food items consumed, illness, injury or death of income earning member of household since mid-March. The response was either Yes or No. Furthermore, respondents were asked how they cope with the shock(s). Respondents were able to choose from the following options: sale of agricultural or non-agricultural assets, engaged in additional income-generating activities, receiving assistance from friends & family, borrowed from friends & family, taking a loan from a financial institution, credited purchases, delayed payment obligations, sold harvest in advance, reduced food consumption, reduced non-food consumption, relied on savings, received assistance from NGOs, took advanced payment from the employer, received assistance from the government, was covered by insurance policy, did nothing, and others.

Receipt of social assistance was measured by finding out from the respondents if any member of the household received any assistance from any institution such as the government, international organisations, religious bodies in the form of food, direct cash transfers, other in-kind transfer (excluding food). The response was either Yes or No. Moreover, the main source of the assistance was obtained by asking them if the assistance was from the federal government, State government, local government, community organization/ cooperative, NGOs, international organization, religious bodies, and others. Food security was measured by asking the respondents if they or any other adult in the households had to skip a meal because there was not enough money or other resources to get food, had to run out of food because of a lack of money or other resources, had to go without eating for a whole day because of a lack of money or other resources during the last 30 days. Other pertinent information includes socio-demographic data on households' region of residence, rural/urban setting, type of household, and age.

2.3 Sampling procedure

A total of 4,976 households selected randomly across the country's six geo-political zones formed the target frame from which the sample size of this study was drawn. This consists of the households interviewed in

wave 4 of the General household survey in January/February 2019. To easily reach study respondents from the 2019 survey, household heads' phone numbers and 3 other close relatives were documented for subsequent studies. These contact numbers were subsequently used to get in touch with the selected respondents for the 2020 monitoring survey. This study sample was thus drawn randomly from the pool of 4,976 households in order to have a representative sample.

In total, over 3000 phone numbers were selected from the target frame using a balancing sampling approach (sex and education status of household head, household size, location) in order to retain the characteristics of the frame.

2.4 Sample size

This study used three rounds (1, 2, and 3) of the GHS panel data. Though a sample size of 1800 was targeted, a larger number (an additional 60%) was contacted to cater for non-response and loss of interest in the study. Subsequently, the study's sample size varied across the rounds due to non-response, unreachable phone lines and the likes.

2.5 Response rate

Round 1

Out of the 3000 household targeted, about 2070 sampled households were successfully contacted in the first round of the survey, out of which 1950 (representing 94%) were completely interviewed.

Round 2

Out of the 1950 sampled households in round 1, only 1852 were successfully contacted, and 1820 (93.3%) were completely interviewed in Round 2.

Round 3

Again, all 1950 interviewed at the baseline round (1) were targeted for round 3, except for 25 households that refused to attempt Round 2. Summarily, only 1790 households were successfully interviewed in Round 3.

Table 1 gives a breakdown of households that form a complete panel across the three rounds. Data was collected through the help of Computer Assisted Telephone Interview (CATI).

2.6 Research instrument

The questionnaire was used to elicit relevant data from the sampled households in April/May, June, and July 2020 from the head of the participating households. The survey was conducted in three rounds with slight changes in the questionnaire used at each stage.

2.7 Data analysis

To facilitate nationally representative estimations and account for potential sample attrition, weights for the final sample were calculated in several stages and are updated for each survey round. These calculated weights were applied in the analyses, making the results nationally representative. The analyses rely on a balanced panel obtained from merging the first, second, and third rounds of the NLPS, conducted in April/May, June, and July, respectively. Our indicators of interest were similarly measured across the three surveys. We excluded the second round in some cas-

Table 1. Period of interview and sample size per collection round

Cycle	Period	Sample size (Households)
1st Round (baseline)	April/May	1950
2nd Round	June	1820
3rd Round	July	1790

ISSN-Internet 2197-411x OLCL 862804632

es because it did not contain information on some variables of interest. We further applied descriptive and inferential statistical tools to analyze variables of interest and establish the relationship between the explanatory and outcome variables. Descriptive statistics such as percentage, frequencies, and weighted average were employed to explain the pattern of our indicators across the rounds, while inferential statistical tools such as regression as used to explain the relationship between the explanatory variables and food (in)security at 5% level of significance.

3. Results

3.1 Shocks and coping strategies during the COVID-19 pandemic lockdown

Table 2 presents the number and percentages of households affected or not affected by shock because of COVID-19 pandemic lockdown in Nigeria during rounds 1 and 3 surveys. During round 1, about 93% of households reported being affected by a shock. By round 3, the percentage of households affected by shock had increased slightly to about 94%. This result suggests that COVID-19 led to many households experiencing increases in the number of shocks in terms of job losses, nonfarm business closure, theft/looting of cash and other property, disruption of farming, livelihood, fishing activities, increases or fall in the prices of agricultural or business inputs, food insecurity, increases in the prices of main food items consumed, illness, injury or death of an income-earning member of a household, amongst others.

Consequently, households had to devise various means and coping tactics to alleviate the negative effect of COVID-19 shocks. Some of the strategies practiced by households to cope with the shocks experienced during the lockdown period of the COVID-19 pandemic are presented in Table 3. During the earlier lockdown period (round 1), many households (21%), about one out of every five, reduced food consumption as a coping strategy. Additionally, due to reduced income during the period, many households (12.1%) relied on savings, while some (6%) claimed to receive assistance from friends & family; some others did nothing. During the round 3 survey, reducing food consumption remained a leading strategy adopted by most respondents to cope with the Covid-19 lockdown. This is followed by reliance on savings. Pertinent to note is that the percentage of households (13.7%) that engaged in food reduction and those that relied on savings reduced to 13.7% and 7.1% respectively by round 3, as they were the main coping strategies adopted by many households. More so, no household attested to collection of loan from a financial institution, neither did any receive assistance from NGOs or government nor took advanced payment from the employer.

Regarding the assistance received by households dur-

Table 2. The number and percentages of households affected by shock since the start of COVID-19 pandemic lockdown.

Shock	Rounds		
	1	3	Total
Yes	1,816	1,691	3,507
	92.9%	94.4%	93.6%
No	138	100	238
	7.06%	5.58%	6.36%
Total	1,954	1,791	3.745
	100%	100%	100%

Pearson chi2(1) = 12.7010 Pr = 0.000

ing the COVID-19 pandemic lockdown, Figure 1 illustrates the percentages of households who received assistance from any institution such as the government, international organizations, and religious bodies in the form of food, direct cash transfers, other in-kind transfers (excluding food). One striking feature of Figure 1 is that a high percentage of households claimed they did not receive any form of social assistance in terms of food, direct cash transfers, and other in-kind transfers (excluding food) during the COVID-19 pandemic lockdown. The figure revealed that, in round 1, about 16% of the sampled households received social assistance in the form of food, direct cash transfers, other in-kind transfers (excluding food). In round 2, the percentage of households who received social assistance was quite similar to that of round 1 at 15.87%, while the percentage of households who received assistance reduced to only 8% in round 3.

Social assistance, in the form of food, direct cash transfers, other in-kind transfers, was received by households from the government and different organizations. The different sources of social assistance received by households during the COVID-19 pandemic lockdown are illustrated in Figure 2. There is an indication that much of the assistance received by households comes from the state government and religious bodies, followed by other sources and federal government (although the federal government may have contributed to the relief package offered by the state). Out of nearly 16% of households who were recipients of social assistance in round 1 (Figure1),

Table 3. Coping strategies adopted by households affected by shock due to COVID-19 pandemic lockdown and associated problems.

	Round 1			Round 3	
	n	%		n	%
Sale of assets	31	1.7		51	3
Engaged in additional income generating activities	55	3		110	6.5
Received assistance from friends & family	109	6		49	2.9
Borrowed from friends & family	63	3.5		25	1.5
Took a loan from a financial institution	1	0.1		0	0
Credited purchases	49	2.7		34	2
Delayed payment obligations	3	0.2		10	0.6
Solid harvest in advance	31	1.7		16	0.9
Reduced food consumption	372	20.5		231	13.7
Reduced non-food consumption	130	7.2		56	3.3
Relied on savings	219	12.1		120	7.1
Received assistance from NGOs	3	0.2		0	0
Took advanced payment from employer	1	0.1		0	0
Received assistance from government	4	0.2		0	0
Was covered by insurance policy	0	0		1	0.1
Did nothing	152	8.4		74	4.4
Others	85	4.7		77	4.6
Total	1816	100		1690	100

ISSN-Internet 2197-411x OLCL 862804632

about 33% of them received assistance from the state government, 26% from religious bodies, and 8% from the federal government. Similarly, in round 2, 27% of households received assistance from religious bodies, 24% from the state government, and 13% from community/cooperative societies. Moreover, out of about 8% of households who received social assistance in Round 3, approximately 27% received assistance from religious bodies, 23% from the state government, and 12% from federal government and community/cooperative societies in round 3.

3.2 The level of food (in)security during the COVID-19 pandemic lockdown

Table 4 reveals the level of food (in)security during the COVID-19 pandemic lockdown. The result clearly shows that food insecurity was quite high during the COVID-19 pandemic lockdown periods. Dur-

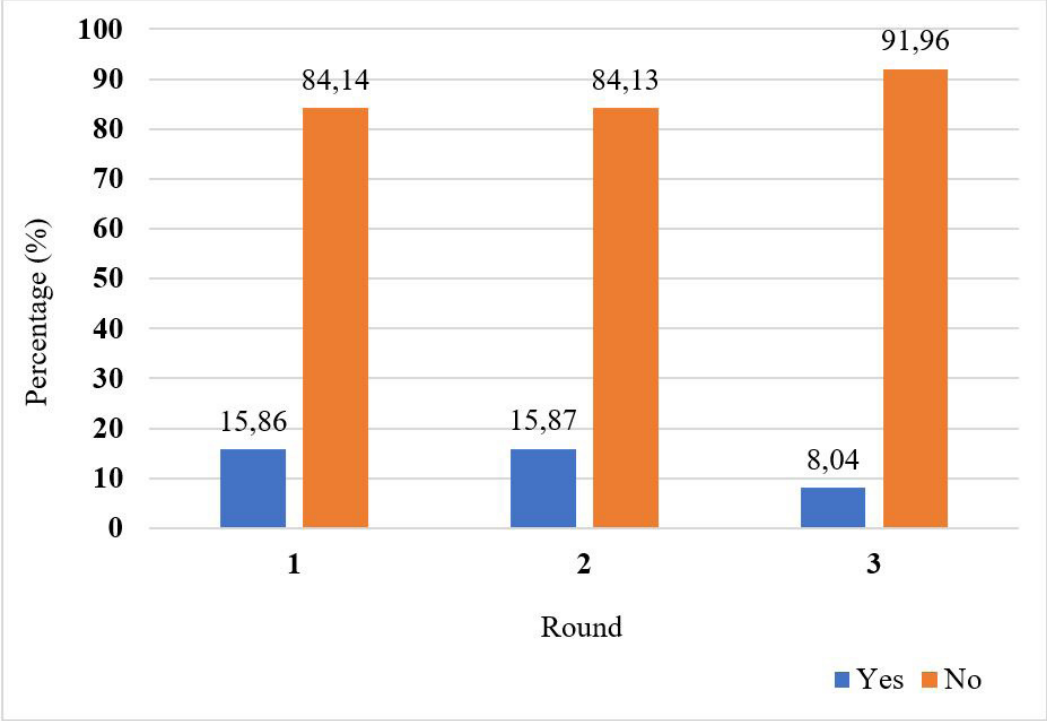

Figure 1. Percentages of households who received assistance from sources such as government, international organizations, religious bodies in form of food, direct cash transfers, other in-kind transfers (excluding food).

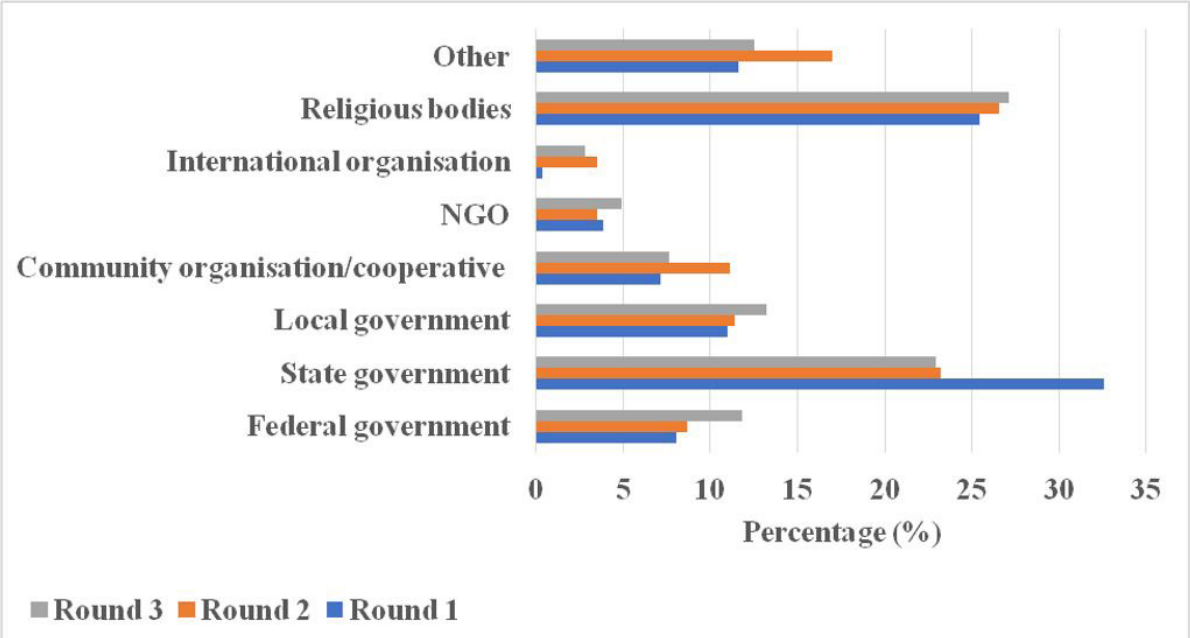

Figure 2. Sources of social assistance during COVID-19 pandemic lockdown

ing Round 1, about 73% of households had to skip a meal due lockdown, while 70% of households skipped meals in round 2. Similarly, about 57% of households ran out of food during round 1, and 59% ran out of food during round 2. Concerning the level of food security, a considerable percentage of households (75%) said they could not afford to eat persistently for a whole day in round 1, while 69% could not afford that in round 2.

3.3 The effect of social assistance obtained on food security during the lock-down period.

Table 5 presents the effect of social assistance on food security during the lock-down period. The effect of social assistance on food security during the lock-down period was obtained by regressing the variable, social assistance, on the outcome variable of interest, food (in)security. Other pertinent household-level control variables, such as zone, metropolitan status, household type (male-headed versus female-headed household), and age of head of household, were also included in the model. Technically, the effect was determined by estimating a binary logistic equation of the form:

$$F_j = \alpha + \beta S_j + \gamma Z_j + \mu_j$$

Where j index household, F_j is a binary/dummy indicator variable for households' food (in)security, S_j is a dummy variable indicating whether a household receives social assistance or not, Z_j is a vector of the aforementioned control variables, β and γ are vectors of parameters and μ_j is the error term. This model indicates that urban food in(security) is a function of receipt of social assistance and a number of household-level variables, including zones in which households are located, type of household, households' metropolitan status, and age of household head. The result shows that, in round 1, households who were beneficiaries of social assistance are less likely to experience food insecurity, though the coefficient is not significant at any conventional level. Likewise, in round 3, beneficiaries were 0.6% less likely to suffer from food insecurity. However, households from the South-East, South-South, and South-West were less likely to experience food insecurity. Households in the South-West had an 11% and 3% probability of suffering from food insecurity in rounds 1 and 2, respectively. Compared with households in urban areas, those in rural areas

Table 4. Level of food (in)security during COVID-19 pandemic lockdown

	Round 1		Round 2	
	n	%	n	%
Household members had to skip a meal?				
Yes	1423	72.8	1273	69.9
No	531	27.2	548	30.1
Total	1954	100	1821	100
Household members ran out of food?				
Yes	1111	56.9	1088	59.7
No	843	43.1	733	40.3
Total	1954	100	1821	100
Household members went eating for a whole day?				
Yes	479	24.5	558	30.6
No	1475	75.5	1263	69.4
Total	1954	100	1821	100

ISSN-Internet 2197-411x OLCL 862804632

were more likely to suffer food insecurity during both periods. Moreover, male-headed households have a lesser probability of suffering from food insecurity than female-headed households. Older household members were also less likely to experience food insecurity during the lockdown than younger ones.

Notably, the $R^{2,}$ a statistic that indicates the percentage of the variance in the dependent or outcome variable that is explained collectively by the independent variables, shows that 2% and 3% of the variation in the outcome variable is jointly explained by the independent variables in rounds 1 and 2, respectively. Meanwhile, the F-statistics indicates that the estimated coefficients are jointly significant and improved the model.

4. Discussion

The emergence of the COVID-19 pandemic has undoubtedly affected and disrupted various facets of global economies. The attendant challenges of the pandemic have been felt in abrupt employment reduction in some sectors, decrease in income and revenue, disruption of individual, business, and government productive activities, inflation, and food insecurity.

Table 5. The effect of social assistance on food security during the lock-down period

	Dependent variable is food (in)security	
	Round 1	Round 2
Social assistance (yes)	-0.000	-0.006
	(0.028)	(0.029)
North East	-0.031	-0.106**
	(0.037)	(0.037)
North West	-0.061	-0.167***
	(0.038)	(0.039)
South East	0.059	0.026
	(0.020)	(0.036)
South South	0.062	-0.004
	(0.021)	(0.038)
South West	0.101***	0.043
	(0.036)	(0.037)
Rural	0.011	0.068*
	(0.023)	(0.024)
Male-headed household	-0.077*	0.327
	(0.046)	(0.198)
Female-headed household	0.252	0.338
	(0.379)	(0.204)
Age	0.001	0.001
	(0.003)	(0.003)
Age-squared	-0.000*	-0.000
	(0.000)	(0.000)
Constant	0.786***	0.381
	(0.107)	(0.208)
R^2	0.02	0.03
Adjusted R^2	0.01	0.02
F-Statistics	2.82	4.55
Observations	1954	1821

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

More pertinently, the scourge of the pandemic has exacerbated food insecurity in different parts of the developing regions, particularly in Africa, where food insecurity has been a major socio-economic challenge before the outbreak of the pandemic. The findings from this study have important implications for addressing the longstanding problem of food insecurity that has continued to plague the continent, Nigeria in particular, and became worsened during the COVID-19 pandemic lockdown, thus further plunging vulnerable households into poverty and hunger. For instance, our findings indicate that there was a slight increase in the proportion of households that were affected by shock, notably food-related shocks (in terms of job losses, nonfarm business closure, theft/looting of cash and other property, disruption of farming, livelihood, fishing activities, increases or fall in prices of agricultural or business inputs, food insecurity, increases in the price of major food items consumed, illness, injury or death of an income-earning member of a household, amongst others) as a result of COVID-19 pandemic lockdown in Nigeria. These results suggest that COVID-19 really led to many households experiencing increases in the number of shocks. In fact, many households resorted to rationing food and reducing food consumption as coping strategies to mitigate the undesirable effect of the lockdown. This finding resonates with a similar study in India that found that as a result of COVID-19 lockdown, about 72% of respondents reported job losses, 60% of households were without enough cash to purchase essential commodities that could last them for a week (APU 2020). Similarly, it was reported that about 80% of households that responded in a phone survey had to reduce food consumption to cope with the COVID-19 lockdown.

Further findings show that the level of food insecurity during the lockdown was quite high. In contrast, the percentage of households who received social assistance from any institution such as the government, international organizations, religious bodies in the form of food, direct cash transfers, other in-kind transfers (excluding food) was quite low, despite the high level of vulnerability, poverty, and hunger in the country. Much of the social assistance, in the form of food, direct cash transfers, other in-kind transfers, received by households were from the government and religious bodies. Other findings indicate that the receipt of social assistance positively affected food security during the lockdown period.

However, households from South-East, South-South, South-West, rural areas, female-headed households, and younger household members had a higher probability of suffering from food insecurity during the lockdown periods than their respective counterparts. These findings clearly show that government, through its various public institutions and agencies, has an important role in ensuring food security and citizens' wellbeing, especially during an economic shock. The roles of religious bodies and leaders in Nigeria are also very crucial in ensuring both the spiritual and physical wellbeing of their members. As such, these institutions should be further strengthened to perform this function effectively. Moreover, the distribution of food should be done equitably and fairly such that all the regions and affected categories of people are well taken care of.

Ultimately, tackling food insecurity in Nigeria will require the concerted efforts of all relevant stakeholders, including the government, private sector, non-state actors, and other relevant international institutions. In collaboration with other pertinent stakeholders, the Nigerian government needs to take drastic actions in setting up viable mechanisms that will ensure increases in agricultural production and the revamp of the agricultural sector for greater agricultural outputs.

The government must develop a diversification strategy that will put agriculture and, by extension, food security in the forefront if the country is to achieve its national food-security goal and several international commitments to ensuring the fundamental right of every citizen to safe, quality, and nutritious food. More importantly, reducing incidences of food insecurity during a negative and unexpected economic shock, such as the unprecedented COVID-19 pandemic, will require increased food production, storage, and distribution channels and capacities.

5. Policy recommendations

From the foregoing, it is thus recommended that:

i. Ensuring food security at all levels of society should remain a policy priority among policymakers and

ISSN-Internet 2197-411x OLCL 862804632

pertinent stakeholders.

ii. Food security should be enhanced by revamping the agricultural sector and implementing a viable diversification programme that focuses on increasing agricultural production, distribution, and storage.

iii. Government should partner with other private and religious institutions by creating an enabling environment that could improve food security and social protection of their citizens.

iv. Government should further build a resilient and robust social protection system that is posed to protect vulnerable and poor people, especially during a negative economic shock or an unprecedented pandemic.

v. There is a need for a more robust, comprehensive data bank of poor and vulnerable individuals in Nigeria, which should be systematically reviewed and updated at all levels of governance, including national, state, and local governments. This would inform and guide the proper distribution of social safety nets and further ensure that the right targets are not excluded.

Conflict of interest

The authors declare no conflict of interest.

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ISSN-Internet 2197-411x OLCL 862804632

Future of Food: Journal on Food, Agriculture and Society
10 (1) February 2022

The potential of red kidney beans and brown rice-based flakes for breakfast to reduce obesity

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Data of the article

First received : 05 August 2021 | Last revision received : 13 September 2021
Accepted : 11 January 2022 | Published online :15 February 2022
DOI : 10.17170/kobra-202110144903

Keywords

Breakfast meal; Brown rice; Flakes; Obesity; Red beans

The global epidemic of obesity has become one of the most important public health issues. It is predicted that by 2030, 38% of global adults will be overweight. One of the factors that cause obesity is skipping breakfast. Breakfast meal flakes are popular and ready-to-eat in several countries. However, the breakfast flakes on the market are high in carbohydrates, causing consumers to have a limited choice of breakfast products, especially for patients who suffer from obesity. The nature of the problem described above inspired the design of this research to produce and develop breakfast flakes made with brown rice and red kidney beans as the main ingredients to prevent obesity. The study was designed with four formulas (F1-F4) and five attributes. The results included the organoleptic data, total fat, SFAs, MUFAs, PUFAs, dietary fiber, and proximate analysis. Based on the organoleptic results, formula F4 had the highest hedonic score, and the nutritional content (F4) was contained (373.81 kcal per 100 g), whereas nutrients (moisture, ash, protein, carbohydrate, fat, and dietary fiber) were 9.68 % w/b, 6.43 % w/b, 23.57 % w/b, 52.67 % w/b, 7.65% w/b and 14.53 %w/b respectively. The ash content was high due to sodium content; therefore, reducing the salt in the formula will decrease sodium content. The ratio between ω-6 to ω-3 fatty acids in flakes F4 was 0.53 that may provide nutritional benefits. Furthermore, Fe, Ca, Na, and K content was 3.98 mg, 137.10 mg, 1381.64 mg, and 793.15 mg, respectively. Based on these results, no nutrition claims can be proposed to the F4 flakes due to their high sodium content. When reformulation is conducted to reduce the sodium content to be lower than 300 mg per serving size, the F4 flakes can be claimed as high protein and high fiber, which helps consumers feel full longer and may make it a weight loss-friendly food. It also contains essential minerals, including iron and potassium. In conclusion, red beans flakes are suitable for consumption as a breakfast meal and may be a good suggestion for preventing obesity.

1. Introduction

The global epidemic of obesity is growing at an unprecedented pace and has become one of the world's most important public health issues. It is predicted that by 2030, 38% of the world's adult population will be overweight without effective intervention (Wang et al., 2019). Several influences correlate with obesity and metabolic disorders, including genetics and physiological differences (gender and age), living environments, and habits (diet, stress, smoking, alcohol, and exercise). Obesity contributes to multiple metabolic conditions, such as pathologies linked with inflammation, cardiovascular diseases, hypertension, coronary

problems, and diabetes mellitus (Wang *et al.,* 2019). To manage obesity, dietary changes and herbal solutions may be used to prevent their adverse effects, instead of medications. One of the main health care priorities is the prevention and management of chronic diseases, as it accounts for nearly 60% of all deaths worldwide (World Health Organization 2003). Accordingly, the nutritional process through some functional foods is an alternative and effective treatment for the delivery of some effective food components in the management of chronic diseases, specifically considering the high costs of health care in some countries, especially in developing countries (Gehan 2017).

Breakfast meal flakes (BMF) is a popular ready-to-eat breakfast food commonly consumed by children, school youth, andadults at breakfast and is served with liquid milk or Yoghurt (Nuriana *et al.,* 2019). Currently, existing breakfast food products are made from wheat, corn, millet, and rice, high in carbohydrates. This creates consumer limitations to breakfast choices, especially for individuals with obesity. One of the factors that cause overweight or obesity is skipping breakfast. This is because those who skip breakfast often succumb to eating junk food containing high carbohydrates content and fats like fried foods (Mishartina *et al.,* 2018). Data from the Indonesian Food and Drug Authority (BPOM 2016), showed that there are about 1,015 products that were officially registered with the keyword "grains" and only 67 products were officially registered with the keyword "flakes." Most of the grains and flakes listed are generally made of corn and wheat. However, it is still rare to find flakes made from legumes such as red beans. There is an important need to search for functional foods that have multiple health benefits, provide many different nutritional values, and reduce obesity (Abdulrashed *et al.,* 2016). In this study, we prepared nutritional breakfast flakes food with ingredients such as brown rice, red beans, chia seeds, and ginger as a functional food with nourishing properties targeted for reducing the risk of overweight and obesity.

Red beans are known as a plant protein source, which contains around 21- 27% per 100g with a low glycemic index value, namely 26, which is good for obesity and diabetes mellitus sufferers because the increase in sugar levels in the blood is slow, and peak sugar content is slow (Astuti *et al.,* 2019). Red kidney beans have a water-soluble fiber that can reduce cholesterol levels and blood sugar levels ((Mishartina *et al.,* 2018) and contain alpha-amylase and alpha-glucosidase inhibitory activity contributing to delayed digestion of carbohydrates (Riantiningtyas and Marliyati, 2017). Hence the selection of red beans is a good source of protein used as a ready-to-eat cereal or flakes (Rakhmawati *et al.,* 2014).

Brown rice contains many bioactive compounds and is an important source of dietary fiber and minerals, including the rare mineral selenium, which is instrumental in inducing DNA damage repair and the synthesis of damaged cells to promote apoptosis (Ravichanthiran *et al.,* 2018). Moreover, brown rice is rich in magnesium, which has a vital role in our bodies, as it acts as a cofactor for more than 300 enzymes. Brown rice also contains a high amount of dietary fiber; therefore, brown rice has a lower glycemic index than white rice. In addition, it has vitamin E, which is an antioxidant, aids DNA repair, immune support, and metabolic processes (Ravichanthiran *et al.,* 2018). Furthermore, brown rice flour is the finest and most nutritious cereal flour because it has many anti-allergic proteins and low calcium salts and does not contain gluten protein (Singh *t al.,* 2017). This study aimed to develop breakfast meals (flakes) with brown rice and red kidney beans as the main ingredients. Organoleptic and nutritional content analysis including total fat, SFAs, MUFAs, PUFAs, dietary fiber, and proximate analysis were conducted considering that consumption of the breakfast meals as part of a calorie-controlled diet.

Hypothesis: "Formulating a nutritionally balanced breakfast flakes food with the main ingredients brown rice and red kidney beans as a functional food in a dietary plan, with high protein and dietary fiber, with improved nutritional properties targeted to prevent the risk of overweight and obesity."

2. Material and Methods

Materials

In this study, dried red kidney beans (Phaseolus vulgaris L.), brown rice (Oryza Sativa L.), ginger, honey, table salt, coconut oil, chia seeds, and water were used as raw materials obtained from the local market in Bogor, West Java, Indonesia.

Materials and reagents used in this study include distilled water, hexane, concentrated sulfuric acid

ISSN-Internet 2197-411x OLCL 862804632

(H_2SO_4), selenium mix, ion-free water, phosphate buffer nitric acid (HNO3), 30% NaOH, HCl (0.03 N; 0.1 M and 6 M), indicators methyl red, methylene blue, ethanol 78%, 95%, MES-TRIS (Buffer pH 8.2), alpha-amylase, protease, amyl glucosidase, filter paper, and acetone.

Methods

2.1. Raw Ingredients Preparation

Brown rice and red kidney beans were the main ingredients used to make the flakes. Red kidney beans were soaked in water at room temperature for 24 hours, with periodic replacement of the water every 12 hours, then washed with running water (Riantingtyas and Marliyati 2017). This step was followed by drying for 15-20 minutes, then followed by a peeling process aimed at reducing the coagulation of the flour (Akaerue and Onwuka 2010), improving the appearance, and decreasing flour density (Pangastuti *et al.,* 2013). The deshelled beans were dried in an oven at 60°C for 12 hours. Next, a mixer and disk mill were used to ground the red kidney beans and then sieved them with 60 meshes, which resulted in the kidney beans flour. The same methods were used to obtain brown rice flour (Riantingtyas and Marliyati 2017).

Fresh ginger root was peeled, washed well, diced, and dried with a cabinet dryer for 8 hours at 50° C. The dried samples were ground using a commercial manual milling machine to produce a ginger powder which was stored in an airtight moisture-controlled cabinet (Wang *et al.,* 2019). The reason for using ginger powder is the availability of a crucial active ingredient in ginger called "shogol", which is produced more in dried ginger and has anti-cancer and anti-inflammatory effects (Wang *et al.,* 2019).

2.2. Production of flakes

Four different flake types (F1-F4) were made from four different ratios of brown rice flour to red kidney beans flour (70:30; 60:40; 50:50 and 40:60). Equal amounts of coconut oil, ginger powder, chia seeds, honey, and salt were added to each formula for obtaining four formulations of dough. Next, the dough was steamed for 3 minutes at 70 ° C using a steamer pan (Astuti *et al.,* 2019). After steaming, the dough was formed into a circle and flattened with a 0.5 mm thick noodle maker, cut into 1 cm x 1 cm slices, and placed on a tray, then roasted in the oven at 130°C for 13 minutes. The product was then cooled and stored in airtight polyethylene plastic containers (Riantingtyas and Marliyati 2017).

2.3. Sensory Evaluation

Thirty-four semi-trained panelists who participated in the sensory evaluation were students from the Department of Human Nutrition, IPB University, and consisted of both genders. They were instructed to evaluate four formulas regarding sensory characteristics such as color, taste, aroma, texture, and overall acceptability and then indicate the preference of the specified attributes by providing the appropriate number related to the hedonic scale. The rating scale used is a scale of 1 (lowest score) to 5 (highest score): (1) MOST DISLIKED, (2) DISLIKED, (3) NEUTRAL, (4) LIKE, (5) MOST LIKED. Assessment attributes used

Table 1. The composition of four formula

Ingredients	Formula			
	F1	F2	F3	F4
Brown rice (g)	98 (70%)	84 (60%)	70 (50%)	56 (40%)
Red bean (g)	42 (30%)	56 (40%)	70 (50%)	84 (60%)
Chia seeds (g)	7.5	7.5	7.5	7.5
Ginger powder (g)	2	2	2	2
Salt (g)	2	2	2	2
Honey (g)	15	15	15	15
Coconut oil (g)	7	7	7	7
Water (g)	70	70	70	70

in the hedonic test include color, aroma, taste, texture, and overall acceptability.

2.4. Chemical Analysis

Nutritional content analysis carried out on selected flakes included moisture content by vacuum oven, ash content using the gravimetric method, protein content analyzed by Kjeldahl method, fat content analyzed by Soxhlet method, and the determination of carbohydrates is carried out by the difference method (AOAC 2005), namely: 100% - (Moisture content + ash + protein + fat). The levels of dietary fiber were analyzed by the enzymatic gravimetric method. Fatty acid components were analyzed by Gas Chromatography (GC), and minerals analysis (Na, Ca, K, and Fe) were analyzed by using Atomic Absorption Spectrophotometer (AAS).

2.5. Analysis of the Nutritional contribution of flakes

According to BPOM (2016), the serving size is the amount of food product usually consumed in one meal. In this study, the percentage contribution of the nutritional content of flakes products was calculated by dividing the number of nutrients contained in one serving size flakes with each Nutrient Reference Values (NRVs). The serving size of the flakes is determined based on the average yield of suggestions for serving commercial products.

2.6. Statistical Analysis

Data were analyzed using Microsoft Excel 2010 computer program and the Statistical Program (SPSS), version 26.0 for the Windows operating system. Hedonic data was tested for normality using the Kolmogorov-Smirnov test ($p > 0.05$). The data from the organoleptic analysis used the Kruskal Wallis test because the data variables were not normally distributed. Then continued with the Mann Whitney difference test with a confidence level of 95% ($p \leq 0.05$).

3. Results

3.1. Sensory Evaluation Results

Thirty-four semi-trained panelists from IPB University's Department of Human Nutrition participated in the sensory evaluation, from both genders. Due to their prior sensory test experience, they could discriminate the food products tested. They were instructed to evaluate four formulas regarding sensory characteristics such as color, taste, aroma, texture, and overall acceptability and then indicate the intensity of the specified attributes by providing the appropriate number related to the five hedonic scales. The scale fits with the sensory test trait being measured, and the scale was chosen so that the distance between scale points gets closer to each other to measure the acceptability of the flakes product and the flakes preferences of panelists.

The hedonic test includes four formulas (F1, F2, F3, F4) with five attributes, color, aroma, taste, texture, and overall acceptance. Based on Table 4.1, there are significant differences between formulas on texture and taste attributes ($p<0.05$). The formula F4 had the highest average score for taste and overall criteria, so this was the best acceptable formula because F4 had better taste and overall acceptance than F2, F3, and F1.

Color and taste are important factors in the acceptance of a food product. Color is the number one sensory attribute that consumers see. Therefore, product preference is influenced by color. The hedonic test results showed no significant difference ($p > 0.05$) between F1, F2, F3, and F4, although F3 (3.88) received the highest color preference. The preference of the brownish-yellow color of these products is determined by the additives of brown rice and red beans flour. The Kruskal Wallis test results plus the Mann Whitney test showed a significant difference in the taste attributes of flakes formulas ($p <0.05$). Usually, red beans flour has a strong, distinctive taste caused by the presence of the lipoxygenase enzyme, which naturally gives the nuts a special aroma (Pertiwi *et al.,* 2017).

However, in this study, the red beans used were dry, so the unpleasant taste was not too strong. Roasting can enhance sensory properties and improve the taste of foodstuffs (Fellows 2000). Based on the results F4, has the highest value, namely 3.61. The differences in taste of each formula were due to the different proportions of red beans flour and brown rice. The greater proportion of brown rice caused the taste to

ISSN-Internet 2197-411x OLCL 862804632

Table 2. Hedonic test statistical analysis results

Formula	Brown rice flour	Red beans flour	Aroma	Color	Taste*	Texture*	*Overall*
F1	70%	30%	3.58±0.82 [a]	3.58 ±0.82 [a]	3.08 ± **0.75**[a]	2.94 ±0.88[a]	3.29±0.67 [a]
F2	60%	40%	3.42±**0.56** [a]	3.79±**0.76** [a]	3.23±**0.78**[a]	3.88±**0.76**[b]	3.55±**0.65** [a]
F3	50%	50%	3.44±**0.66** [a]	3.88±**0.76** [a]	3.17±**0.86**[ab]	3.14±**0.89**[a]	3.44±0.78 [a]
F4	40%	60%	3.47±**0.56** [a]	3.5±**0.70** [a]	3.61±**0.77**[ab]	3.70±**0.83**[b]	3.61±0.77 [a]

* The sensory attribute based on the Kruskal Wallis test, p-value is significant if <0.05. The notation a, b = different test results based on the Mann Whitney continued test between formulas. Different letters in the column indicate significant differences (p <0.05). The rating scale used is a scale of 1 to 5: (1), MOST DISLIKED (2), DISLIKED (3), NEUTRAL (4), LIKE (5) MOST LIKED.

be less favorable to the panelists. This can be seen in the result of the taste attribute, which differs greatly between F4 (40:60) compared to other formulas.

Aroma caused by the food ingredients determines the properties and satisfaction of these foods. In this study, the red beans used were dry. Therefore the unpleasant aroma of red beans, usually caused by the presence of lipoxygenase enzyme, was not too strong. The classification test results on the aroma attribute showed the difference in the formula has no significant effect on the panelists' preference scores (p> 0.05), although sample F1 has the most liked aroma value (3.58) followed by F4 (3.47), F3 (3.44), and F2 (3.42).

Similarly, flakes products' texture recommends that it be crispy but not easily damaged with water or milk. Kruskal Wallis test results continued with the Mann Whitney test results showed that the flakes difference in composition has a significant effect on the panelists' preference scores of the texture attribute of the flakes (p <0.05). Flakes formula, F2 received the highest preference value (3.88), followed by F4 (3.70), F3 (3.14), and F1 (2.94). F2 and F4 have a very crispy texture compared to F1 and F3, due to the additional effect of a greater proportion of red bean flour. This is probably because of the texture factor of dry kidney beans, which is hard and crispy (Kurnianingtyas *et al.,* 2014).

The texture of red beans can be attributed to the starch (amylose and amylopectin) content, as amylose and amylopectin play a role in the formation of gelatinization, causing a crispy texture (Rohmah 2013).

Based on the overall acceptability results, F4 (40%: 60%) scored the highest. We attributed the panelists' level of preference of F4 over other flakes products to its higher composition of red beans flour. The trend with other flakes also showed that the more red beans added, the greater the choice value for the flakes product. This indicates that the addition of red bean flour influences the level of preference of panelists over flakes products. The more red beans added, the greater the value of preference for the flakes product. This can be seen in the results of adding red bean flour with Formula F4 (3.61), which resulted in a higher level of preference for panelists compared to F2 (3.55), F3 (3.44), and F1 (3.29).

3.2. Nutritional Content of Selected Flakes (F4)

The results in Table 3 show the contents of energy, moisture, ash, protein, carbohydrates, and fat in F4 were compared with SNI (Indonesian National Standard). Based on the results, the energy value of F4

flakes was 373.81 kcal per 100 g. Carbohydrates contributed 56 % of the total energy and 52.67% of the total weight. The SNI requires at least 60% of carbohydrates to be present in the product. The main source of carbohydrates in F4 flakes was brown rice flour. The moisture content value of the F4 flakes was 9.68% wet basis. This value was higher than the maximum value of SNI that is 3.0% but also is a slightly higher moisture content requirement for high-grade grains than (4%-8%), based on Nielsen (2010). The high moisture content could be due to protein content found in red beans, which have functional binding properties and water holding capacity, and most of the red beans' fiber content can absorb more moisture (Pangastuti et al.,2013). This may increase the water activity. Hence, it is recommended to control the water activity to prevent spoilage and maintain shelf life and food quality.

In this study, the primary sources of the fat content of the F4 flakes are derived from coconut oil and chia seeds. This study showed that the fat content of F4 flakes was 7.65 % wet basis. These levels met the standards set for Cereal products according to SNI (7. 0%). The protein content of F4 flakes was 23.57 % wet basis, andthe high protein value is due to the addition of red kidney beans as a source of protein, which is around 21-27% per 100 g of material (Astuti *et al.,* 2019). The protein in red kidney beans may lower cholesterol and LDL (low-density protein) and increase HDL (high-density protein) cholesterol levels (Rakhmawati *et al.,* 2014). The ash content of the F4 flake was 6.43 % wet basis. The high percentage of ash indicates that the product is possibly rich in minerals, maybe because of brown rice, chia seeds, ginger, and kidney beans which contain several minerals that can increase mineral content (Agustina *et al.,* 2013).

The F4 flakes product analysis results showed a total dietary fiber content of 14.53 % wet bases. Based on the Indonesian Food and Drug Authority (BPOM 2016) and the European Food Safety Authority (EFSA 2008), processed food can claim high fiber if it contains at least 6 g per 100 g. Therefore, F4 flakes can be classified as high-fiber nutritional products. Previous studies have shown that consumption > 25 g/day of fiber helps prevent the risk of obesity by maintaining the stability of lipids in the blood, slowing the absorption of fats from the small intestine, and increasing satiety. Additionally, it reduces the secretion of the hormone ghrelin. Hence, consuming high-fiber flakes with low caloric energy can prevent obesity (Nelson *et al.,* 2009).

Table 3. Nutritional content of selected flakes (F4)

Nutrients (100 g)	Result of proximate analysis	
	(%WB)	SNI (%WB)
Energy (Kcal)	373.81	
Protein	23.57	Min. 5.0
Fat	7.65	Min. 7.0
Carbohydrate	52.67	Min. 60.0
Moisture	9.68	Max. 3.0
Ash	6.43	Max. 4.0
Calcium (mg)	137.10	
Sodium (mg)	1381.64	
Potassium (mg)	793.15	
Iron (mg)	3.98	
Fiber	14.525	

ISSN-Internet 2197-411x OLCL 862804632

3.3. The Fatty acid content of F4 flakes (fatty acid profile)

The fatty acid composition of F4 flakes has been analyzed, and thirteen fatty acids have been found, as can be seen in Table 4, consisting of eight saturated fatty acids (SFA), three monounsaturated fatty acids (MUFAs), and two polyunsaturated fatty acids (PUFAs). The essential fatty acids in humans are ω-3 (omega 3) PUFA, alpha-linolenic acid (ALA) and ω-6 (omega 6) PUFA, linoleic acid (LA). Generally, SFAs were primarily distributed in higher amounts than MUFAs and PUFAs. Lauric acid was the highest value in SFAs because lauric acid is presen t in coconut oil with content ranging from 45% – 50% and coconut oil is its primary source (Assunção *et al.,* 2009). Studies have confirmed that medium-chain saturated fatty acids (such as lauric acid found in coconut oil) and monounsaturated fatty acids such as oleic acid are less likely to increase insulin resistance, fat storage, and obesity compared to long-chain saturated fatty acids (such as palmitic acid). Interestingly, lauric acid and oleic acid have high oxidation rates of fatty acids, which may lead to their burning of energy and reduced storage potential in adipose tissue, thus promoting increased energy consumption (DiNicolantonio and O'Keefe 2017).

As seen in Table 4, the highest level of PUFAs was in Alpha-linolenic acid (ω-3). Particularly, linolenic fatty acids are greater than linoleic fatty acids, with a ratio of 1222:655 mg/100g. According to the recommendations of FAO/WHO (Lunn and Theobald 2007), high-quality fatty acids should have a ratio of linoleic fatty acids to linolenic fatty acids that does not exceed 4:1. The n-6/n-3 ratio is considered to be the key factor for balanced nutritional importance. The potential health benefits of alpha-linolenic have gained attention in recent years, and evidence on the role is growing. We need to consume more long-chain n-3 PUFAs and less saturated fatty acids. This is consistent with current dietary recommendations of consuming a minimum of 1% energy as n-6 PUFAs and 0.2 % energy as n-3 PUFAs (Lunn and Theobald 2007). The UK Department of Health recommends an ideal ratio of ω-6/ω-3 should be at least 0.20 to provide nutritional benefits for human health. The ratio ω-6/ω-3 showed a value of 0.53% to provide nutritional benefits and remain within appropriate and safe consumption limits, as stated by Simopoulos 2008.

Table 4. The fatty acids content of selected flakes

Types of fatty acids (mg/100g)	F4 Flakes
Saturated fatty acid (SFA)	
Caprylic acid	332
Capric acid	265
Lauric acid	2018
Myristic Acid	796
Palmitic Acid	928
Stearic Acid	253
Arachidic Acid	13
Dodecanoic Acid	6
Unsaturated fatty acids	
Monounsaturated fatty acids (MUFA)	
Palmitoleic acid	3
Oleic acid /omega 9 /n-9	870
11- Eicosanoic acid C20: 1	7
Polyunsaturated fatty acid (PUFA)	
Linoleic acid (ω-6)	655
Alpha-Linolenic acid /omega (ω-3)	1222
Ratio ω-6/ω-3	0.53

The Omega-3 (PUFAs) content of the F4 flakes can be attributed to the addition of chia seeds. Simultaneously, n-3 polyunsaturated fatty acid alpha-linolenic acid (ALA)] may be protective and enhance insulin resistance, lower blood cholesterol (LDL) and increase HDL. Interestingly, Omega-3 can be anti-obesity effects (such as increased fatty acid oxidation, increased basal metabolism, increased protein, and muscle formation (DiNicolantonio and O'Keefe 2017). Increasing the ratio-6 / ω-3 to the maximum can pose a risk to human health (Domiszewski et al.,2011).

3.4. Contribution of nutrition of the selected flakes to RDA and nutrition claims

Table 5 shows the contribution of nutrition of the selected flakes to RDA, nutrition claims, and Nutrient Reference Values (NRVs). The nutritional content was obtained from the proximate analysis results and was compared with the nutritional needs of the general population based on the Nutrient Reference Values (NRVs) to obtain the nutritional contribution of the flakes to energy and nutrient needs, when taken with 250 ml of milk. The Recommended Dietary Allowance (RDA) is set at 2,150 kcal per day, and requirements for breakfast meal energy is 20-25% of the daily RDA (Sukasih and Setyadjit 2012). The selected flakes provide an energy contribution of 8.69 % and 15.90 % if consumed with milk. This value is less than the required compared with the recommended breakfast requirementswhich is 20-25% of daily nutritional needs (Sukasih and Setyadjit 2012).

Based on Table 5, the selected flakes' energy, protein, fat, and carbohydrate content were 373.81kcal, 23.57 g; 7.65 g, and 52.67 g per 100 g, respectively. Furthermore, the contribution of Fe, Ca, Na, and K content per 100 g of the selected flakes product was 3.98 mg, 137.10 mg, 1381.64 mg, and 793.15 mg, respectively The selected flakes (F4) contributed 17.38 % of the total daily energy requirement.

According to Regulation No. 13 of The Indonesian Food and Drug Authority (BPOM 2016), a portion of processed food with a claim on the label must meet the requirements of intake per serving no more than 18 g of total fat; 4 g saturated fat; 60 mg cholesterol; and 300 mg sodium. As the sodium contents in the selected flakes product are more than 300 mg, no nutrition claim can be made for this food product.

When a reformulation can be conducted by reducing salt content to make the product contain sodium lower than 300 mg, a nutrition claim may then be proposed. By this concern, the selected flakes (F4) satisfy about 39%, 24%, 18%, and 17% of NRVs for protein,

Table 5. Contribution of nutrition of the selected flakes to RDA and nutrition claims

Ingredient	Nutritional content serving (50 g)	Milk 250 ml	F4 with milk	NRVs	% RDA	% RDA	
				General	Serving Size 50g	Serving Size 50g with milk	Nutritional Claims
Energy (Kcal)	186.90	155	341.9	2150	8.69	15.90	
Protein (g)	11.78	8.3	20.08	60	19.64	33.47	High protein
Fat (g)	3.82	8.38	12.2	67	5.7	18.21	
Carbohydrate (g)	26.33	11.65	37.98	325	8.1	11.68	
Fiber (g)	7.26	0	7.26	30	24.2	24.20	High fiber
Fe (mg)	1.99	0.08	2.07	22	9.045	9.40	Source iron
Ca (mg)	68.55	291	359.55	1100	6.23	32.68	
Na (mg)	690.82	103	793.82	1500	46.05	52.92	
K (mg)	396.57	369	765.57	4700	8.43	16.28	Source potassium

ISSN-Internet 2197-411x OLCL 862804632

dietary fiber, iron, and potassium, respectively. Based on BPOM (2016) regulation, the flakes product may be considered high protein because it contains more than 35% NRVs per 100 g product. These selected flakes also contain dietary fiber of more than 6g/100g and are considered as high fiber. The iron and potassium contents in the selected flakes product are also higher than 15% of the NRVs for those minerals. Thus, the food product may also be classified as the source of iron and potassium when the sodium content can be reduced to be less than 300 mg per serving size.

3.5. Comparison of the selected flakes (F4) with other commercial flakes

Table 6 compares the nutritional content and dietary fiber in flakes products made from red beans and brown rice flour with commercial flakes products. The nutritional content of the selected flakes was compared to commercial flakes available in Indonesia and other countries from different manufacturers to compare the usage effects of red beans and brown rice flour based on the nutritional content of the flakes chosen. The total dietary fiber content in the selected flake products was 14.525 mg/100g, much greater than other commercial flake products. This high fiber is due to red kidney beans, brown rice, and chia seeds. The protein content in the selected flake products was 23.57%, higher than other commercial flake products. This high protein is due to the use of red kidney beans as a source of protein. The selected flakes provide an energy contribution of 368 kcal. The selected flakes contribute 52.67 g to carbohydrates. The nutritional value of the selected flakes product has higher protein, high fiber, and lower prices than other flakes.

Table 6. Comparison of the selected flakes (F4) with other commercial flakes

Product flakes	Weight	Nutritional Value					
		Calories	Protein	Fat	Carbo Hydrate	Dietary fiber	Price
	(g)	(kcal)	(g)	(g)	(g)	(g)	(Rupiah)
Forbidden organic Brown Rice Flakes	100	368	6.8	2	78.9	1.4	96600
Brown rice flakes	100	352.7	7.1	2.4	72.3	5.0	23658
Natural Brown rice	100	376.6	8.2	2	80	0	162400
Bigoz Organic Free Brown Rice Flakes	100	362	8	4.5	74.6	4.7	60248
Kellogs Coco pops Brown Rice	100	113	1.5	0.6	26.1	0.8	25000
Barbaras Brown Rice Crips non organic	100	160	2	1	25	1	102480
Selected Formula	100	373.8	23.5	7.6	52.67	14.52	15900

4. Discussion

4.1. The Potential Effects of Dietary Fiber on Appetite Regulation and Obesity

Dietary fiber has many functions in the diet, one of which may help control energy intake and reduce risks (diabetes, cardiovascular disease, obesity, bowel cancer, and constipation) which may lead to hemorrhoids when its effects are prolonged, and disorders that have serious negative effects on human health as a result of lifestyle changes. When there is an imbalance in the diet or a lack of dietary fiber intake, it will lead to some health problems that may last a lifetime (Al Hammadi 2017). Fiber has lower energy density, and it contains fewer calories than protein and fat but a larger volume and is richer in micronutrients. One of the beneficial effects of fiber is promoting a feeling of fullness and desire to consume food, thus decreasing food intake. High-fiber foods can hold water and require more salivation and chewing, which therefore bring about satiety (Al Hammadi 2017). The recommended daily dietary fiber intake for healthy adults is between 20 and 38 grams per day. One serving of F4 flakes contains 7.26 g of fiber, giving 24.2% fiber needed per day. Hence, it can be classified as high fiber (6 g per 100 g) based on BPOM (2016).

Recent studies have clearly shown that increasing dietary fiber can cause weight loss by automatically reducing calorie intake, slowing digestion, and the absorption of nutrients which helps prevent blood sugar levels from rising too quickly after eating and increasing the feeling of fullness (Howarth *et al.,* 2001). Additionally, other epidemiological studies indicate an association between low fiber intake and higher BMI (Howarth *et al.,* 2001). Importantly, fiber has been associated with reduced weight gain, reduced risk of obesity, and has become rare in people who eat a high fiber diet gaining less weight than those on a low-fiber diet (Slavin and Green 2007). Foods rich in fiber naturally require more chewing effort and/or time. This is hypothesized by reducing the intake rate to promote satiation.

4.2. The Potential Effects of High Protein Diet and Weight Loss

The Recommended Dietary Allowances (RDAs) for protein are set at a minimum of 0.8 g/kg of body weight, whereas high-protein diets are advisable for approximately 1.2 g to 1.5 g/kg body weight and lower than 2 g/kg body weight. Based on the results of F4 flakes, the contribution of protein intake was 19.64% per serving size, which can be considered a high protein meal. Recently, scientific evidence has suggested that the right high-protein diet may be a useful tool in the fight against obesity, being more likely to help keep the weight off, improve weight maintenance, and increase satiety (Tang *et al.,* 2013). Interestingly, the human body burns more calories in digesting protein than it does digesting carbohydrates or fat because protein has a higher rate of thermogenesis than three times the rate of carbohydrate and ten times the rate of fat so that it can control weight or the amount of energy required for the digestion, absorption, and metabolization of nutrients. Another scientific evidence showed that a high-carbohydrate diet breaks down about 35% of lean tissue and 65% of fat, but a high-protein diet reduces lean tissue breakdown to 20% while increasing fat breakdown to 80% (Tang *et al.,* 2013).

Skipping or eating a low-protein breakfast promotes protein breakdown rather than fat loss until a high-protein meal (more than 30 g) is consumed. During a catabolic state, muscle protein synthesis decreases while muscle protein breakdown increases. Thus, a high-protein breakfast slows protein breakdown and keeps people feeling fuller for longer. In light of these findings, breakfast becomes the most ctritical high-protein meal of the day. It can promote protein synthesis rather than energy intake, which means that eating high-quality protein throughout the day can protect lean tissues while losing weight (Tang *et al.,* 2013).

5. Conclusion

In this research, breakfast meals (flakes) were developed with brown rice and red kidney beans as the main ingredients. Based on organoleptic and nutritional content analysis, the best formula flakes were obtained from a formula based on the ratio of brown rice flour to red kidney bean flour (60:40) as the main ingredients (F4). These selected flakes contained a high amount of several nutrients but a relatively low amount of calories (373.81 kcal per 100 g). Im-

ISSN-Internet 2197-411x OLCL 862804632

portantly, it is high in protein and fiber, which may help consumers feel full longer and make it a weight loss-friendly food. It also contains essential minerals, including iron and potassium. Expectedly, red beans flakes are suitable for consumption as a breakfast meal and maybe a good suggestion for reducing overweight and obesity.

Conflict of Interest

The authors declare no conflict of interest. Furthermore, the funder had no role in the study's design, in the interpretation of data or collection, analyses, the decision to publish the results, and the manuscript's writing.

This research was supported by the Directorate General of Higher Education, Ministry of Education and Culture, Republic of Indonesia, through the KNB Scholarship.

Appendix

Analysis of Dietary Fiber Content (Asp and Björck 1992).

The analysis of food fiber content with the enzymatic method begins with sample preparation, weighing 10 g of sample (W) into an Erlenmeyer flask, then adding 25 ml of Na-phosphate buffer and making a suspension. Buffer is added to stabilize the termanyl enzyme. The Erlenmeyer flask was added 100 µl termanyl then the flask was closed and incubated at 100 °C for 15 minutes while occasionally stirring, and it was removed and cooled. The addition of termanyl breaks down the starch by the gelatinization process first. After that, 20 ml of distillate water was added, and the pH was adjusted to pH 1.5 by adding 4 M HCl, then adding 100 mg of pepsin. PH regulation aims to ensure optimum environmental conditions for pepsin activity. The Erlenmeyer flask was closed and incubated at 40 °C and agitated for 60 minutes. After reaching 60 °C, Erlenmeyer was removed and added 20 ml of distilled water. The pH was adjusted to 6.8 by adding 4 M NaOH (the optimum pH for pancreatin enzyme activity). After the pH is appropriate, 100 mg of pancreatin enzymes are added, then the flask is closed and incubated at 40 °C and agitated for 60 minutes. After that, the pH was lowered to 4.5 using HCl. The solution was filtered with a dry crucible of known weight (porosity 2) containing 0.5 g of dry celite, then washed 2 times each with 10 ml of distilled water, and the final result was the residue and filtrate.

Analysis of Fatty Acids (AOAC 2005)

This study's analysis of fatty acids used Gas Chromatography (GC). The extraction process using the Soxhlet method is the first stage of fatty acid analysis, after which the fat is weighed up to 20 grams in the form of oil. The next stage is the methylation process, and this process aims to form compounds derived from fatty acids, namely methyl esters. The methylation process is carried out by flowing back the fatty acids in a water bath using NaOH-methanol, isooctane, and BF3 solvents. The 20 mg sample was put into a test tube, and 1 ml NaOH-methanol was added to the sample 0.5 N, heated for about 20 minutes, and then refrigerated. 2 mL of 20% BF3 solution and 5 mg / mL internal standard, then the sample was heated again for 20 minutes and cooled. After cooling with 2 mL saturated NaCl and 1 mL isooctane, the mixture was carefully whipped. The isooctane solution is then transferred to a tube that has been mixed with 0.1 g of anhydrous Na_2SO_4 salt using a pipette and left for 15 minutes before adding up to 1 µl of the standard FAME mixture (Supelco 37 components of methyl fatty acid) Esther blend) then injected. 1 µl sample was injected into gas chromatography (GC). Fatty acid determination is done by injecting methyl ester into gas chromatography with the following conditions:

Column: Cyanopropyl methyl sil (capillary column
Column dimensions: p = 60 m, Ø in = 0.25 mm, 025 µm Film Tickness
Flow rate N_2: 30 mL / minute
Air flow rate: 400 mL / min
Flow rate He: 30 mL / minute H_2
Injector temperature: 220℃
Flow rate: 40 mL / min
Detector temperature: 240℃
Column temperature: Program temperature

Column temperature:
Split Ratio: 1:8
Inject Volum: 1 µL
Linear Velocity: 23.6 cm/sec
Retention and peak times were measured for each fatty acid and compared with standard retention times.

Rate (°C/minutes)	Temp (°C) Hold	Time (minutes)
125	5	-
10	185	5
5	205	7
3	225	10

This is done to obtain information about the type and amount of fatty acids in the sample. The fatty acid content in the sample can be calculated using the following formula:

$$Fatty\ acid\ content\ in\ sample(\%) = \frac{\frac{Ax}{As}\ x\ C\ standar\ x\ \frac{V\ example}{100}}{example\ gram}\ x\ 100\%$$

Note:
Ax = Sample area
C standard = standard concentration
V standard = Sample volume
As = Standard area

Calcium levels analysis using the atomic absorption spectroscopy (AAS) method (Apriyantono 1989)

The sample was prepared for calcium levels using wet ash. The sample was weighed 0.5-1.0 g and placed in an Erlenmeyer flask. Then 10 ml of concentrated H2SO4 solution and 10 ml of concentrated HNO3 solution were added. Then the solution is heated until clear and left to stand even cold. The solution is then diluted and measured with ion-free water in a 100 ml measuring flask. The solution was then homogenized with a stirrer. The solution was filtered with Whatman 42 filter paper and then read with AAS. The same procedure is performed for blanks. A standard Ca curve must be worked out in advance to calculate the Ca content in the sample. The calculation of the calcium content of a sample can be seen in the following calculation formula:

Information:

$$Ca\ content\ (\frac{mg}{100g}) = \frac{[\frac{mm\ sampel - mm\ blanko - b}{a} \times \frac{Vol\ aliquot}{1000} \times \frac{Fp}{100}]}{sample\ weight\ (gram)}$$

mm of sample = length of sample curve of AAS reading
mm blank = length of AAS reading blank curve.

Analysis of Fe levels using the Atomic Absorption Spectrophotometry (AAS) Method (Tautkus *et al.*, 2004).

Analysis of sample Fe content has the same procedure as analysis of Ca content, the only difference is the standard curve used. Ca content uses a standard Ca curve, while Fe content uses a standard Fe curve. Calculation of sample Fe content is carried out using

$$Fe\ content\ (\frac{mg}{100g}) = \frac{[\frac{mm\ sampel - mm\ blanko - b}{a} \times \frac{Vol\ aliquot}{1000} \times \frac{Fp}{100}]}{sample\ weight\ (gram)}$$

the formula below:

Information:
mm of sample = length of sample curve of AAS reading
mm blank = length of AAS reading blank curve.

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ISSN-Internet 2197-411x OLCL 862804632

Research Paper

Future of Food: Journal on Food, Agriculture and Society
10 (1) February 2022

Analysis of social-economic effects of hazelnut cultivation in development of villages in Amlash County

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Data of the article

First received : 02 July 2021 | Last revision received : 25 December 2021
Accepted : 15 January 2022| Published online : 15 February 2022
DOI : 10.17170/kobra-202110144904

Keywords

Hazelnut cultivation, Economic effects, social effects, Rural development, Amlash County

One of the most important economic activities in rural areas of Iran, especially in the north of the country, is agriculture. In the present study, considering the importance of the hazelnut crop in the rural life of Amlash County, the economic and social effects of hazelnut cultivation on villages and farmers were investigated. This was descriptive-analytical research that the required information was obtained through documentary sources and field studies. The statistical population includes all hazelnut growers in 38 villages of the mountainous area, Amlash County. The sample size was determined 384 items using the Morgan standard table and was distributed among the operators using the random-quota sampling method. The results showed that the economic effects of hazelnut cultivation in the indicators of economic welfare (with an average of (3.76), economic security (3.81), and employment quality (3.72) were higher than the social effects of hazelnut cultivation in indicators of participation (with the average of 3.27) and social capital (3.40) in the study area. Expanding the area under hazelnut cultivation, the government supports by providing low-interest banking facilities and appropriate repayment terms, product insurance, and the construction of conversion and complementary industries are some of the most important ways to develop this activity and increase its economic and social effects in villages of Amlash County.

1. Introduction

The rural economy has a long history on the planet and plays an important role in the location, continuity of residence, wealth production, and job creation. It is one of the most important among the various functions of rural settlements. The initial foundations of the rural economy should be based on agricultural activities. This activity has undeniably affected the system of economic production, nutrition pattern, and many material aspects of rural life to date (Riahi & Azizi, 2020). Agriculture as an economic activity is a set of exploits that humans make from natural inputs to earn a living. In developing countries, agriculture plays a key role in strengthening the foundations of its economy. Since the agricultural sector is important in terms of meeting the food needs of the people, the supply of industrial raw materials, employment, income generation, stability, and its growth can be considered as major factors contributing to the economic and social stability of society (Akbari et al., 2016).

One of the most influential sectors in the economy in Iran is agriculture. It is one of the best ways to develop employment, increase rural households' income, and expand agricultural activities such as cultivation, hor-

ticulture, etc. In this regard, horticultural activities in areas with the necessary potential are among the most critical factors in rural development (Asghari Lafmejani et al., 2016).

As one of the most important sub-sectors of agriculture, Horticulture plays a vital role in job creation, income generation, and rural development. The development of horticultural activity in rural areas has positive economic, social, and environmental effects. Iran is one of the most talented countries producing horticultural products because of climatic conditions and environmental diversity. These conditions make Iran one of the major horticultural countries in the world, and a large share of the occupation and income of villagers are provided through horticultural activities (Ramazannia et al., 2018). Guilan province is the most important geographical area of the country in terms of area under cultivation and hazelnut production because it has suitable environmental conditions.

With 19023 hectares under cultivation and production of 21 tons of crop, this province produces 85% of the country's hazelnuts. So, Guilan is the hub of hazelnut production in the country (Agricultural Jihad Organization of Guilan Province, 2019). Amlash County is one of the most important areas of Guilan province in terms of area under cultivation, production, and number of operators. Amlash has extensive hazelnut orchards in mountainous villages because of the favorable geographical conditions. The study area includes rural settlements of Samam, Kojid, Shabkhus Lat, and South Amlash in the Rankuh District of Amlash County, Guilan Province. Most of the hazelnut orchards in the County are located in the summer highland pasture of Rankuh district, which has three villages, Samam, Kojid, and Shabkhus Lat. In addition to producing hazelnuts, the villagers of this area also grow Echium, walnuts, produce honey and animal products. Among these, the largest share of income is allocated to the cultivation and production of hazelnut, the economic and social effects of which in the villages of this area have been studied and analyzed.

As mentioned, in the mountainous villages of Amlash County, which are less developed in terms of facilities, hazelnut cultivation is the main source of income. So, expanding the area under cultivation, increasing production through the use of high-yielding cultivars, and government support are some strategies to develop villages and improve living standards, income, and prevent rural migration to urban areas that can lead to the development of villages that exploit this product. Based on this, the present study seeks to answer the main question. How much has the cultivation and production of hazelnuts affected the economic and social development of the villages of Amlash county?

Review of literature

Numerous studies have been conducted on the subject of research and in general, the cultivation and production of horticultural products. Kardavani & Pourramazan (2004) investigated hazelnut cultivation and its economic and social effects in the Eshkevarat region of Rudsar County and concluded that this region is the hazelnut hub of Guilan province and the country in terms of area under cultivation and also production. One of the most important economic and social effects of cultivating this crop in rural areas of Eshkevarat is job-creating by attracting workers, creating and generating income for rural households, and the prosperity of agricultural tourism. Omidi (2006) examined the role of agriculture in the development of villages in Shaft County with an emphasis on rice and tea and reported that agriculture plays a key role in the economy and rural life of the County.

However, farmers in this area suffer from some problems such as lack of education, market instability, and lack of government support. Monazzam Ismailpour & Kardvani (2010) investigated the role of agricultural products emphasizing saffron in rural development of Kashmar County and stated that the economic effects of saffron on rural development, welfare and security, job creation, increasing income, population stabilization, and reduction of migration are felt. Pourtaheri et al., (2013) analyzed the economic and social effects of pistachio cultivation on rural development of Damghan County and concluded that the economic impacts of pistachio cultivation in the indicators of economic welfare and job quality were higher than the social effects of pistachio cultivation in the indicators of participation and social capital in the study area. There is also a significant relationship between the economic and social characteristics of farmers in the region and the economic and social effects of pistachio cultivation. Mahdavi & Abdi (2014) analyzed the role of raisin production in the economic development of Jozan district of Malayer County,

ISSN-Internet 2197-411x OLCL 862804632

Hamadan province. They reported that agricultural activities related to dried fruit production improved income and employment in the studied villages and led to increased public and private sector investment in these villages. Akbari et al., (2017) investigated the sustainability of pistachio production in rural areas of Rafsanjan County. This study shows that environmental, social, and economic indicators of pistachio cultivation have a positive and significant effect on the sustainability of villages in Rafsanjan County, in which the share of economic and social indicators is more than the environmental index. Ramezania et al., (2018) analyzed the role of horticulture in sustainable rural development with emphasis on pistachio cultivation in the Shahabad district of Bardaskan County.

They concluded that there is a positive relationship between horticulture (pistachio cultivation) and improving the lives of villagers with a 99% confidence level. The results also showed that the expansion of horticultural activity had increased employment and income in the Shahrabad rural district of Bardaskan County. Ziaeian Firoozabadi et al. (2019) investigated the effects of expanding Rosa damascene cultivation on the economy of rural settlements in the Lalehzar district in Kerman province. They reported that the expansion of Rosa damascene cultivation created employment in making Rosewater and related activities, attracting rural tourists, earning income, saving, and investing in its activities. Thus, the expansion of Rosa damascene cultivation was influential in the economy of the rural settlements studied. Riahi & Azizi (2020) examined the effects of saffron cultivation on the economy of operators in rural areas of Tehran.

They concluded that the saffron cultivation has a positive effect on the economic components studied, including employment with an average of 4.09, improving the quality of services and facilities with an average of 4.06, access to services and facilities with an average of 4.01, income with an average of 3.28, savings and investing with an average of 3.81, and social welfare with an average of 3.80. Each of the mentioned components had positive effects on economic indicators among operators and rural households of the operator, so that income, savings, employment, diversity of economic and occupational activities increased to an acceptable level in rural areas.

In the literature, rural development is related to the village's structural economic, social, and natural relations. Development plans should be based on these conditions, capabilities, and limitations of the rural environment to provide the ground for growth, sustainability, and continuous development. In the economic structure of rural areas of different countries, agriculture is the main axis of livelihood (Yasouri & Javan, 2015). Agricultural activities play a significant role in achieving rural development. Given the growing population and increasing demand for food, and the key role of agricultural products in providing food security, achieving a favorable economic and production situation that makes the country needless of imports, is always one of the goals of the agricultural sector (Pourramzan, 2015). Developing countries, including Iran, often rely on agricultural products, and agricultural activities are often carried out in rural areas. So, the issue of rural development is important to improve the traditional methods of agricultural production and optimal use of land and resources of production and distribution of products, as well as for the social and cultural modernization of villages (Mahdavi, 2007). Villages play an important role in the national economy and sustainable food security through the production of agricultural products, and in order to continue this role, the need for attention and planning in these areas is strongly felt (Rezvani, 2008).

Famous theorists have always proposed various theories about agriculture in rural development. Arthur Lewis considers agriculture as the basis and axis of development and states that achieving economic development requires raising the rate of per capita production in the agricultural sector. Neil Smelser believes that rural society can achieve comprehensive development through agriculture moving from subsistence farming to agricultural production for trade (Motiei Langroudi, 2003). Ricardo believes that the three groups, "capitalist, worker, and landowner," organize the production process. The capitalist plays a key role in Ricardo's economic model. The capitalist leases the land, employs the worker, and provides the factors and means of production. In this way, production is organized. To make more profit, the owner of the capital tries to use the best employment opportunities for his capital. Efforts to make better use of capital in different sectors of the economy also lead to the optimal allocation of factors. More importantly, profit reinvestment causes capital accumulation, which is nec-

essary for the creation and continuation of economic development (Motevaseli, 2007).

Horticulture, as a subset of the agricultural sector, has significant economic effects such as job creation, improving living standards, income generation and production, economic welfare, employment quality, economic security, improving the livelihood of villagers, poverty reduction, helping the agricultural sector in the region, and creating savings and capital formation.

Cultivation and production of hazelnut are important in terms of economic. Hazelnuts can provide significant income for farmers because of their long shelf life and easy transportation. Cultivating hazelnuts in sloping lands can, in addition to soil stabilization, turn low-yielding rainfed lands into economic gardens. Be very effective in creating productive employment. Cultivating hazelnuts on sloping lands can lead to soil stabilization and the conversion of low-yield rainfed lands into economic gardens. In the present study, the economic and social effects of hazelnut cultivation on villages in Amlash city are investigated.

2. Materials and Method

2.1. Study area

The geographical area of this research is Amlash County, Guilan province. This County with an area of about 515 km2 is located in the geographical coordinates of 36° and 50' to 37° and 8' North latitude of the equator and 50° and 60' and 50° and 16' East longitude of the meridian of origin. Amlash County is limited from the north to the Countis of Langrud and Rudsar from the west and south to the County of Siahkal and from the east to Rahimaabad Rudsar (Management and Planning Organization of Guilan, 2019). Amlash County has two districts, Rankuh and Central. Samam, Kojid, and Shabkhus Lat rural districts are districts of Rankuh and North Amlash, and South rural districts are part of the central district. Based on the latest administrative-political divisions, this County has 146 villages, of which 77 villages are located in Rankuh and 69 villages are located in the central part (Statistical Yearbook of Guilan Province, 2018). The study area includes 38 villages with hazelnut cultivation in Samam, Kojid, Shabkhus Lat, and South Amlash rural districts.

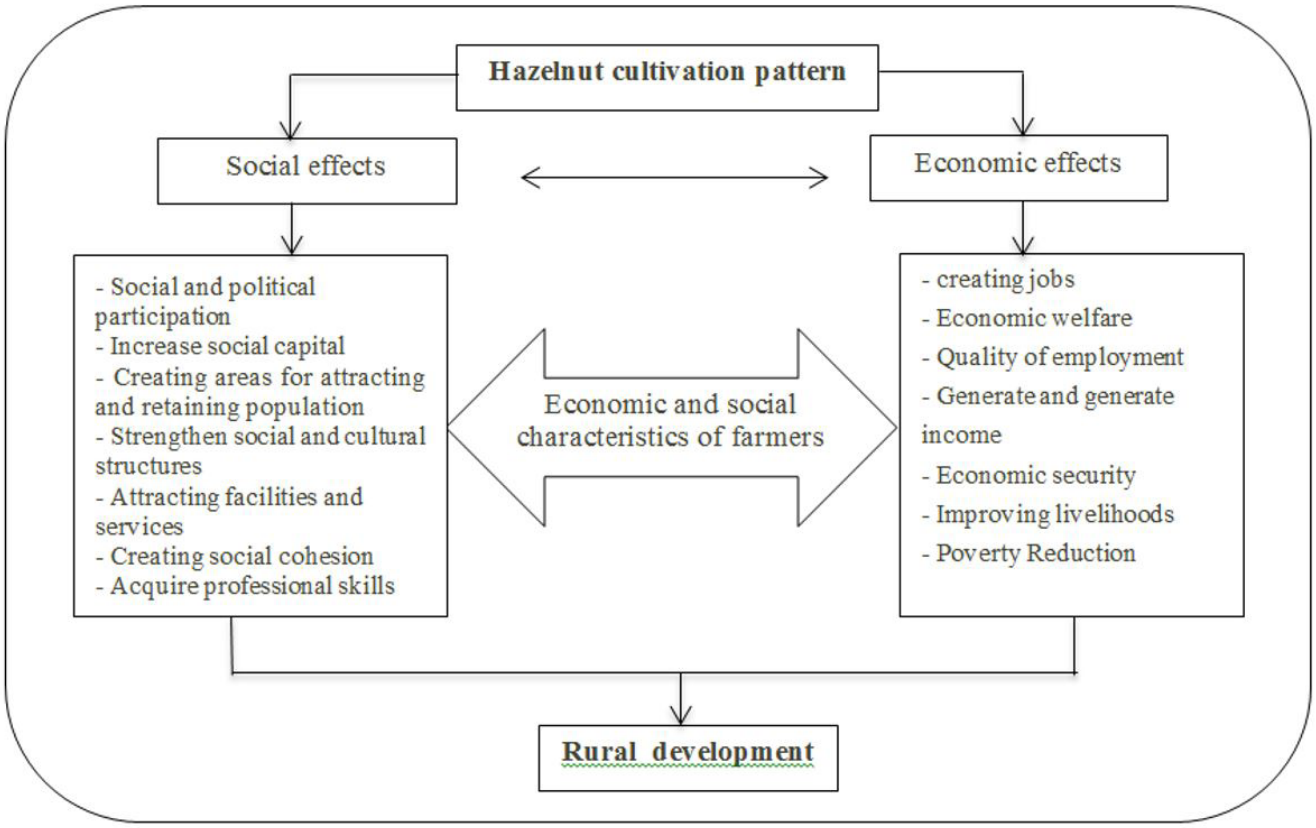

Figure.1 Conceptual model of research

ISSN-Internet 2197-411x OLCL 862804632

2.2. Study area

The present research is applied in terms of purpose and a descriptive-analytical from the type of correlational research in terms of nature and method. The required information related to the theoretical foundations of the research, research background, and geographical features of the study area were obtained through documentary sources and determining the economic and social effects of hazelnut cultivation on the development of villages in Amlash County. Because it is not possible to study all operators of this product in the villages of the County, the random-quota sampling method was used to collect information. Statistical methods such as correlation coefficient test, Cramer`s V test, T-test, ETA correlation coefficient (ETA), and X2 test were used to analyze the data. Data were processed through SPSS software, and tables and maps were drawn using Excel and Arc GIS software. The statistical population of the study was 38 villages with hazelnut cultivation in Amlash County. The sample size was prepared using the Morgan standard table, and because of the multiplicity and dispersion of villages and population in the study area, the random-quota sampling method was used. The number of hazelnut cultivation villages was divided into small to large villages based on population. To determine the sample size based on population, the number of hazelnut cultivation villages was divided into small to large villages. The sample size was identified as 9 villages and 384 questionnaires for distribution and completion.

The validity and reliability of the questionnaire were obtained 0.848 using experts and Cronbach's alpha test. In this study, hazelnut cultivation is considered an independent variable, and economic and social effects with its components listed in Table (1) are dependent variables.

3. Results and discussion

3.1. The area under cultivation, production, and distribution of hazelnut cultivation

Amlash County is located in the east of Guilan province. This County has 2 districts and 5 rural districts that Hazelnut is cultivated, and produced in 4 villages of Samam, Kojid, Shabkhus Lat, and South Am-

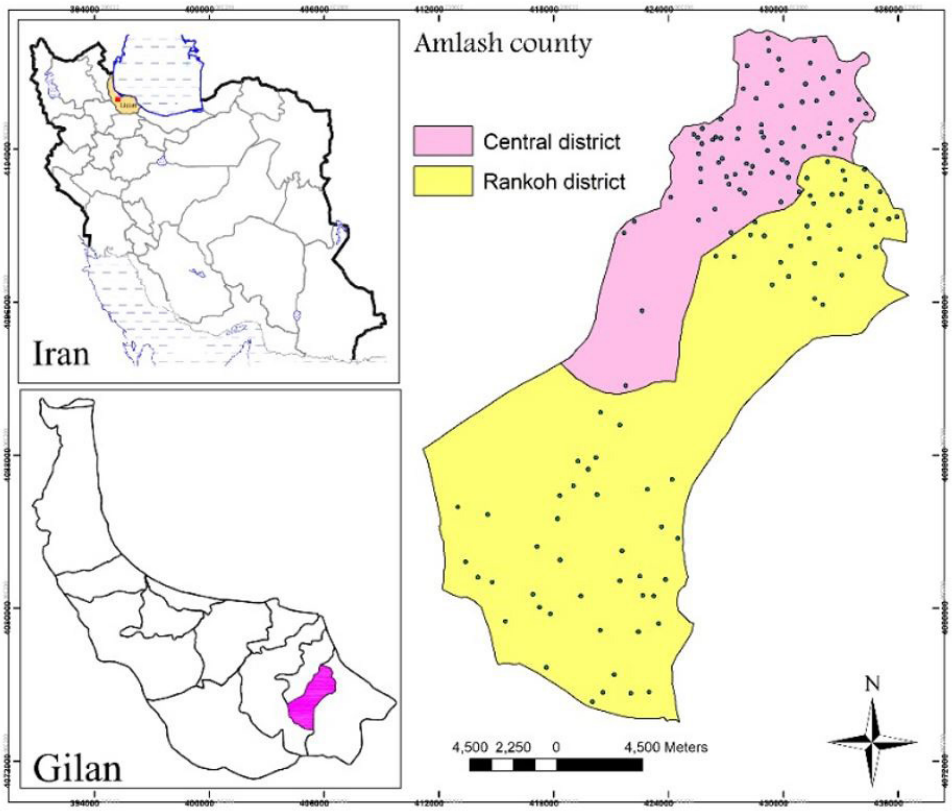

Figure.2 The geographical location of the study

Table 1. Research variables and components

Independent variable	Dependent variable	
	Social effects	Economic effects
Cultivation of hazelnuts	-Prosperity of city-village relations -Creating areas for attracting and retaining population -Concentration of agricultural service centers -Social and political participation -Increase social capital -Strengthen social and cultural structures -Attracting village facilities and services -Acquire professional skills related to hazelnut cultivation - Creating social cohesion	-Creating jobs -Economic welfare -Quality of employment -Economic security -Poverty Reduction -Improving the livelihood of the villagers -Generate and generate income -Assistance to the agricultural sector

lash. The area under hazelnut cultivation in Amlash County is 1950 hectares, its production amount is 2340 tons, and the yield per hectare is 1200 kg (Jihad Agricultural Management of Amlash County, 2019). The villages of Amlash County with hazelnut cultivation, which are located in mountainous areas, have high capabilities for the cultivation and production of this product. Hazelnut cultivation in these villages is the most important source of income and livelihood for the villagers. This product is also environmentally important, prevents soil erosion in sloping areas, and generates income and jobs for rural households.

Although there is a great deal of importance in the cultivation and production of hazelnuts, its production faces problems and issues such as lack of conversion and complementary industries, lack of processing plants, lack of water resources, and crop insurance. Production of Hazelnut in the villages of Amlash County in recent years has an upward trend. The most important reasons were the increase in the price of hazelnuts in the market, the welcome of food and cosmetics factories, pharmaceutical industries, and therapeutic properties. Climate change sometimes results in an unfavorable crop year for the farmer. For example, snowfall and frost in April, which is the time of flowering of the hazelnut fruit, causes frost and loss of that year's crops.

3.2. Economic effects of hazelnut cultivation

In this part of statistical analysis, research hypotheses are examined using statistical tests. To test the first and second hypotheses, the independent variable of hazelnut cultivation and the dependent variable of economic prosperity and social prosperity were assessed simultaneously. The effect of the independent variable on the dependent variable was asked directly from the sample units. T-test was used to test this hypothesis. In these hypotheses, the effect of hazelnut cultivation on the economic prosperity of the villages of Amlash County is investigated using the parametric test t (one-sample t-test) with the test value of 3. The reason for choosing the test value of 3 was to evaluate each item using the Likert scale. In the Likert scale, the value of scores is in the range of numbers 1 to 5. The number 3 indicates the average affections. In other words, if the average of this index is more than 3 and the level of significance of the test confirms that there is a significant difference, the effect of hazelnut cultivation on economic prosperity will be confirmed. Hypothesis 1: Hazelnut cultivation causes economic prosperity in the villages of Amlash County. In this hypothesis of the research, the null hypothesis and the opposite hypothesis are as follows:
H0: Hazelnut cultivation doesn't cause economic prosperity in the villages of Amlash County.

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Table 2. Area under hazelnut cultivation in Amlash County

Amlash South district	Shbkhoslat district	Kojid district	Somam district	Number of operators	Amlash County	Area under cultivation
413	10	388	1139	3900	1950	hectare

Source: Jahad Agricultural Management of Amlash County, 2019

H1: Cultivation of hazelnut crop causes economic prosperity in the villages of Amlash County.

$$H_0: \mu \leq 3$$
$$H_1: \mu > 3$$

Given that economic prosperity is measured by three variables of economic welfare, economic security, and quality of employment, in the t-test table, first, each component is examined separately and finally as a whole (economic prosperity).

According to Table (3), it is observed that for the sample of 384 people, the average, standard deviation, and standard error of economic welfare is 3.76, 0.44, and 0.023, respectively. The average, standard deviation, and standard error of economic security is 3.81, 0.97, and 0.051, respectively. The average, standard deviation, and standard error of the quality of employment is 3.47, 1.06, and 0.56, respectively. Also, the index of economic effects has an average, standard deviation, and standard error of 3.72, 0.58, and 0.03, respectively. Based on this, the economic effects of hazelnut cultivation and production on the development of villages in Amlash County can be confirmed and considered relatively high.

Economic welfare

According to Table (4), it is observed that the value of t-test statistics is 32.58, and the significance level of the test for economic welfare is equal to 0.000 and is less than 0.05 error. The mean difference of this index shows that economic welfare is 0.76 units higher than the test value. So, the null hypothesis, which indicates that hazelnut cultivation has no effect on economic welfare is rejected, so it is concluded that hazelnut cultivation led to the development of economic welfare in the villages of Amlash County. The economic welfare includes housing type, housing size, number of family trips, consumption of red and white meat, purchase of necessities, purchase of durable goods such as refrigerators and televisions, and so on. In the meantime, the effect of hazelnut cultivation on each of the above items and the proof of this matter proves the economic effects of this product on the operators. This means that as the income from hazelnut cultivation increases, the welfare of people will certainly increase, for example, a better car, a better home, more durable goods, and better nutrition. It is well evident in the study area that people who had more hazelnut orchards and higher income from the sale of hazelnuts, had a better life and more facilities, which has been one of the economic effects of hazelnut cultivation in improving the livelihood of villagers.

Economic security

According to Table (4), it is observed that the value of t-test statistics is equal to 15.91, and the significance level of the test for economic security is equal to 0.000 and less than 0.05 error. The mean difference of this index shows that economic security is 0.81 units higher than the test value. Therefore, the null hypothesis, which indicates that hazelnut cultivation has no effect on economic security is rejected, and it is concluded that hazelnut cultivation led to the development of economic security in the villages of Amlash County. Usually, in the production and cultivation of crops, people do not take the risk to do so if there is no economic security. This means that all aspects of the matter are considered for the production of the product and then proceed to production.

In this regard, the people of the study area consider hazelnut cultivation to be partly within the scope of economic security. They believe that the production

Table 3. Descriptive indicators for the economic impact index and its components

Description	Number of Observations	Average	Standard Deviation	Standard Error
Economic welfare	384	3.76	0.44	0.023
Economic security	384	3.81	0.97	0.051
Quality of employment	384	3.47	1.06	0.56
Economic effects	384	3.72	0.58	0.03

Table 4. T-test and significance level of economic impact index and its components

Description	Test Statistics t	df	sig	Mean difference	lower bound	upper bound
Economic welfare	32.58	383	0.000	0.76	0.71	0.80
Economic security	15.91	383	0.000	0.81	0.71	0.91
Quality of employment	8.39	383	0.000	0.47	0.36	0.58
Economic effects	23.59	383	0.000	0.72	0.66	0.78

and cultivation of hazelnuts can lead to stability in the production and continue as a continuous activity, and in all conditions, good or bad, can be considered as a safe work with almost reasonable profit. According to the respondents, fluctuations in the price of hazelnuts greatly affect their economic security. With the increase in the selling price of hazelnuts, the villagers continue to cultivate. But price fluctuations greatly threaten this security. Also, if the banks are not good supporters and do not help the villagers by providing facilities and loans, rural households will no longer want to stay in the village, and as a result, agricultural activity in the area will virtually disappear. Therefore, all factors must work together to motivate the production of hazelnuts and create opportunities for progress and development in agriculture. With the direct and continuous support of the government, agriculture continues to thrive in rural areas, and its economic effects are visible at the national level.

Quality of employment

According to Table (4), it is observed that the value of t-test statistics is equal to 8.39, and the significance level of the test for employment quality is equal to 0.000 and is less than 0.05 error. The mean difference of this index shows that the quality of employment is 0.47 units higher than the test value. Therefore, the null hypothesis, which indicates that hazelnut cultivation has no effect on the quality of employment is rejected, and it is concluded that hazelnut cultivation improved the quality of employment in the villages of Amlash County. Regarding the quality of employment, the villagers use traditional agriculture methods and do not believe in new technology. The production and cultivation of hazelnuts had not much effect on the quality of employment in the area. This means that it played a small role in the production of new jobs or the improvement of production activities and, consequently, the quality of employment in the

ISSN-Internet 2197-411x OLCL 862804632

region. Given the current economic situation, hazelnut cultivation is for income to meet the basic needs of the villagers. Also, hazelnut cultivation has created some jobs in the village, one of the reasons for which is the lack of sufficient motivation to stay in some villages and the lack of facilities and as a result, the tendency to urban space.

According to Table (4), the value of t-test statistics is equal to 23.59, and the significance level of the test for economic effects is equal to 0.000 and is less than 0.05 error. The mean difference of this index shows that economic effects are 0.72 units higher than the test value. Therefore, the null hypothesis, which indicates that hazelnut cultivation has no effect on economic development is rejected, and it is concluded that hazelnut cultivation led to economic development in the villages of Amlash County. The results showed the role of hazelnut cultivation and production in rural development and improving people's lives working in hazelnut areas. This role and impact on economic welfare were more than in other cases. With increasing efforts in the cultivation and production of hazelnuts, its output leads to economic development and progress of families and the village. Meeting the basic needs and necessities of life, including proper housing and cars, better-living facilities, economic security and safety resulting from production, and improving the quality of employment in the region are also the economic results of optimal hazelnut cultivation.

Definitely having a suitable land and garden, providing water resources needed for the garden, good improvement and maintenance of gardens, using the opinions of experts, and using new methods and inputs are effective in the rate of crop yield and creating income and employment, and finally creating welfare and improving livelihood for the villagers. Therefore, the first hypothesis based on the economic impact of hazelnut cultivation on the development of villages in Amlash County and economic prosperity in the region is proven.

In this hypothesis of the research, the null hypothesis and the opposite hypothesis are as follows:

$$H_0: \varphi = 0$$
$$H_1: \varphi \neq 0$$

At this stage, to measure the relationship between economic characteristics and economic effects of hazelnut growers, 10 items in economic characteristics and 5 items in social characteristics of hazelnut farmers were used. According to the type of data scale, Phi and Cramer's V correlation coefficient and ETA correlation coefficient were used. As shown in Table (5), the relationship between economic characteristics and calculated economic effects has a significance level of less than 0.05, indicating a significant relationship between economic characteristics and economic effects. The results obtained from the correlation coefficient measures are given in Table (5).

3.3. Social effects of hazelnut cultivation

The social effects of hazelnut cultivation were measured by two variables of social and political participation and social capital. In the t-test table, first, each component is examined separately and finally as a whole (social prosperity).

Test of the second hypothesis: Hazelnut cultivation causes social prosperity in the villages of Amlash County. In this hypothesis of the research, the null hypothesis and the opposite hypothesis are as follows:

H0: Hazelnut cultivation doesn't cause social prosperity in the villages of Amlash County.

H1: Cultivation of hazelnut crop causes social prosperity in the villages of Amlash County.

$$H\_0: \mu \leq 3$$
$$H\_1: \mu > 3$$

According to Table (6), it can be seen that for the 360 people, the average, standard deviation, and standard error of social and political participation is 3.27, 0.65, and 0.034, respectively. The average, standard deviation, and standard error of social capital is 3.4, 0.7, and 0.611, respectively.

Social and political participation

According to Table (7), it can be seen that the value of t-test statistics is equal to 8.07, and the significance level of the test for this index is equal to 0.000 and is less than 0.05 error. The mean difference of this index

Table 5. Relationship between farmers' economic characteristics and economic effects of hazelnut cultivation based on Kramer Phi and V correlation coefficient and ETA

correlation coefficient	Type of housing	Quality of housing	Dating housing	Residential unit size	Number of trips	Vehicle ownership	Ownership of durable goods	Consume red meat	Consume white meat	Economic security	Quality of employment
Cultivation history	0.43	0.61	0.54	0.61	0.57	0.59	0.83	0.53	0.57	0.79	0.75
Type of land ownership	0.36	0.66	0.50	0.55	0.63	0.55	0.61	0.51	0.58	0.70	0.66
Area under cultivation	0.60	0.67	0.65	0.69	0.54	0.65	0.86	0.68	0.76	0.86	0.86
Yield per hectare	0.56	0.70	0.79	0.70	0.64	0.74	0.82	0.76	0.73	0.95	0.93
The amount of investment	0.27	0.47	0.49	0.41	0.53	0.53	0.56	0.50	0.50	0.70	0.56
Use of bank credits	0.29	0.60	0.66	0.52	0.76	0.71	0.63	0.70	0.56	0.89	0.77
Market familiarity	0.48	0.69	0.63	0.60	0.54	0.61	0.77	0.60	0.52	0.90	0.88
How to sell a product	0.49	0.55	0.62	0.69	0.43	0.49	0.59	0.50	0.50	0.69	0.77
Use of mechanization	0.16	0.12	0.16	0.13	0.14	0.13	0.09	0.21	0.11	0.14	0.20
Transformation of cultivated lands	0.20	0.19	0.23	0.28	0.20	0.22	0.25	0.22	0.44	0.27	0.28

Table 6. Descriptive indicators for the social impact index and its components

Description	Number of Observations	Average	Standard Deviation	Standard Error
Social and political participation	360	3.27	0.65	0.034
Social capital	360	3.4	0.7	0.037
Social effects	360	3.36	0.61	0.032

Table 7. Results of t-test and significance level

T test with test item value 3						
Description	**Test Statistics t**	**df**	**sig**	**Mean difference**	**lower bound**	**upper bound**
Social and political participation	8.07	359	0.000	0.27	0.021	0.34
Social capital	11	359	0.000	0.4	0.33	0.48
Social effects	12.08	359	0.000	0.36	0.29	0.42

ISSN-Internet 2197-411x OLCL 862804632

shows that the social and political participation is 0.27 units higher than the test value. Therefore, the null hypothesis, which indicates that hazelnut cultivation has no effect on social and political participation, and it is concluded that hazelnut cultivation led to the development of social and political participation in the villages of Amlash County.

The effect of crop production on the creating social and political participation of villagers in the region is one of the social effects of any agricultural activity. This means that agricultural activity, in addition to forcing the villagers to cooperate in cultivation and production and creating a sense of cooperation among the people, also causes them to participate in non-agricultural activities in the village. This participation is both socially and politically.

In the social participation, the villagers are involved in civil, service, infrastructure measures and creation of various transportation water, electricity, gas networks, construction of schools and clinics, creation of festivals, educational classes and social programs, etc. Political participation also includes participation in village council elections and government programs in rural development, etc., which is almost appropriate and good in the study area. This varies in different regions and villages. For example, in small villages, participation is in the form of assistance and cooperation of individuals in harvesting or planting hazelnuts and other agricultural matters. In harvesting hazelnuts, instead of taking labor from other villages, they try to help each other. Their participation in the political issues of the country and the region is also in the form of their active presence in these issues.

In medium and large villages, this participation is seen on a larger scale, meaning that people in several groups work together to harvest hazelnuts. They play an important role in the development and productive affairs of the village, they also participate in the political affairs and elections of the council, but their participation, both social and political, is lower compared to the social capital index. The social cohesion resulting from hazelnut cultivation in the form of intellectual participation is also evident. In other words, they consult and cooperate with village managers to prepare rural plans and projects so that everyone can better participate in rural development.

Social capital

According to Table (7), it is observed that the value of t-test statistics is equal to 11, and the significance level of the test for this index is equal to 0.000 and is less than 0.05 error. The mean difference of this index shows that social capital is 0.4 units higher than the test value. Therefore, the null hypothesis, which indicates that hazelnut cultivation has no effect on social capital is rejected, and it is concluded that hazelnut cultivation led to a boom in social capital in the villages of Amlash County. One of the consequences of agricultural activities is the creation of social capital. Social capital is evident in indicators such as obtaining professional training related to hazelnut cultivation, acquiring professional skills and knowledge related to hazelnut cultivation, sustainability in the village, strengthening the socio-cultural structures of the village, stability of political and social security of the village and attracting facilities and services to the village. In the study area, the share of social capital is higher than socio-political participation. Respondents believe that hazelnut cultivation increases spatial belonging to the village and reduces migration to the city. Also, if the villagers remain and increase hazelnut cultivation and production activities, facilities and services will increase. As the people have more contact with agricultural departments and service centers, they gain experience and professional skills related to hazelnut cultivation. They also can express the problems of a village, and as a result, enter the facilities and services required to the village. The cultural and social structures of the village, including the connection with educational, cultural, and social centers, are also strengthened by hazelnut cultivation and production activities.

According to Table (7), the value of t-test statistics is equal to 12.08, and the significance level of the test for this index is equal to 0.000 and is less than 0.05 error. The mean difference of this index shows that social effects are 0.36 units higher than the test value. Therefore, the null hypothesis, which indicates that hazelnut cultivation has no effect on social effects is rejected, and it is concluded that hazelnut cultivation caused positive social changes in the villages of Amlash County. According to the output of information obtained from the respondents (villagers) in the two components of social and political participation and

social capital, participation seems to be less and the role of capital seems more prominent. This means that participation in matters such as the implementation of rural plans and projects and civil works is done by all people in the village, and most of them are special people who work in intellectual, civil, production, and partnerships. People who have a higher level of hazelnut cultivation and consequently a higher income try to get more involved in rural development projects, which is evident in the study areas. Of course, this participation is more visible in small villages, and their cooperation in various fields of hazelnut production was more significant than in larger villages.

But in terms of social capital, people had positive and better views about this component and believed that hazelnut cultivation could be an important factor in preventing people from migrating to the city, establishing centers and services in the village, and acquiring skills and professional knowledge related to hazelnut cultivation. This has been quite evident in the selected villages. However, the social effects of hazelnut cultivation seem less than the economic effects. Because until the economic affairs of cultivation are reformed and institutionalized, the social effects and consequences cannot be accepted.

4. Conclusion

The present study investigated the economic and social effects of hazelnut cultivation in 32 items in the villages of Amlash County. Statistical analysis has shown that economic effects such as well-being, economic security and quality of employment are more related to the areas of knowledge and professional skills than the social effects of hazelnut cultivation such as political and social participation and social capital. Considering the process of hazelnut cultivation and production as well as the spatial and production appendix, it can be said that the formation and development of hazelnut cultivation pattern in the villages of Amlash County is mostly due to economic characteristics such as high income and added value created by this product in each is the year. The social effects of the development of hazelnut cultivation in the region, including increasing the level of participation, training, knowledge, and professional skills of hazelnut growers in the villages of Amlash County, can be considered as initial and background measures to increase the economic effects of hazelnut cultivation in the region.

Similar research has been done in hazelnuts, almonds, saffron, olives, pistachios, and Rosa damascena. Kardavani and Pourramzan (2004) studied the problems of hazelnut cultivation and its economic and social effects in the Eshkevarat region of Rudsar city. Their research showed that hazelnut cultivation is the main source of income for the villagers in the region. Creating jobs by attracting labor and generating income for rural households were the most important economic effects of cultivating this crop. The present research is in line with the research of Kardvani and Pourramzan.

Monazzam Ismailpour and Kardavani (2010) investigated the role of saffron cultivation in Kashmar city and its economic and social impact, which are consistent with the results of the present study. Pourtaheri et al. (2013) investigated the economic and social effects of pistachio cultivation. The economic effects (the increase in pistachio prices in recent years and the creation of jobs and incomes for farmers) of pistachio cultivation were more than the social effects. Also, the results of the present study were consistent with the research of Akbari et al. (2017) on the sustainability of pistachio production in rural areas of Rafsanjan city and the positive impact of environmental, social, and economic indicators of pistachio cultivation on the sustainability of villages in this County and the greater share of economic and social indicators than the environmental index. The results of the present study were consistent with the research of Ramezania et al. (2015), who examined the role of horticulture in sustainable rural development with emphasis on pistachio cultivation and concluded that there is a positive and significant relationship between pistachio cultivation and improving the lives of villagers and increasing employment and income in Shahrabad rural district, Bardaskan. The results of the present study were also consistent with the research of Ziaeian Firoozabadi et al. (2017), who investigated the effects of the expansion of Rosa damascena cultivation on the economy of rural settlements in Lalehzar district, Kerman province and concluded that Rosa damascena cultivation creates employment in the field of making Rosewater and related activities, attracting rural tourists and also earning income saving and investing in its activities. The results of the present study were also consistent

ISSN-Internet 2197-411x OLCL 862804632

with the research of Riahi and Azizi (2016).

They investigated the effects of saffron cultivation on the economy of farmers in rural areas of Tehran and the positive effect of saffron cultivation on economic components, including employment, access to services and facilities, improving the quality of facilities and services, savings and capital, income, social welfare and the positive effects of economic indicators among the beneficiaries that increased income, savings, employment, diversity of economic and employment activities in the studied villages.

Generally, it can be concluded that the cultivation and production of agricultural products have many economic and social effects. The creation of income, employment, and social participation of individuals is the most important of these effects. Of course, if the cultivation of crops, whether horticultural or agricultural, is done in a principled and scientific manner and with the advice of experts, it will certainly have significant economic and social effects and results. All this is possible thanks to the government's widespread support for farmers. Of course, the cultivation of hazelnut in Amlash is also associated with issues and problems that are directly related to the low yield of hazelnut trees in the region. Issues such as severe water shortage, non-use of high yielding cultivars, pests and diseases, high production of basal shoots, non-observance of cultivation intervals, and multi-base hazelnut trees are the most important issues in hazelnut cultivation in the study area. Gardeners in the region are facing a series of problems because of the existence of these issues, such as water shortage, low yield of local cultivars, the existence of business brokers, lack of guaranteed purchase price of hazelnuts, lack of factories and processing of hazelnut, and lack of government support through financial facilities, crop yields, wildlife attacks, etc. are among the most important problems. Hazelnut as a dominant garden product in Amlash County is of special importance because its cultivation is intertwined with the life of the region's people and has created a close relationship between the establishment of rural households and the cultivation and production of this crop. This product has important economic and social effects such as creating employment by attracting labor, creating and generating income for rural households, improving the living conditions of villagers, prosperous urban-rural relations, creating opportunities for attracting and retaining population, social and political participation, and strengthening cultural and social structures are prominent examples.

According to the results, the following solutions can be suggested to increase the economic and social effects and reduce issues and problems related to hazelnut cultivation:

- Development and expansion of the area under hazelnut cultivation in the villages of Amlash County in order to increase income and reduce economic and social issues such as unemployment, migration.

- Support and encourage the government to employ educated people in the field of agriculture to improve the situation of hazelnuts cultivation and production.

- Payment of bank facilities with easy repayment to farmers to improve hazelnut orchards and cultivate high-yielding and drought-resistant cultivars.

- Government support for hazelnut farmers in the form of insurance and guaranteed purchase of hazelnut products.

- Creating a suitable platform to promote and teach new horticultural methods and cultivate high-yielding cold and pests-resistant cultivars for the villagers.

- Mechanization of hazelnut production stages and creation of appropriate facilities in the village for marketing and exporting hazelnut products.

- Establish the hazelnut product research and processing center, and create value chains and business clusters.

- Construction of conversion and complementary industries and efforts to brand hazelnut products in the villages of Amlash County.

Acknowledgements

The present study is the result of independent research and has not been done with organizational financial support.

Conflict of interests

The authors declare no conflict of interest.

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ISSN-Internet 2197-411x OLCL 862804632

Future of Food: Journal on Food, Agriculture and Society
10 (1) August 2022

Exogenous extracellular vesicles and microRNAs cargo can be considered micronutrients?

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Data of the article

First received : 14 October 2021 | Last revision received : 07 January 2022
Accepted : 15 January 2022 | Published online : 15 February 2022

It is well recognized that diet components are important genomic regulators even if RNA transcripts as messenger RNAs (mRNAs) represent less than 2% of the whole genome. In the old-fashioned understanding of genetics, mRNAs are encoded to synthesize a specific protein. Nevertheless, this representation has substantially increased in complexity with the discovery of non-coding RNAs in which microRNAs (miRNAs) gained significant attention in the past 15 years - because its discovery was awarded by the Nobel Prize in physiology or medicine in 2006 to Andrew Z. Fire and Craig C. Mello. MiRNAs are small (18 to 25 nucleotides-long), endogenous non-coding RNA-nucleotide evolutionary conserved, shown to modulate gene expression at the posttranscriptional level through the binding to the complementary sequences of their target mRNAs at the 3' untranslated regions (3' UTRs) (1,2). Based on the interactions between the 3′ UTR of mRNAs, miRNAs can control numerous genes' expression levels. MiRNAs are secreted in lipid bilayer-delimited nanoparticles called extracellular vesicles (EVs), along with proteins and other biomolecules with no replication ability. EVs include microvesicles, apoptotic bodies, and exosomes (Exo), a unique subpopulation of nanosized, spherical membrane vesicles with sizes between 30 and 150 nm. Therefore, EVs and Exo represent a new paradigm in cell biology and medicine, with the idea that the available content may be directly delivered to cells (3).

Similarly, exogenous miRNAs derived from dietary sources and kept in EVs-Exo have been transferred to the mammalian system. Lanfang Wang et al. show that miRNAs present in bovine milk are found in human blood circulation (4). However, it is still to prove if remain active to regulate the host-gene expression and to be effective on their targets in mammalian miRNAs should be around 1000 copies (5).

These special groups of miRNAs were categorized as xenomiRs. Some of them have been found to enter the host through food ingestion, like breast milk from mother to infant may modulate the immune system of newborns through dietary miRNA present in milk (6). This gives rise to a new concept of food-derived miRNAs or dietary miRNAs. Although, we point out with a systematic review that it is crucial further to investigate the bioavailability of miRNAs in different milk fractions and characterize other non-coding RNAs that are largely unstudied (7).

RegardigIn this view, recently, Kleinjan et al. fractionated the bovine milk. Demonstrating also that industrial pasteurization alone or homogenization does not decisively influence the vesicles' stability (8). These findings align with our results from human milk in which pasteurization at 62.5°C for 30 minutes does not significantly affect miRNAs abundance (9). The presence of EVs and exo-miRNAs in human milk, which remain stable after gastric/pancreatic digestion,

via in vitro simulation (10), led studies in mice - using bovine, porcine, and murine milk which - demonstrated that the exo-miRNAs have a unique tissue distribution (11). The Ultra Heat Treatment (UHT) used in industrial processes to ensure long-life commercial milk has a detrimental effect on the EVs structure containing miRNAs. Destroying the lipid nanoparticles of the EVs envelope makes miRNAs vulnerable to RNAse enzyme degradation.

Consequently, these components of bovine milk EVs are reduced in processed milk (8). The presence and the abundance of miRNAs in human milk compared to other body fluids (12) could designate them as EV-miRNA-based micronutrients in the future? More than 100 are highly conserved amongst species, particularly the pool involved in the regulatory activity of innate and adaptive immune response, which balances inflammatory response (2, 12). Even if the inflammatory process is valuable for dealing with pathogens, it can lead to severe disease if not properly controlled.

MiRNAs are negative regulators of inflammation (13), and, in this view, nutrition-dependent microRNAs regulation, the so-called nutrimiromics (14), has been proposed to manage inflammation and chronic disease (15). Nutrimiromics studies the influence of miRNAs and nutrition on changes in gene expression due to miRNAs' epigenetic process (16). In conclusion, scientists learn from nature, and the first SARS-CoV-2 vaccine mRNA-based encapsulated in lipid nanoparticles now exists (17). Therefore, the scenarios could move from a new food miRNAs based.

Acknowledgements

The authors thank the editors for the invitation to contribute to this editorial. However, the views expressed in this paper are the sole responsibility of the authors.

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ISSN-Internet 2197-411x OLCL 862804632

Phasing out animal agriculture and Shifting to a plant-based diet could significantly reduce greenhouse gas emissions

Animal agriculture has had ongoing emissions that contribute significantly to global warming for a long time.

Scientists from Stanford University and the University of California, Berkeley, have released a new study that shows the significant impact of phasing out animal agriculture. The study revealed that switching to a plant-based diet would drastically stop the increase of greenhouse gases.
"We wanted to answer a very simple question: What would be the impact of a global phase-out of animal agriculture on atmospheric greenhouse gases and their global-heating impact?" said Patrick Brown, a professor emeritus in the department of biochemistry at Stanford University.

The published model explores that the gradual elimination of animal agriculture over the next 15 years would equal a 68 percent reduction of carbon dioxide (CO2) emissions for the next 90 years. This would provide nearly half of the reductions necessary to keep global warming at 2 degrees Celsius above preindustrial levels, which will significantly impact averting the disastrous climate change.

The decrease in the methane and nitrous oxide emissions from livestock will lead to a favourable decrease in the atmospheric levels of those potent greenhouse gases. Moreover, the CO2 that was released into the atmosphere when feed crops and grazing lands replaced forests and wild prairies can be converted back into biomass as livestock are phased out, and the forests and prairies recover.

However, many would laugh at the idea that billions of people will be convinced to switch to a plant-only diet within 15 years. Nevertheless, Patrick Brown, a professor emeritus in the department of biochemistry at Stanford University, says, "Five hundred years ago, nobody in Italy had ever seen a tomato. Sixty years ago, nobody in China had ever drunk a Coke. Mutton was once the most popular meat in America," he said. "People around the world readily adopt new foods, especially if they are delicious, nutritious, convenient and affordable."

1. Michael B. Eisen, Patrick O. Brown. **Rapid global phaseout of animal agriculture has the potential to stabilize greenhouse gas levels for 30 years and offset 68 percent of CO2 emissions this century.** PLOS Climate, 2022; 1 (2): e0000010 DOI: 10.1371/journal.pclm.0000010

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Co-occurring droughts threaten the water security of millions of people

A recent study by Washington State University revealed that continuing fossil fuel dependence might increase the probability of co-occurring droughts by 40% by the mid-21st century and 60% by the late 21st century. That could cause the exposure of 120 million people across the globe simultaneously to severe compound droughts each year by the end of the century.

The recurring climatic variations in oceans have played a huge role in some of the worst environmental disasters in global history. Researchers' report shows that nearly 75% of compound droughts will coincide with these variations in the future.
A clear example is El Nino-fueled droughts that co-occurred across Asia, Brazil and Africa during 1876-1878. These co-occurred droughts led to crop failures, followed by famines that killed more than 50 million people.

The results reported that some North and South American areas suffering from a warmer climate than regions of Asia are more likely to experience compound droughts in the future. This could raise the potential of the food security crisis in such areas and even in other areas as the United States is a significant exporter of staple grains and currently ships maize to countries across the globe.
However, the global efforts to reduce the high fossil fuel emission and lower carbon emissions would significantly mitigate the frequency and intensity of co-occurring droughts by the end of the 21st century.

1. Jitendra Singh, Moetasim Ashfaq, Christopher B. Skinner, Weston B. Anderson, Vimal Mishra, Deepti Singh. **Enhanced risk of concurrent regional droughts with increased ENSO variability and warming.** Nature Climate Change, 2022; 12 (2): 163 DOI: 10.1038/s41558-021-01276-3

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ISSN-Internet 2197-411x OLCL 862804632

Limiting global warming according to the Paris Climate Agreement goal is still possible

The good news about the Paris Climate Agreement goal was published recently by a new study. The study reported that these goals are still in reach, and the goal of limiting global warming by 2 degrees Celsius is still possible. Another good news is that pre-suggested worst-case scenarios are no longer likely to happen.

One previously suggested scenario about global warming is that the temperature would be raised by 4 to 5 C by the end of the century. However, new optimistic news has been revealed reporting that this scenario is implausible.

Researches usually suggest scenarios for the future based on current factors such as projected greenhouse gas emissions and different possible climate policies.

The Representative Concentration Pathways (RCPs), released in 2005, and the Shared Socioeconomic Pathways (SSPs), released as an update in 2010, are the most used scenarios by researchers. Both scenarios were developed by the Intergovernmental Panel on Climate Change (IPCC).

Roger Pielke Jr., professor of environmental studies together with co-authors, analyzed about 1,311 climate scenarios from which the climate research community selected the 11 RCPs and SSPs. It was concluded that the most extreme climate scenarios are unlikely to occur this century. One explanation was that these scenarios were developed long ago, and with renewable energy becoming more affordable and some countries adopting climate policies, carbon emissions have already started to reduce. "There is a need for these scenarios to be updated more frequently. Researchers may be using a 2005 scenario, but we need a 2022 perspective," said Pielke Jr.

1. Roger Pielke Jr, Matthew G Burgess, Justin Ritchie. **Plausible 2005–2050 emissions scenarios project between 2 °C and 3 °C of warming by 2100.** Environmental Research Letters, 2022; 17 (2): 024027 DOI: 10.1088/1748-9326/ac4ebf

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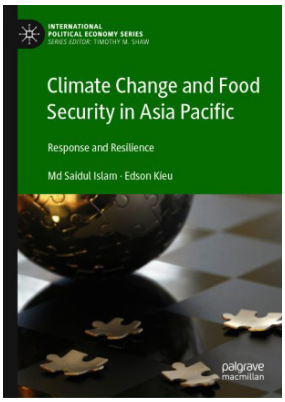
Future of Food: Journal on Food, Agriculture and Society, 10 (1)



Climate Change and Food Security in Asia Pacific

A review by Nayram Ama Doe

Authors (Eds.): Md Saidul Islam and Edson Kieu
Publisher: Springer Nature Switzerland AG
Published year: 2021
Language: English
ISBN: 978-3-030-70752-1
Length: 240 pages

According to the World Food Program, the world continually faces the chronic issue of food security. With the world's current population at 7.8 billion, one out of seven in a part of the world are facing hunger issues. There is still an unacceptable number of hungry people globally, with over one billion people experiencing chronic undernourishment. Climate change and its impact on agriculture are a challenge in guaranteeing food security in the context of an increase in food production demand with decreasing and scarce resources. This book discusses topics of interest such as green movements, food justice and sovereignty in Asia, the way forward towards a sustainable food system in Asia-Pacific Amid Climate Crises, China and India's involvement in land and water grabs, urban food security and sustainability in Asian cities, tackling regional climate change and food security issues and lastly, climate change and food security in different areas.

This book kicks off with an introduction to tackling climate change and food security issues. Poverty and stagnation in crop produce increase continually in Asia despite their economic growth and advancement in science and technology. Food security remains a challenge due to threatening factors such as rapid urbanisation, climate change, competition for land, rural-urban migration and water and energy shortages. It is clear that to achieve food security and meet the hunger needs of the growing population; productivity must increase in the food industry. This increase in food production has become a fundamental food security challenge due to climate change, impacting the four dimensions of food security. In tackling food security issues and climate change, regional organisations are positioned to aid in combating this challenge through the engagement of global partners in their quest to address current and future impacts through market regulations, internal supply chain, cooperation, and good governance.

Further, an exciting part of this book is urban food security and sustainability in Asian cities. Feeding cities in this swiftly changing world with a constant increase in the worldwide population, compounded with urbanisation and climate change, will be a big challenge to sustainability in the coming years hence immensely affecting food security. Some challenges associated with the dimensions of urban food security include increased conflicts, crisis, natural disasters, persisting food losses and waste, transboundary pests and diseases, increased competition for natural resources, impacts of climate change from extreme weather conditions, droughts, floods, and crop diseases. Therefore, agricultural productivity must be improved sustainably to meet high demands and reduce challenges. Moreover, there is a need to address the root causes of migration, provide income-earning opportunities in rural areas, and finally inhibit transboundary pests and diseases.

The closing chapter elucidates the way forward towards a sustainable food system in Asia-Pacific Amid Climate Crises. Some of the significant factors that were mentioned and could lead to increased levels of food security are high democracy levels, low corruption levels, high consumer income and economic growth, obliterating inequality and poverty, effective food production organisation, agricultural investment, and more. Finally, to alleviate climate change impact on food security, short growing seasons should be protracted cooperatively with higher temperatures for growth, adaptable for various countries' ecological factors such as soil properties, hence providing new agricultural opportunities.

In general, this book is very enlightening, educative, and in-

ISSN-Internet 2197-411x OLCL 862804632

formative. It highlights ways of tackling climate change and food security issues, as well as the way forward towards a sustainable food system to achieve a high level of food security. It is recommended to read this book as a helpful resource in agriculture and food security areas.

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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