Ethics, technology, and adaptation:
Consumer behavior and sustainable food system

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Editorial

Ethics, technology and adaptation: consumer behavior and sustainable food system

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With the challenges of climate change and population growth, the attention to sustainability, sustainable production and sustainable consumption has become critical in today's food production and consumption practices. A UN report predicts that if the population were to reach 9.6 billion by 2050, we require the resources of three planets to sustain our current lifestyles (UN 2019).

Although the food production in terms of calories has kept up with population growth, there are more than 820 million people today who are suffering from malnutrition and under nutrition. Many more people consume unhealthy diets, leading to obesity and numerous other health complications. Despite the need for increased food production, the industry's future is severely tested by unpredictable and extreme weather patterns endemic to climate change. Small holders and low-income communities in developing and developed countries who lack sufficient resources or knowhow to adapt to these changes will bear the brunt of these repercussions.

Sustainable food production that involves adapting to threats such as climate change is viewed as a solution to these obstacles.

Sustainable food movement has been gathering momentum in the twenty first century. Sustainable food system contributes to economic, social and environmental goals of the world (Reheul et al., 2001). Its economic aspect involves fair costs of production and consumption. The ecological sustainability includes the preservation of the natural environment, as well the quality of life of humans and animals. The social component comprises of matching the needs of society with agriculture and garnering the support of citizens and governments toward the agricultural sector (Vermeir & Verbeke, 2006, p.171). The implementation of sustainable food systems thus enables the achievement of "overall development plans, reduce future economic, environmental and social costs, strengthen economic competitiveness and reduce poverty" (UN, 2019).

Consumer Behavior

Consumer decision making process can help or hinder the attempts at achieving sustainability in food production. Since food production relies to a large extent on consumer demand, consumers act as agents in shaping local as well as global food systems. Consumer decision-making process largely relies on individual needs and wants. Factors such as convenience, habit, value for money, personal health concerns, hedonism, and individual responses to social and institutional norms paly a significant role in daily consumption decisions (FSA, 2000; IGD, 2002a, 2002b; SDC, 2003).

Consumer behavior further varies according to a country's level of development and socio-economic status. Consumers in developed countries maintain lifestyles that require higher levels of consumption of natural resources compared to developing countries. Consequently, they leave a larger carbon footprint. With globalization and the rising standards of living in the developing world, more and more consumers are aspiring to reach higher standards of living, putting increasing pressure on scarce resources on our planet.

Sustainable consumption

Sustainable consumption and production is about "promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life for all" (UN, 2019). Sustainable consumption involves a decision-making process that takes into account individual needs and wants as well as consumer's social responsibility (Meulenberg, 2003). The objective of sustainable consumption is "doing more and better with less," or increasing net welfare gains from economic activities by decreasing resource utilization, thereby, minimizing the negative effects on the environment. This process involves the participation of producers as well as consumers, including increasing the awareness of consumers on sustainable consumption, "providing them with adequate information through standards and labels and engaging in sustainable public procurement, among others" (UN, 2019).

Reflexive Consumer

Although consumer behavior is determined primarily by value and convenience, the complexity of the decision-making process and the diversity of motivations involved in consumption point to the potential for change. In sustainable consumption, an important stimulus for change can come from post-modern society's tendency towards reflexivity, where individuals actively reevaluate existing norms. While not strictly a social activist, the reflexive consumer (Giddens, 1991) conducts his "own individualized risk assessment" (Dupuis, 2000). For reflexive consumers, deciding what they will or will not let into their bodies is an important decision. Hence reflexive consumers negotiate this process with great care and concern, there lies a potential for change towards more sustainable consumption.

Ethical Consumer

An ethical consumer who recognizes an intimate connection between consumption and social and environmental issues has emerged in the last decade. The ethical consumer's purchase decisions respond to his or her sense of responsibility towards society and the ethical repercussions of their behavior (De Pelsmacker et al., 2003; Vermeir & Verbeke 2006). While the main focus of this type of consumption is environmental concerns, it also encompasses "animal welfare, human rights, and labor working conditions in the third world" (Tallontire et al., 2001).

Ethical behavior is closely linked with values that consumers hold. Decisions such as product choice and brand choice can be determined by consumer values (Burgess, 1992; Engel et al., 1995) and hegemonic discourses that penetrate, articulate or (re)configure the consumer. (Withanachchi 2013). Values can motivate people to act and provide them direction and urgency (Kollock et al., 1994). For instance, Vitell et al. (2001) found that consumers are more directed by "principles or values (deontology) than by consequences (teleology) when making ethical decisions" (p.154). Ethical behavior directed by values of sustainability rather than profit or convenience holds the impetus for change toward more sustainable consumption patterns.

Alternative Frameworks

In addition to educating consumers and working towards shifting their behavior towards sustainable consumption, there needs to be alternative frameworks for conceptualizing and directing production and consumption in our society. While individual behavioral change can lead to societal change, these processes often occur over a long period of time. Such gradual change is not sufficient to meet the dire environmental and societal challenges that we confront today.

The nomenclature, consumer, as well as the current consumer – producer model is derived from an economic theory that is a product of capitalist ideology. Ethical and

sustainable consumers still remain 'consumers' within this model. The term 'consumption' itself denotes 'utilization of goods and/or services' within an economic system. Hence, consumption is regarded as a prerogative of the participants of this system, who have the capacity to buy goods. Within this system, 'natural world,' or its 'resources' that can be considered as human constructs, does not have an inherent value in and of itself. The value of our ecosystems are dependent on the economic system within which certain consumers are willing to pay for its most rare, organic or pure forms. Even the most ethical or reflexive of consumers perceive the value of natural world as linked with furthering human and/or personal goals and interests. Ethical 'consumption' thus requires transcending the limits of thinking and doing imposed on us as 'consumers' and envisioning our relationship with food systems in a new light. A reflexive model of ethical consumption can enable us to view our connection with the food system as sacred, symbiotic, life giving and life sustaining rather than a form of economic exchange.

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A sequence analysis of organic and conventional food consumers' visual information acquisition

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Abstract

It is of significant importance in food marketing to know which pieces of information available during shopping are most relevant to consumers. The visual search behaviour of consumers allows inference on the relevance of information based on what information is acquired and when. It is assumed that price is a major barrier to the purchase of organic food. However, little is known about consumers' actual acquisition of information on organic food prices. To examine the information acquisition behaviour of consumers buying organic and consumers buying conventional food, a shopping simulation study was run in which participants (n=189) were invited to choose between different unfamiliar organic and conventional product alternatives while wearing eye-tracking glasses. The data were divided into three visual attention phases: orientation phase, comparison phase, and evaluation phase. The information intake in the phases was investigated comparing organic and conventional consumers. Organic consumers acquired less information on conventional prices in the orientation and evaluation phases. It is concluded that for organic consumers, price information is less relevant to making a purchase decision compared to consumers of conventional food.

Introduction

Daily food choice situations require a large amount of information processing for decision-making from consumers (e.g., Perry & Grace, 2015). Information economics assumes that individuals obtain just enough information necessary to make an informed decision (Solomon, 2015). Consumers weigh up the cost of obtaining pieces of information against benefits - costs being the time, effort, expenditure, and inconvenience of the search (Zander & Hamm, 2012; Hoyer & MacInnis, 2010), and benefits being purchase decisions that satisfy their preferences. If an extra piece of information is higher in marginal cost than in marginal benefit, that extra piece of information will not be collected (Solomon, 2015). Information economics further assumes that the most valuable pieces of information are collected first (Solomon, 2015). Therefore, the analysis of information search behaviour allows conclusions to be made regarding which pieces of information are more relevant for consumers than others (Zander & Hamm, 2010).

Eye-tracking enables the mechanical observation of visual information search and has been applied in many studies related to food marketing (e.g., Bialkova et al., 2014; Clement, 2007; Chandon, Hutchinson, Bradlow, &

Young, 2009; Siegrist, Leins-Hess, & Keller, 2015). However, most studies based on eye-tracking use the sums of the duration or count of eye-tracking parameters such as fixations or dwells. An analysis of the sequence in which pieces of information are visually acquired is less widespread (examples of studies with a sequential analysis of eye tracking data are: Clement, 2007; Krajbich, Lu, Camerer, & Rangel, 2012; Russo and Leclerc, 1994). This study adopts a sequential perspective to analyse its data. The present study is concerned with consumers' decisions to purchase or not purchase organic food products. The organic food market has grown markedly in the last decades (Willer & Lernoud, 2018). However, the results of consumer surveys suggest the organic food market is not reaching its potential. In surveys, consumers expressed very positive attitudes towards organic food and declared their buying intention (Frostling-Henningsson, Hedbom, & Wilandh, 2014; Moser, 2016). Previous findings stressed the importance of price as a barrier to the purchase of organic food products (Aertsens, Mondelaers, Verbeke, Buysse, & van Huylenbroeck, 2011; Buder, Feldmann, & Hamm, 2014; Gottschalk and Leistner, 2013). Therefore, in this study, special attention is paid to consumers' search behaviour for price information during a purchase decision.

The aim of this study is to provide insight into consumers' decision making to purchase or not to purchase organic products with a focus on the search for price information in different attention phases. In section 2, the theoretical background of the research is provided, and the research questions are presented. In section 3, the study design and the methods of data collection, data processing, and data analysis are explained. The results of the study are presented in section 4 and discussed in section 5. In section 6, conclusions are drawn.

Theoretical Background and Research Question

Human gaze behaviour
Human gaze behaviour is distinguished into fixations, where the eye is relatively still while focusing on a locus and taking in information, and saccades, where the eyes move from one locus to another, taking in little and somewhat contextual information (Holmqvist et al., 2011; Rayner, 1998). Usually, fixations and attention are coupled so that the research of fixations allows inference on attention (Holmqvist et al., 2011; Rayner, 1998). Chandon et al. (2009) stated that in the first fixation, the semantic category, the spatial layout, and the level of clutter can be identified. For more details, individuals need to fixate objects, and re-examinations can be interpreted as an increase in information intake (Chandon et al., 2009; Balcombe, Fraser, & McSorley, 2015).

Based on information economics and empirical findings on gaze behaviour, it is assumed that consumers address their visual attention most to those attributes that are most relevant to their decision. This is deemed a utility effect (Orquin & Mueller Loose, 2013). Several studies have shown a close relationship between a high number of fixations or longer fixation durations and product choice (e.g., Chandon et al., 2009; Gere et al., 2016; Gidlöf, Anikin, Lingonblad, & Wallin, 2017; Pärnamets, Johansson, Gidlöf, & Wallin, 2016). Regarding consumers' gaze behaviour, it is known that, compared to the product package, price receives a relatively low amount of visual attention in product choice situations (Balcombe et al., 2015; van Loo, Nayga, Seo, & Verbeke, 2014). This could be the result of a higher amount of attribute information communicated on the package. Moreover, a relation between the last fixations and the final product choice was shown (Krajbich, Armel, & Rangel, 2010).

The visual information acquisition can be divided into several phases. So far, there is no clear evidence on the number of phases, so different authors use different numbers. A basic distinction can be made between the phases 'overview' or 'orientation', 'comparison' or 'discovery', and 'checking' or 'evaluation' (Orquin & Mueller Loose, 2013; Husić-Mehmedović, Omeragić, Batagelj, & Kolar, 2017). The first and the last phase were found to have shorter fixations than the middle phase (Krajbich et al., 2010). The middle phase is characterized by comparisons between products in the consideration set (Orquin & Mueller Loose, 2013).

Research question and hypotheses
The overall research question is: how much information do organic compared to conventional consumers collect on organic and conventional prices and packages during the orientation, comparison and evaluation phase. Two groups of consumers, specifically consumers who chose a conventional product and consumers who chose an organic product in the study, are compared regarding their visual information search. Hereinafter, the groups are called 'organic consumers' and 'conventional consumers' in reference only to their choice in the study. To develop hypotheses (abbreviated H) regarding consumers' visual information search, several assumptions had to be made due to a lack of research on the specific topic.

> **H1:** Both, organic and conventional consumers take in less information on price than package information in the orientation compared to the other phases because more information on product attributes to form a consideration set is given on the package.
> **H2:** Organic consumers take in less information on

Table 1: Characteristics of the sample

		Sample	City under investigation[a]
Gender (n=189)	Female	46.6%	51.0%
	Male	52.9%	49.0%
Age (n=183)	Average (SD)	42.5 (16.6)	42.6
Household members (n=188)	Average (SD)	2.0 (1.3)	1.9
Monthly disposable household income (n=181)	Average (SD)	1735.79€ (1325.88)[b]	1699.33€

Note: SD=standard deviation, [a] Source: Stadt Kassel – Fachstelle Statistik (2017), disposable household income: Hessisches Statistisches Landesamt (2016), [b] respondents were asked to indicate their income class of six classes, disposable household income calculated based on class means excluding the upper class ('6000€ or more' per month). Different sample sizes for gender, age, household members and household income arose from missing and invalid values in the data set.

prices overall than conventional consumers since they are less price-sensitive (Aschemann-Witzel & Zielke, 2017).

H3: The comparison phase is composed of a higher amount of information intake than the other phases because it is the point in the decision process in which information is compared most extensively since a relevant subset of the products offered is compared by consumers.

H4: In the comparison phase, conventional consumers take in more information on prices in total than organic consumers, as they are assumed to be more price-sensitive.

H5: In the evaluation phase, organic consumers take in most information on organic products followed by organic prices since Krajbich et al. (2010) found that the last pieces of information taken in were often related to the final choice.

H6: In the evaluation phase, conventional consumers take in most information on conventional package information followed by conventional price information.

Materials and Methods

Study design

To investigate the information intake of consumers, an eye-tracking study was conducted in a mock-up shop in a laboratory. The idea was to provide the study participants an experience which was as close as possible to a real shopping experience. The general procedure of the study was that participants first went shopping in the laboratory shop with the eye-tracking glasses recording their eye movements, and afterwards completed a self-administered computer-assisted questionnaire. At the end, participants were granted a 10€ allowance.

Three red markers on products not related to the shopping experiment on a shelf were used to calibrate the eye-tracking glasses to each participants' eyes. After calibration, the participants were asked to imagine they were going shopping for strawberry jam in a normal supermarket. The participants were further instructed to choose the product they would normally choose and to take as much time as they usually took (no time limit).

Sampling

Participants for the study were sampled on the main shopping street of a medium-sized German city with an average purchase power of its inhabitants. Quota sampling was applied with quotas on gender and age according to the German population (51% females, 49% males, in each gender group 50% in the age groups 18-44 and 45 or older, respectively). Eligible participants were at least partially responsible for household shopping and bought at least sometimes jams. Of the 255 participants that took part in the study, the data of 189 participants could be used. Five participants were excluded because they did not complete the shopping task or the questionnaire. 52 participants had to be excluded due to the low quality of their eye-tracking data. Nine participants were excluded because they stated that they did notice

Table 2: Brands of strawberry jam used as product stimuli and their prices

	Brands					
	Grandessa	**NaturAktiv (organic)**	**Meinl**	**MigrosBio (organic)**	**Sonngut**	**Grandessa Naturrein**
Price	0.79€	1.99€	2.99€	1.29€	1.39€	1.99€
Unit price (100g)	0.18€	0.40€	0.60€	0.26€	0.31€	0.44€

Note: The order of the brands in the table is equivalent to the order on the shelf. Both price and unit price were given on the price tags.

the organic products on the shelves, yet they purchased an organic product. In Table 1, the sample size for variables differs due to missing or erroneous values. For the variables gender, mean age, mean number of household members, and mean monthly disposable household income, the sample resembles the population of the city under investigation quite well (Table 1).

Product stimulus
Strawberry jam was selected as product stimulus in the laboratory shop because it is bought by many German consumers making it possible to find enough study participants. The use of a seasonal product was avoided since such products are not sold throughout the year and represent a speciality. Moreover, it was important that the product did not require cooling. Jam met all the demands. Strawberry is at the top of the list of popular jam flavours in Germany, thus, strawberry jam was chosen as a product stimulus.

Swiss and Austrian brands not sold in German supermarkets were used to avoid habitual purchases and to ensure that each participant had the same level of knowledge about the items. The unfamiliar brands also minimized the possible internal information search in the memory. Two organic and four conventional product variants were placed on the shelf (see Figure 1). Prices for the test items were set according to a realistic price range and price difference between organic and conventional products. To this end, information on the price of strawberry jams was gathered at two hypermarkets, two discount stores and one supermarket in the study region (see Table 2).

Eye-tracking data collection
Eye-tracking is a mechanical observation technique of the participants' eye-movements permitting the monitoring of visual information intake. It is generally agreed that eye-tracking is a measure for cognitive informa-

tion processing (Feiereisen, Wong, & Broderick, 2008; Feng, 2003). The technique is regarded as an unbiased and objective measure (Feiereisen et al., 2008; Graham, Orquin, & Visschers, 2012; Helmert, Symmank, Pannasch, & Rohm, 2017). Eye-tracking measures all information intake, including unconscious intake, because the level of control over eye-movements is low. Furthermore, it can be used in realistic or close to realistic settings.

Throughout the shopping task in the present study, the participants wore a set of mobile eye-tracking glasses from SensoMotoric Instruments. The eye-tracking glasses sampled both eyes at a rate of 60 Hertz. The device records the locus of vision of the participants during the shopping experiment, indicating which information was looked at, when during the shopping task it was looked at, and for how long. The mobile eye-tracking device has a main camera which records the scene in front of the participant, and two auxiliary cameras which record the eyes. Its similarity to a normal pair of glasses, including its light weight, enables a much more realistic setting than eye-trackers attached to monitors with a head and/or chin rest. The eye-tracking glasses of SensoMotoric Instruments use the reflection of infrared light on the pupil to calculate the position of the gaze in the scene.

The video-based gaze information of the participants was manually mapped on a photo of the product with the SensoMotoric Instruments' software BeGaze™. Areas of interests (AOI's) were created to get quantitative information on the participants' gaze behaviour (see Figure 1). To capture all gaze information, even if there was a small drift in the data, the AOI's were slightly larger than the product packages, and for the price tags the AOI's reached further downwards due to a tendency in the data for a larger drift at the bottom of the scene.

Nowadays, eye-tracking devices are quite accurate, although some data was deemed unworthy of further

Figure 1: Areas of interest for the front view of the strawberry jams

consideration and was removed from the final data sample under analysis. To judge the data quality, the videos of all participants were checked for drift, i.e. imprecise gaze locations, and for gaps between gaze points indicating erroneous recording of the eye movements or faulty aggregation of gaze points by the inbuilt algorithm. Two researchers each independently judged the quality for one half of the participants. 20 videos were checked by both researchers with an intercoder reliability of Kappa 0.82 (SE 0.071) which is a very good result (McHugh, 2012).

Information on time stamps for each AOI in the sequence, indicating at which moment the participants focused their vision on the corresponding AOI, and which moment they moved their eyes away from the AOI was retrieved. The moments during which each participant's eyes are relatively fixed on an AOI are called fixations. If several consecutive fixations happen to occur in the same AOI, the entire time span during which eyes are focused on the same AOI is called dwell time (Holmqvist et al., 2011). Thus, for each participant, a sequence of fixations and a sequence of dwells are available. The difference between the two is that several consecutive fixations on the same AOI correspond to one single dwell on that AOI. In the analyses, sequences of dwells and dwell counts are used because the research interest of this paper pertains to the order of information intake from different products and price tags rather than the information intake of different pieces of information from each package.

Questionnaire

A structured questionnaire was used to collect information on respondents' attitudes and socio-demographic characteristics. Fifteen questions were asked, starting with the frequency of the purchase of strawberry jam and the reasons for the product choice in the test market, followed by a rating of statements on food purchasing involvement, price of food, organic food and purchase of organic products. It was also asked if the participants had noticed the organic variants and how much of their food budget they usually spend on organic food. The questionnaire ended with socio-demographic questions.

Methods of data analysis

The hypotheses on the amount of information collected on organic and conventional prices and packages in the different phases were analysed by calculating the average dwell counts and using descriptive and bivariate statistics (t-tests). To tackle the research question, the orientation, comparison and evaluation phase had to be identified.

In this study, the definition of the phases was made using the same criteria as Russo and Leclerc (1994), i.e. the first phase (screening or orientation/overview) is characterized by a lack of dwells back on an AOI that was previously looked at, meaning that in this phase no item is looked at twice. With the first repeated dwell (re-dwell) the comparison phase begins ('evaluation phase' in Russo and Leclerc, 1994). The third phase, evaluation phase, is again characterized by a lack of re-dwells, counted from the end of the dwell sequence to the beginning ('verification phase' in Russo and Leclerc, 1994).

Several studies found that in the first and last phase, the fixations are shorter than in the middle phase (Clement, 2007; Glöckner and Herbold, 2011; Krajbich et al., 2010; Russo and Leclerc, 1994). Glöckner and Herbold (2011) defined the different phases based on the fixation durations. However, Reutskaja, Nagel, Camerer and Rangel

(2011) found that the average fixation duration decreases with increasing numbers of items in a set which could lead to different durations of fixations in the three phases in different studies. Therefore, in this study the phases are defined by re-dwells, as described above.

Results

The most frequently 'purchased' product was the cheapest jam which was a conventional product (29.1%). The most expensive jam which was also conventional was chosen the least. In total, 39.7% of participants chose an organic jam and 60.3% chose a conventional jam. The number of dwells needed before finishing the shopping task was on average 36.5 dwells.

Gaze behaviour in different attention phases
In figures 2a) to 2c), the average dwell counts of organic and conventional consumers in the orientation phase (OP), comparison phase (CP), and evaluation phase (EP) are depicted in response to the hypotheses. The orientation phase was relatively short with, on average, 4.8 dwells, considering that there were six jam brands on the shelf and, on average, only about 3.4 packages were looked at before looking back to packages that had been previously noticed. It is also noteworthy that price information was already acquired in the orientation phase. As expected (H1), less price than package information was acquired in the orientation phase by both organic (OC) and conventional consumers (CC) ($T_{OC}(74)=-11.3$, $p<0.01$; $T_{CC}(113)=-7.4$, $p<0.01$).

The comparison phase consisted of the most dwells of all phases, with on average 25.5 dwells (H3 confirmed). The evaluation phase was shortest with 3.9 dwells on average. Overall, there were significantly more dwells on prices in the comparison than in the orientation and evaluation phases ($T_{OP-CP}(188)=-11.9$, $p<0.01$; $T_{CP-EP}(188)=12.0$, $p<0.01$). The dwell counts on packages differed significantly between the three phases - the comparison phase with the most and the evaluation phase with the least dwells ($T_{OP-CP}(188)=-14.1$, $p<0.01$; $T_{CP-EP}(188)=15.3$, $p<0.01$; $T_{OP-EP}(188)=5.9$, $p<0.01$).

It stands out that in the orientation phase, conventional consumers have, on average, more dwells in total than organic consumers, while in the comparison phase, organic consumers have more. In the orientation phase, organic consumers acquired significantly more information on organic packages than conventional consumers who searched significantly more for conventional price information. Also, considering the sum of dwells on organic and conventional prices in the orientation phase, organic consumers had significantly less dwells on pric-

es than conventional consumers ($T(175.4)=2.9$, $p<0.01$). This confirms the previously formed assumption that organic consumers search less for price information in the orientation phase than conventional consumers.

In the comparison phase, it was the organic consumers who searched more for organic price, organic package, and conventional package information, and less for conventional price information than conventional consumers. The differences were, however, only statistically significant for the dwell count on organic packages. The assumption (H2) that conventional consumers take in more information on prices (sum or organic and conventional) cannot be confirmed ($T(187)=0.5$, $p=0.63$).

In the evaluation phase, a significant difference between the groups became apparent in the number of dwells on conventional prices and on organic packages, with organic consumers taking in less conventional price and more organic package information. Regarding the hypothesis (H5) on the gaze behaviour of organic consumers in the evaluation phase, it cannot be confirmed that this group acquired the most information from organic packages because their gaze dwelt significantly more on conventional packages ($T(74)=-3.7$, $p<0.01$). Organic and conventional prices were, without a significant difference in the number of dwells on them ($T(74)=-0.6$, $p=0.55$), looked at least by organic consumers.

For conventional consumers, on the other hand, the hypothesized gaze behaviour could be confirmed (H6). This group looked the most at conventional packages, second most at conventional prices, followed by organic packages, and finally, the least at organic prices. These differences were significant ($T_{conv.pack.-conv.price}(113)=3.6$, $p<0.01$; $T_{conv.price-org.pack.}(113)=-8.8$, $p<0.01$; $T_{org.pack.-org.price}(113)=2.7$, $p<0.01$).

Importance of product characteristics for choice
In the questionnaire, consumers rated the importance of several product characteristics to their choice of jam. The price of jam was significantly more important for consumers picking a conventional jam in the test shop than for those choosing an organic jam (see Table 3). This is reflected in the dwell sequence patterns, as organic consumers searched less for price information in the orientation and evaluation phases. Another significant difference between the two groups was their interest in the country of origin of the product and its indication. This characteristic was more important to organic consumers than to conventional consumers. The package size, referring to the amount of content for a given price, was significantly more important for conventional consumers. The results of the analysis of dwells in the three defined
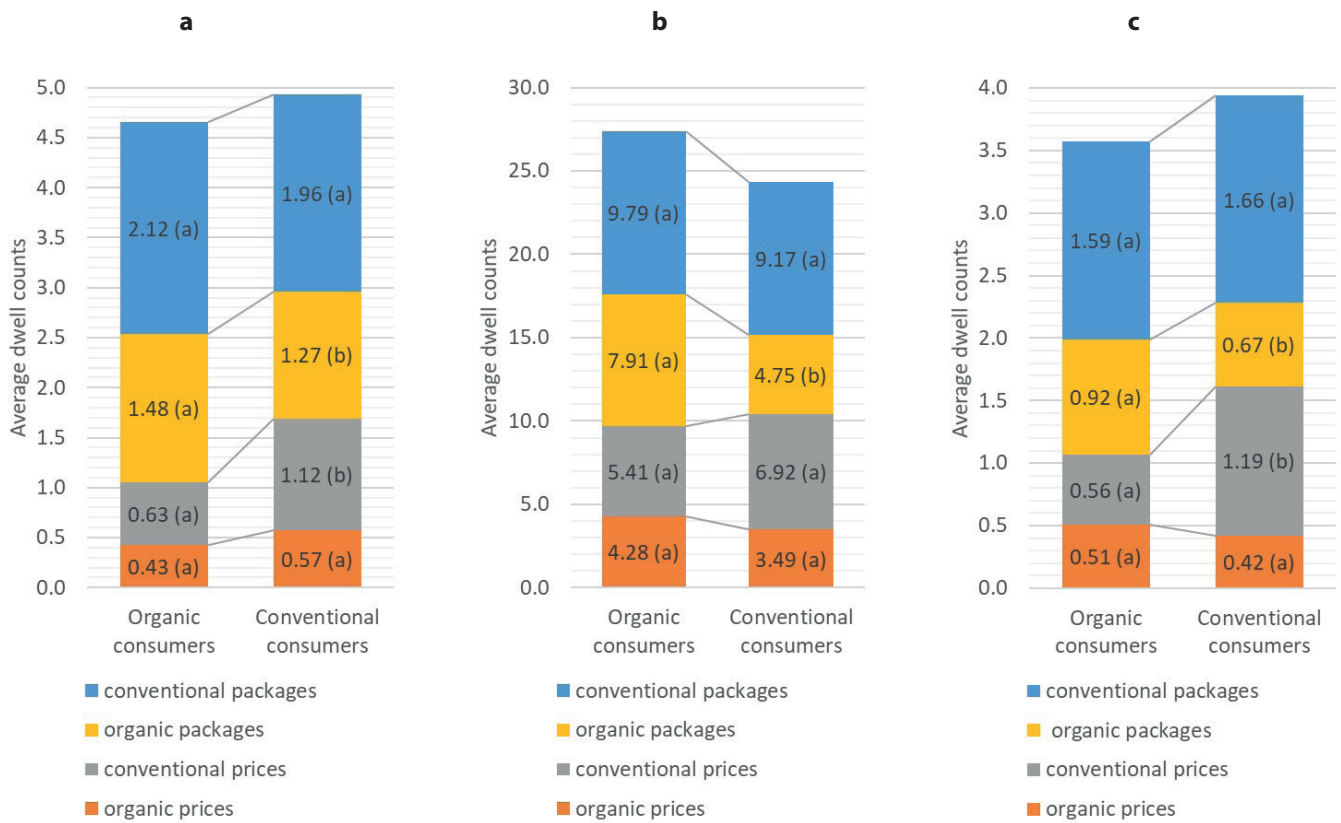
Figure 2: Dwell counts on organic and conventional prices and packages in the a) orientation, b) comparison, and c) evaluation phase

Note: Different letters mean significant differences at α=0.05 between organic and conventional consumers. Na,b=189, Nc=175. There were two organic and four conventional variants on the shelf.

Table 3: Importance of product characteristics for choice of organic and conventional consumers

Importance of … for 'purchase' decision	Consumer group	Mean rating[1]	Test statistic (T)[2]	Effect size (Cohen's d)
Price	Conventional	5.4	3.5**	0.52*
	Organic	4.5		
Country of origin	Conventional	3.6	-2.8**	-0.42
	Organic	4.5		
Package size	Conventional	4.5	2.7**	0.40
		3.8		

Note: [1]scale from 1=not at all important to 7=very important, [2]degrees freedom=186, * significant at a=0.05/intermediate effect, ** significant at a=0.01/large effect.

attention phases shows that the country of origin and organic production are characteristics that need more search on the package, which might explain the longer time organic consumers needed to decide. On the other hand, price and package size are features that are more directly visible which might explain the shorter decision-making of conventional consumers.

Discussion

Based on theoretical considerations, the comparison phase was expected to yield the most interesting differences between participants who decided for an organic and those who decided for a conventional jam, since it was assumed that it constitutes an evaluation of the subset of jams considered for choice (H3, see Orquin & Mueller Loose, 2013). However, the only significant difference between consumers who chose an organic and those who chose a conventional jam was that the former had more dwell counts on organic packages. This indicates that participants who decided for an organic jam had conventional brands in their consideration set, too. The expected difference in the information intake of prices (H4) was not found.

In the evaluation phase, consumers 'buying' organic had on average 0.92 dwells on organic and 1.59 on conventional packages. From these numbers, it can be inferred that a large share of participants who decided for an organic jam did not fixate an organic jam last. This contradicts H5. Instead, most seemed to have looked at a conventional jam before finishing their purchase. In contrast, Krajbich et al. (2010), who conducted an eye-tracking experiment in which the stimuli were shown on a screen, found a relationship between the last fixation and product choice. The deviation between Krajbich et al.'s (2010) findings and the gaze behaviour of participants in this study could be the result of this study's rather realistic conditions in which participants walked through a simulated supermarket aisle instead of sitting in front of a computer screen. It was observed that some participants let their gaze roam along the shelf when they walked out of the test shop, and due to the higher number of conventional jams on offer the probability was higher that the gaze landed last on a conventional alternative.

The rating of the importance of product attributes for the choice of participants picking a conventional or organic jam allowed for the interpretation that the utility effect is reflected in the sequence of dwells. First, consumers 'purchasing' a conventional jam searched for significantly more conventional price information in the orientation and evaluation phases of the choice

decision. This is in line with the great importance these consumers placed on price. Moreover, this agrees with previous findings showing that for consumers of organic food, price is less important than for conventional consumers (Aschemann-Witzel & Zielke, 2017; Bezawada & Pauwels, 2013; van Herpen, van Nierop, & Sloot, 2012). Second, organic consumers' significantly higher number of dwells on organic packages but also relatively high amount of acquisition of conventional package information can be interpreted as an indicator of their search for products from organic farming or from a certain country, based on their importance ratings.

Regarding the validity of the orientation, comparison, and evaluation phases, this study's results are in line with those of Glöckner and Herbold (2011) who found no effect of an initial screening, indicating that there was no screening of all information before a comparison. Glöckner and Herbold (2011), however, defined screening based on the duration of fixations. In this study, a lack of a total screening before changing to the comparison phase is suspected, since all except for three participants looked at some information in the comparison phase that they had not seen previously in the orientation phase. This was also found by Russo and Leclerc (1994) who pointed out that brands that had not been noticed in the first phase are examined in the second phase. Also, in Russo and Leclerc's (1994) study not all phases were present for all participants. In this study, the first two phases could be identified for all participants while in 14 cases the third (evaluation) phase was lacking.

This study confirmed the finding of Balcombe et al. (2015) and van Loo et al. (2014) of less visual attention being allocated to prices than to packages. The mentioned studies, however, gained this insight from choice experiments combined with eye-tracking where participants were sitting in front of a computer screen. This study confirmed the finding from a close to realistic shopping situation with mobile eye-tracking glasses.

Conclusions

This paper presents findings from a sequential analysis of eye-tracking data yielded from a shopping task that participants conducted in a laboratory mock-up shop. Participants had to choose between unfamiliar organic and conventional strawberry jam brands. The analysis of the data revealed that consumers who buy organic food look less at price than consumers purchasing conventional food in the orientation and evaluation phases, but do seem to compare organic and conventional prices for their decision. Moreover, organic consumers searched significantly more than conventional consumers for information from organic packages in the orientation,

comparison, and evaluation phases.

Considering the utility effect apparent in gaze behaviour (see Orquin and Mueller Loose, 2013), it is concluded that characteristics inherent to the product core, such as process characteristics, are more important to organic consumers, since they first searched package information before they started weighing up the costs.

Conventional consumers, on the other hand, searched significantly more than organic consumers for information on conventional prices in the orientation and evaluation phases. Based on the utility effect in gaze behaviour and this groups' importance ratings for price and package size, it is concluded that information on price-performance-related product characteristics is more relevant to them.

The hypotheses on the gaze behaviour of consumers choosing organic products presented in section 2.2 was partly confirmed. While the results showed that all consumers search less for price information in the orientation phase compared with in the comparison and evaluation phases, it was not found that consumers of organic food gaze overall less at prices than buyers of conventional food. It was confirmed that information intake is highest in the comparison phase, while it could not be confirmed that conventional consumers take in more price information in this phase. The results confirmed the hypothesised gaze behaviour of conventional consumers in the evaluation phase, while organic consumers' gaze behaviour deviated from expectations by not looking mostly at organic packages.

The study has several limitations. First, it was conducted in just one German city and cannot therefore be considered representative of the German population. Second, the results of this study cannot be translated to normal shopping situations since the study participants faced unfamiliar brands in the test shop and could not select the jams that they usually purchase. Furthermore, the range of products offered is much larger in normal supermarkets, which is presumed to influence decision-making and gaze behaviour. Third, the study relies on one product only. It is possible that there is an effect from the chosen product category on the choice and gaze behaviour. Fourth, since all products had only one facing and the package sizes were similar, no saliency bias is expected from these factors. Products were, however, not tested regarding the saliency of their package designs, which might have biased the participants' gaze behaviour (see Milosavljevic, Navalpakkam, Koch, & Rangel, 2012).

It is suggested that in a future study, the phases could be defined based on the fixation duration and then be compared to this study's results to provide insight on the effect the method of defining the phases has. Since German consumers are assumed to be more price conscious than consumers of other nationalities, it is suggested to replicate this study in other countries. It is furthermore suggested that future studies investigate whether different products would lead to different results.

Acknowledgements

Conflict of Interests

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

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Ultrasound treatment (low frequency) effects on probiotic bacteria growth in fermented milk

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Keywords	Abstract
Probiotic bacteria, Ultrasound, Fermented milk, β-galactosidase	The effect of ultrasonic treatment at 40 kHz for 0, 5, 10, 15 and 20 minutes on the growth of five different strains of probiotic bacteria (*Lactobacillus acidophilus* LA-5*, Lactobacillus casei* LC*, Lactobacillus reuteri* LR-MM53*, Bifidobacterium bifidum* Bb-12 *and Bifidobacterium loungm* BB-536) in fermented milk was investigated. The study findings indicate that ultrasound treatment (10 minutes) increased the viable cells and total acidity for LA-5, LC and LR-MM53 samples but decreased viable cells and total acidity in the Bb-12 and BB-536 samples. All probiotic bacteria strains were ruptured by ultrasound treatment causing an increase in the extracellular release of β-galactosidase enzyme. Increased exposure time led to higher enzymatic activity. 2.9 unit/ml of β-galactosidase was measured in LR-MM53 after ultrasonic treatment for 20 minutes. The fermentation time of LA-5, LC and LR-MM53 samples were reduced after 10 minutes of ultrasound treatment compared with the control sample. Added 5 percent (10^8 CFU/ml) of probiotic bacteria led to reduce at the fermentation time during ultrasonic treatment compared with control sample. The optimal time span of ultrasound treatment (40 kHz, 116 W) was 10 minutes for all fermented milk samples, which can be applied to increase the number of viable cells of probiotic bacteria and β-galactosidase enzyme.

Introduction

Sound waves or acoustic energy with frequencies above 20.000Hz is called ultrasound. Ultrasound causes cavitation in growth media that brings about many chemical and physical changes. Bacterial cells can grow in low intensity of ultrasound treatment because of the following characteristics of ultrasound (Pitt and Ross, 2003). Ultrasound treatment increases the transfer of small particles in the growth media, and incompetence to fully remove microorganism's cells or even non-living molecules from surfaces media. Stable cavitation production results when the low ultrasound intensity is sufficient that the bubbles do not collapse totally during their contraction

cycle (Elder, 1959; Chau et al., 2017).

Historically, the effectiveness of low acoustic intensity in inhibition bacterial cells has been limited through the protection provided to the organisms by the food environment. Recently, the systems such as Langevin transducers with high output of ultrasound power at low frequency have greatly increased the effect on bacterial growth, bacterial biological activity and their enzyme production. In general, inhibition of the bacterial cells is more pronounced at high ultrasound treatment by the increasing processing time of this treatment (Pohlman

et al., 1997; Dong et al., 2017; Wu and Narsimhan, 2017). According to the effects of ultrasound in the in food systems, the ultrasonic treatment frequencies can be divided into low frequency (20-100 kHz), medium frequency (100 kHz-1MHz) and high frequency (1-10 MHz) (Abbas et al., 2013; Al-Hilphy et al., 2016).

Climatic changes affect dairy products in all world zones. Climatic changes are expected to hold back and increasingly adversely affect the dairy industry in the upcoming years. The importance of modern techniques such as Ultrasound to dairy production, therefore, will rise in the coming years in proportion to the changes in ecological temperatures (IPCC, 2007).

Ultrasound power is important in food processing. It is commonly used for controlling the viscosity of food systems, emulsification, sugar crystallization, meat tenderization, drying, brining, cutting processes and improving cleaning and flux during ultrafiltration and microfiltration (Ünver, 2016; Carrillo-Lopez et al., 2017; de Lima Alves et al., 2018; Ojha et al., 2018). Al-Hilphy et al. (2012), using 338 and 430W of ultrasound power (high efficiency) for milk homogenization and to decrease the number of bacteria, found that a higher power (430W) decreased the homogenization index and D-values of bacterial numbers. Low-frequency ultrasound treatment increases the viability of bacteria and the breakdown of some complex compounds such as sugars and protein (Al-Hilphy et al., 2016). Probiotic bacteria are defined as active microorganisms, which, when taken in adequate quantities, grant a health benefit on the host (humans and animals) (Ranadheera et al., 2010). The dose effect of probiotic bacteria is dialectical and the majority of past studies were in-vitro tests. The usual active dose in humans is 10^7-10^9 CFU/mg/day. However, the level of probiotic bacteria in dairy products should include a lower number, 10^6-10^7 CFU/mL, of viable cells at the time of consumption (Gustaw et al., 2011). Probiotics weak growth in milk and dairy products. They need more time to produce their enzymes (such as ß-galactosidase) compared with lactic acid bacteria.. β-galactosidase enzyme hydrolyses lactose (milk sugar) into glucose and galactose (Nguyen et al., 2009). Previous studies show the use of some substances to stimulate probiotic bacteria, such as added gum Arabic and mannan extraction to produce probiotic yogurt (Niamah et al., 2016; Al-Manhel and Niamah, 2017).

The goal of this study was to study the effect of low frequency ultrasound over different time periods on the viability of probiotic bacteria strains, β-galactosidase activity and fermentation time in fermented milk samples.

Materials and Methods

Sources of strains
Freeze-dried probiotic strains of *Lactobacillus acidophilus* (LA-5), *Lactobacillus casei* (LC), *Lactobacillus reuteri* (LR-MM53), *Bifidobacterium bifidum* (Bb-12) and *Bifidobacterium loungm* (BB-536) were purchased from CHr. Hansen company (Denmark). The strains were cultured in deMan Rogosa Sharpe media (Hi-media, India) with 0.05% L-cysteine-HCI (Sigma–Aldrich, Italy) at 37°C for 24-48 hour under anaerobic conditions.

Fermented milk by probiotic bacteria
Restarted skimmed milk (Param dairy, India) of 12% (W: V) was made by dissolving skimmed milk powder (120gm) in 1 litre of water at 50°C. It was pasteurized at 90°C for 5 minutes then cooled at 40°C. 5 percent (10^8CFU/mL) (W: V) of old probiotic strains were added to the pasteurized milk and mixed by vortex with a mixer (VM-300, Germany). The samples were exposed to ultrasonic power (power sonic 405, Korea) at amplitude of 30 percent (conforming to approximately 116 W) and a frequency of 40 kHz for 5, 10, 15 and 20 minutes, respectively. The samples were then incubated at 37°C for 12 hours and cooled at 4°C for 12 hours. Thereafter the following tests were conducted.

Enumeration of probiotic bacteria
Enumeration of viable probiotic cells was conducted by pouring plate method, which used deMan Rogosa Sharpe agar with 0.05% L-cysteine-HCl incubated at 37°C for 24-48 hours under anaerobic conditions. The survival percentage of probiotic bacteria was calculated (Niamah et al., 2017).

Total acidity and pH
Total acidity and pH (pH-meter, SD-300, Germany) of fermented milk samples were measured after fermentation by probiotic strains (Niamah, 2017).

β-galactosidase activity assay
β-galactosidase was measured using O-nitrophenyl-β-D-galactopyranoside (ONPG) (Sigma–Aldrich, Italy) as described by Nguyen et al. (2009). 1 ml of fermented milk by probiotic strains was mixed with 5 ml of sodium phosphate buffer (at pH 7) and incubated at 37°C for 15 minutes. 3 ml of ONPG, prepared by dissolving 0.4gm in 100 ml of sodium phosphate buffer, was added into tubes. The tubes were incubated at 37°C for 15 minutes. To stop the reaction, 2 ml of 1 M Na_2CO_3 (BDH, UK) were added. After cooling 10 ml of acetonitrile (BDH, UK) was added, and the mixture was centrifuged at 5000 rpm for 20 minutes to remove the milk protein and bacterial cells of samples. The samples were measured in absorbance
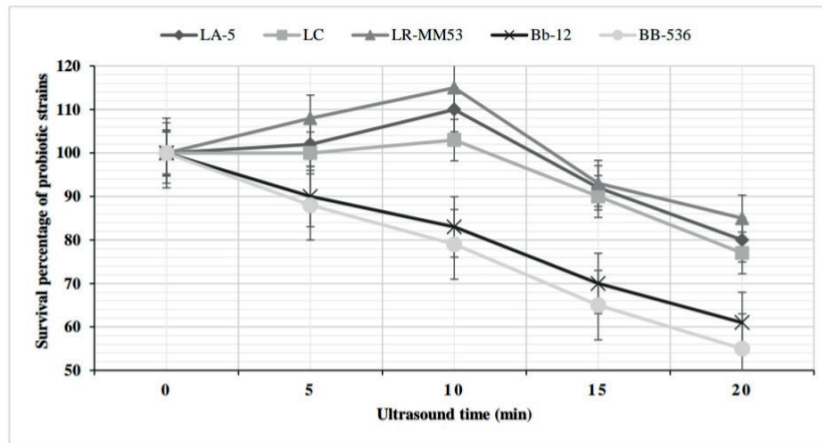
Figure 1: Survival percentage of bacterial strains after ultrasound treatment for 0, 5, 10, 15 and 20 minutes. The results are expressed as mean values with standard deviation (SD), n = 3 for any treatment

at 420 nm by spectrophotometer UV-2900 (Biotech Engineering, UK). A standard calibration curve was created using pure ONP (Sigma-Aldrich, Italy). The activity unit of enzyme was determined by defining the amount of ONP liberated from ONPG.

Water holding capacity (WHC)

In order to determine the WHC percentage of the fermented milk samples after ultrasound treatment, 10 g of fermented milk was weighed and centrifuged at 5000 rpm for 10 minutes at 25°C. The top layer (whey) was removed and weighed. WHC percentage was reported as the ratio of the top layer of the initial fermented milk weight (Niamah et al., 2016).

Fermentation time

After ultrasound treatment, pasteurized milk samples with 1,3 and 5% (10^8CFU/mL) of probiotic bacteria were incubated at 37°C until reaching the pH value of 4.5 ± 0.2, which indicates the end of fermentation time. The results were compared with a non-treated sample (without ultrasound treatment) of each probiotic strain.

Statistical analysis

In order to evaluate the effect of ultrasound treatment on the probiotic bacteria under study, experiments involving fermented milk of each probiotic strain were triplicated. The average of the three values (n=3) for each sample was calculated. An ANOVA table was used to analyse the data in SPSS (version 16.0). The Significance level was set at $p<0.05$ to make comparisons between the means using Least Significant Difference (LSD). Graphs of the findings were created using Microsoft Excel (version 2016). Results were presented as means ± standard deviations.

Results and Discussion

Survival percentage of probiotic bacteria

The changes in survival percentage of probiotic bacteria strains in fermented milk samples after different times of ultrasound treatment are shown in figure 1. The survival percentage of LR-MM53, LA-5 and LC strains increased after 10 minutes of ultrasound treatment as compared with Bb-12 and BB-536 strains (115, 110, 103, 83 and 79 percent survival, respectively). Clearly, the effect of ultrasound treatment on five-probiotic bacteria strain is dependent on the strain type. Their resistance to ultrasound power can be explained by their property's: differences in cell sizes, cell walls, and chemical components of cell walls such as the structure of the phospholipid and protein. Resistance in different strains of bacteria to ultrasonic power with 20 kHz of frequency and 80% amplitude at different time periods, in fermented milk by using *Lactococcus lactis* subsp. *lactis, Lactococcus lactis* subsp. *cremoris*, *Lactobacillus acidophilus* and *Lactobacillus casei* is detailed in Tabatabaie and Mortazavi (2008). An increase in exposure times to ultrasound treatment leads to inhibition of bacterial cells, and therefore all survival percentages of bacterial strains decrease with increasing the time period of ultrasound treatment. *Bifidobacterium longum* BB536 strain was highly effective with increased exposure time of ultrasound treatment: the survival percentage of this strain was 55% after 20 minutes. This result agrees with the findings of Nguyen et al. (2009) who found the viable cells of *Bifidobacterium* spp. strains decreased when increasing the time of ultrasound treatment. Wang and Sakakibara (1997) reported the decreasing viability of *Lactobacillus* spp. through ultrasound treatment, but that after the ultrasound process stopped, the viability of bacteria was increased in fermented milk. This indicates that the ultrasound treat-

Table 1: Total acidity percentage and pH values of fermented milk samples after ultrasound treatment. The results are expressed as mean values with standard deviations (SD), n = 3 for all

Bacterial strains	Ultrasound treatment time (min)									
	0	5	10	15	20	0	5	10	15	20
	Total acidity (%)					pH values				
LA-5	0.80[a] ±0.1	0.80[a] ±0.3	0.82[a] ±0.2	0.70[b] ±0.3	0.61[c] ±0.2	5.0[a] ±0.1	5.0[a] ±0.4	4.8[a] ±0.1	5.7[c] ±0.1	6.0[c] ±0.1
LC	0.80[a] ±0.1	0.81[a] ±0.1	0.83[b] ±0.1	0.68[c] ±0.5	0.62[d] ±0.5	5.0[a] ±0.3	5.0[a] ±0.3	4.9[a] ±0.1	5.6[b] ±0.5	6.0[c] ±0.1
LR-MM53	0.79[a] ±0.3	0.80[a] ±0.1	0.81[a] ±0.2	0.65[b] ±0.5	0.60[c] ±0.2	5.1[a] ±0.2	5.1[a] ±0.3	5.0[a] ±0.3	5.7[b] ±0.3	6.1[c] ±0.1
Bb-12	0.75[a] ±0.0	0.65[b] ±0.2	0.64[b] ±0.5	0.60[c] ±0.4	0.55[d] ±0.1	5.3[a] ±0.5	5.6[a] ±0.3	5.5[b] ±0.3	6.1[c] ±0.3	6.3[c] ±0.2
BB-536	0.76[a] ±0.2	0.64[c] ±0.1	0.70[b] ±0.3	0.55[d] ±0.2	0.50[f] ±0.0	5.2[a] ±0.5	5.7[b] ±0.2	5.9[b] ±0.2	6.0[b] ±0.1	6.1[c] ±0.3
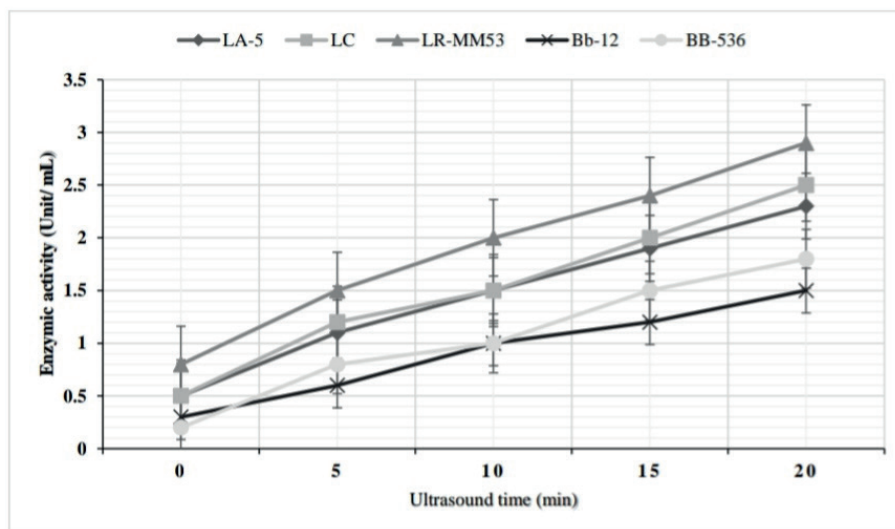
Figure 2: The β-galactosidase enzyme of probiotic bacteria strains after ultrasound treatment for different time periods. The results are expressed as a mean values with standard deviations (SD), n = 3 for all treatments

ment has no effect on the diffusion ability of bacterial cells.

Changes in total acidity and pH

Table 1 shows the changes in total acidity percentage and pH values of fermented milk samples after ultrasound treatment over different time periods. After ultrasound treatment at 10 minutes, the total acidity percentage of milk samples increased while pH values decreased. Increasing acidity of samples can be attributed to the activity of probiotic strains' residual after ultrasound treatment. Higher acidity percentage of fermented milk

samples is the result of the encrusting of viable cells of bacteria after 10 minutes of ultrasound treatment. Ultrasound treatment causes cavitation bubbles which have a mechanical effect on the bacterial cells. One possible result is the devastation of the cell wall of the bacterial cells, such that the cells are unable to carry out metabolic activities. Our results were in good agreement with past studies. For example, Shershenkov and Suchkova (2015) reported an increase in the total acidity of yoghurt samples when using 5W of ultrasound treatment (30kHz) for 3 minutes compared with 6W of ultrasound treatment (30kHz) for 1 minute.
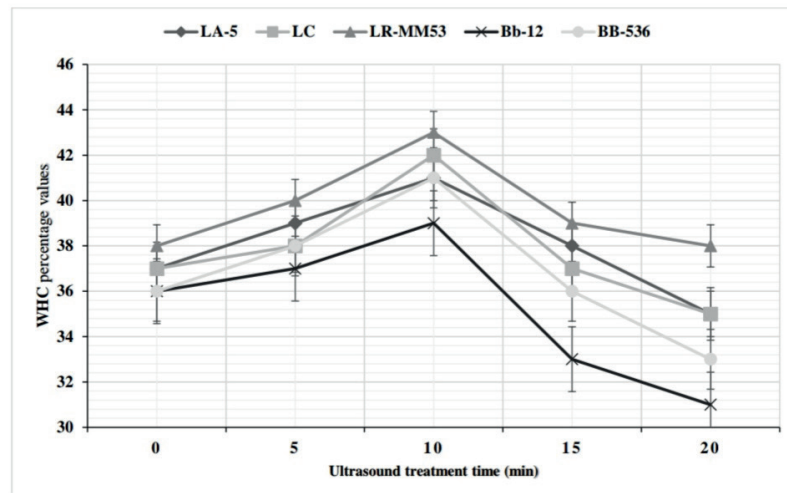
Figure 3: WHC percentage of fermented milk sample by probiotic bacteria after ultrasound treatment for different time periods. The results are expressed as mean values with standard deviations (SD), n = 3 for all treatments

β-galactosidase activity in fermented milk samples

The β-galactosidase activity in sonicated milk fermentation with five probiotic strains increased with increasing time of ultrasonic treatment (figure 2). Increased ultrasound treatment time provided higher β-galactosidase activity in all samples. LA-5, LC and LR-MM 53 strains excelled in enzyme production compared with the Bb-12 and BB-536 strain. The higher β-galactosidase activity of the fermented milk samples after ultrasound treatment identifies the treatment as a preferred agent for dairy fermentation products by probiotic bacteria. Ultrasound treatment effects in milk lead to increase in transfer reactions and lactose hydrolysis. It provides more monosaccharides, such as galactose and glucose. It was reported that lactose utilization by a starter yoghurt consisting of *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* were speedier when carbohydrate of milk (lactose) was partially pre-hydrolyzed (O'Leary and Woychik, 1976). Ultrasound treatment method helped in the fast lactose hydrolysis in fermented milk by Bifidobacterium spp (Nguyen et al., 2009). These changes in β-galactosidase enzyme levels and lactose hydrolysis might have enhanced the growth rate of probiotic bacteria and increasing total acidity during milk fermentation. The different activating agents in fermented milk samples by different strains may be imputed to two agents: (1) the viability of bacteria cells under ultrasonic treatment, and (2) the amount of β-galactosidase enzyme produced from these bacteria after ultrasonic treatment.

WHC percentage values of fermented milk

The changes in the water holding capacity (WHC) percentage of fermented milk are presented in figure 3. The WHC percentage values gradually increased after 10 minutes of ultrasound treatment for all probiotic strains, but WHC percentage values of fermented milk decreased after 15 and 20 minutes of ultrasound treatment. The whey separation or lower water holding capacity is partly because of the uneasy gel network of fermented milk. The colloidal linkage of protein molecules is weak and it can not bind water inside a three-dimensional network (Yang and Li, 2010; Niamah et al., 2016). The ultrasound treatment was effected on a three-dimensional network of fermented milk. Vercet et al. (2002) reported milk treatment by manothermosonication process used for the production of yoghurt. This process improved yoghurt texture by breaking the fatty granules and increasing the water holding capacity.

Effect of ultrasonic treatment on fermentation time

The results show a close correlation between the percentage of viability of probiotic bacteria after ultrasound treatment and the decrease of fermentation time, as shown in Table 2. Significant differences were observed at $P \leq 0.05$ between the fermentation time of the control sample (without ultrasound treatment) and the different time periods of ultrasound treatment for all probiotic strains. The data show that a longer period of ultrasound treatment leads to a lower viability percentage of probiotic bacteria. This may be expounded by the reality that when ultrasonic treatment time is increased, more cavitation bubbles were produced and the breakdown of these bubbles imparted chemical and physical effects which break down bacterial cell walls. Therefore, the fermented milk, which was exposed to a longer ultrasonic treatment time, has a lower viability percentage of bacteria (Racioppo et al., 2017; Kassem et al., 2018).

An increase in the initial probiotic bacteria starter (vol-

Table 2: The fermentation time of fermented milk samples by different starter volumes of probiotic strains after ultrasound treatment. The results are expressed as mean values with standard deviations (SD), n = 3 for all treatments

Starter volume (10^8 CFU/mL)	Bacterial strains	Ultrasound treatment time (min)				
		0	5	10	15	20
1%	LA-5	$15.0^c \pm 0.3$	$14.0^c \pm 0.5$	$13.5^{ab} \pm 0.8$	$18.0^b \pm 0.5$	$21.5^a \pm 0.1$
	LC	$16.0^c \pm 0.2$	$15.5^c \pm 0.6$	$15.0^c \pm 0.3$	$19.0^b \pm 0.4$	$22.0^a \pm 0.5$
	LR-MM53	$14.0^b \pm 0.1$	$13.5^b \pm 0.1$	$13.0^b \pm 0.5$	$16.0^a \pm 0.5$	$18.0^a \pm 0.3$
	Bb-12	$20.0^b \pm 0.1$	$20.5^b \pm 0.3$	$21.0^a \pm 0.7$	$22.0^a \pm 0.4$	$23.0^a \pm 0.6$
	BB-536	$21.0^b \pm 0.6$	$22.0^a \pm 0.8$	$23.0^a \pm 0.2$	$23.5^a \pm 0.3$	$24.0^a \pm 0.1$
3%	LA-5	$14.0^b \pm 0.5$	$13.5^c \pm 0.3$	$13.0^c \pm 0.2$	$16.0^b \pm 0.2$	$19.0^a \pm 0.5$
	LC	$15.5^b \pm 0.3$	$15.0^b \pm 0.6$	$14.0^c \pm 0.9$	$17.0^b \pm 0.3$	$20.0^a \pm 0.0$
	LR-MM53	$13.0^b \pm 0.2$	$12.5^c \pm 0.4$	$12.0^c \pm 0.5$	$15.0^b \pm 0.3$	$19.0^a \pm 0.6$
	Bb-12	$18.0^b \pm 0.1$	$18.5^b \pm 0.6$	$19.0^b \pm 0.4$	$20.0^a \pm 0.8$	$22.0^a \pm 0.1$
	BB-536	$19.0^b \pm 0.1$	$20.0^b \pm 0.5$	$21.0^a \pm 0.2$	$23.0^a \pm 0.1$	$23.5^a \pm 0.5$
5%	LA-5	$12.5^c \pm 0.6$	$12.0^c \pm 0.7$	$11.0^{cb} \pm 0.5$	$15.0^b \pm 0.4$	$18.5^a \pm 0.2$
	LC	$14.0^c \pm 0.5$	$13.0^c \pm 0.2$	$12.5^c \pm 0.3$	$16.0^a \pm 0.0$	$18.0^a \pm 0.5$
	LR-MM53	$12.0^c \pm 0.9$	$12.5^c \pm 0.2$	$11.0^c \pm 0.1$	$13.0^b \pm 0.4$	$16.0^a \pm 0.1$
	Bb-12	$16.0^c \pm 0.1$	$16.5^c \pm 0.1$	$17.0^b \pm 0.1$	$19.0^b \pm 0.6$	$21.5^a \pm 0.8$
	BB-536	$17.0^b \pm 0.7$	$18.0^b \pm 0.6$	$20.0^a \pm 0.3$	$21.5^a \pm 0.3$	$22.0^a \pm 0.2$

ume 5 percent compared with volume 1 percent) led to a greater decrease in fermentation time of fermented milk production because of increasing numbers of bacteria (Table 2). This result agrees with that found by Ojha et al. (2017). This may be expounded by the certainty that in milk fermentation, production of lactic acid is mostly executed by viable cells of lactic acid bacteria. This occurs because the increasing cell number of this bacteria results in a speedy acidification (lactic acid production) when the fermentation process ends. Low frequency ultrasound power was able to catalyse the fermentative activities of probiotic bacteria such as *Lactobacillus* spp. and *Bifidobacterim* spp. in milk. Ultrasound treatment over different time periods caused different effects on lactose metabolism by probiotic bacteria. The fermentation time changes and β-galactosidase enzyme production depend on the survival percentage of probiotic strains in fermented milk samples after ultrasound treatment.

Conclusions

Ultrasound treatment is one of the most promising modern technologies that can be applied in food industries such as dairy production. It is inexpensive compared with other techniques. Low-frequency ultrasound treatment increases the viability of bacteria starters such as lactic acid bacteria and probiotic bacteria. The results of the current study show that increased exposure time of ultrasound treatment leads to decreased viability of probiotic bacteria strains and increased β-galactosidase activity. The best exposure time of ultrasound treatment was 10 minutes. It improved some chemical properties of fermented milk by probiotic bacteria.

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Conflict of Interests

The author hereby declares that there are no conflicts of interest.

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The eating culture of the Sundanese: Does the traditional salad (*Lalapan*) improve vegetable intake and blood β-carotene concentration?

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Keywords

Abstract

This study explores how consumption of the traditional salad *Lalapan*, central to the eating culture of the Sundanese, is associated with skin quality perception, daily β-carotene intake and blood β-carotene concentrations. This cross-sectional study was conducted in Gunung Malang Village and Leuweung Kolot Village, Bogor District, West Java. 60 healthy Sundanese women, aged 30-49 years, were selected using simple random sampling. Their body weight and height were measured, and they were interviewed about the eating culture of *Lalapan*, skin quality perceptions after consumption of *Lalapan*, and consumption habits of *Lalapan* using a semi-quantitative month-long food frequency questionnaire (SQ-FFQ). The blood β-carotene concentrations of about 25% of the subjects were analysed and Chi-square used to evaluate the association between variables. The results show that about 60% and 51.7% subjects had a good eating culture of *Lalapan* and good skin quality perceptions respectively. The eating culture of *Lalapan* had a positive association with skin quality perception (p=0.000), β-carotene intake from *Lalapan* (p=0.008), daily β-carotene intake (p=0.035), and blood β-carotene concentrations (p=0.031). The consumption of *Lalapan* is a wisdom culture in Sundanese society that serves to improve vegetable consumption at the community level. In particular, it increases nutrient intake, especially β-carotene that is beneficial to health. Given that vegetable consumption is low in the community, maintenance of the good eating culture of *Lalapan* should be an urgent policy priority to ensure the nutrition and health of the community.

Introduction

Vegetable consumption in Indonesia is very low, i.e. 107g/capita/day (BPS, 2017), less than half of that recommended by the World Health Organisation, i.e. 250g/capita/day (WHO, 2015). The low rate of consumption is puzzling because Indonesia is a tropical country with an abundance of fruits and vegetables. Community perception of positive habits is one way to improve consumption of vegetables. One good example of local, indigenous wisdom is the Sundanese people's age-old eating culture of *Lalapan* (Hendariningrum, 2018). Other eating cultures that are believed to provide health benefits include torbangun leaves (Coleus amboinicus Lour) (Da-

manik, 2009), jamu (Paryono, 2014), and tambelo, snail, and clam (Hardinsyah et al., 2006).

The Sundanese, who originate from West Java, are the second largest ethnic group in Indonesia (15.5%) (BPS, 2010). The Sundanese traditional salad or *Lalapan* consists of fresh tender coloured leaves, cucumber, and stinky beans that are consumed with sambal (chilli sauce) (KBBI, 2018). Always consumed fresh, other varieties of *Lalapan* include basil leaves, poh-pohan leaves, gandaria leaves, lettuce, long beans, leunca, takokak, and cabbage. The Sundanese believe that the eating culture of
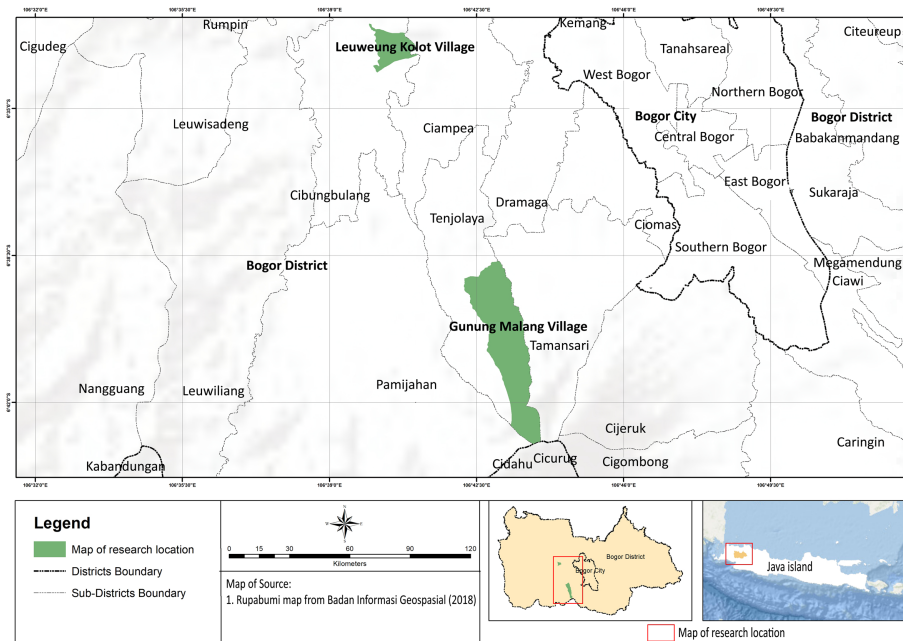
Figure 1: Map of research location: Leuweung Kolot Village to south and Gunung Malang Village to north, Bogor district, West Java, Indonesia

Lalapan provides bodily health benefits and makes their skin smoother and brighter (Hendariningrum, 2018).

Many of the components in fresh vegetables could affect skin quality such as nutrients and phytochemical compounds including amino acids (N-Acetylcysteine), carotenoids (β-carotene, lutein, zeaxantin, and lycopene), fatty acids (Linoleic acid, Eicosapentaenoic acid, and Docosahexaenoic acid), vitamins (vitamin C, vitamin E, and vitamin B3), minerals (copper, selenium, and zinc), and polyphenols (Souyoul et al., 2018; Zouboulis et al., 2019). Some components are useful as antioxidants, skin pigmentation cofactors, to protect skin from damage, increase skin safety and heal wounds. The indicator of skin quality that is easiest to observe is the brightness of the skin. Among the components in vegetables, carotenoids affect skin colour the most.

The consumption of vegetables could brighten skin colour because vegetables contain high levels of carotenoid compounds (Whitehead et al., 2012). The carotenoids consumed from food are absorbed through the intestine and then transported through the bloodstream to various target tissues including the skin layer (Mayne et al., 2010), brightening skin colour. The sampling of blood carotenoid concentrations enables an evaluation of the effect of vegetable consumption on the level of blood β-carotene (Pezdirc et al., 2016).

β-carotene is one of the most abundant carotenoid groups contained in vegetables, blood, and human tissue (Rodriguez-Amaya et al., 2008; Britton et al., 2008; Schagen et al., 2012). The main role of β-carotene is its activation of provitamin A. β-carotene also plays a role as an antioxidant in the human body and regulates skin quality (Grune et al., 2010; Schagen et al., 2012). Stahl et al. (1998) show that the blood carotenoid concentration (including β-carotene) is related to skin carotenoid concentration. Meinke et al. (2010) found that increasing carotenoid intake increases blood and skin carotenoid concentration. This research is perhaps the first to explore the eating culture of the Sundanese traditional salad (*Lalapan*) and its association with skin quality perception, β-carotene intake, and blood β-carotene concentration.

Methods
Design, location, and time

This cross-sectional study was conducted in Gunung Malang Village and Leuweung Kolot Village, Bogor District, West Java from November 2018 to February 2019. Ethical clearance was obtained from the ethical clearance committee of Bogor Agricultural University, Bogor, Indonesia (No:117/IT3.KEPMSM-IPB/SK/2018). The study location was chosen purposively by considering differences in location and sample characteristics. Gunung Malang Village is a village located in the Tenjolaya sub-district near Mount Salak and far from urban areas. By contrast, Leuweung Kolot village is located in Cibungbulang sub-district, close to urban areas (Figure 1).

Sample size and technique

60 healthy Sundanese women, aged 30-49 years, were recruited and their body weight and height measured. The minimum sample at each of the two locations was 30, so that the total number of subjects became 60 (Gay & Diehl, 1992). The women were interviewed about their consumption habits of *Lalapan* and their skin quality perceptions after consumption of *Lalapan*. After that, a sub-sample of about 25% of the subjects was taken to analyse blood β-carotene concentrations, using the following criteria: BMI <35 kg/m^2, non smokers, not taking β-carotene supplements, not alcoholics, and absence of needle allergy. A BMI less than 35 kg/m^2 is necessary to avoid the influence of body fat storage on β-carotene levels. The subjects' β-carotene intake were assessed. Finally, the blood β-carotene concentration levels of 14 subjects with the highest and lowest β-carotene intake from *Lalapan* were evaluated.

Types and modes of data collection

The variables in this study are the eating culture of *Lalapan*, skin quality perception, and consumption habits of *Lalapan*. Eating culture of *Lalapan* and skin quality perception data was collected through interview. Eating habits of *Lalapan* were assessed using a month-long semi-quantitative food frequency questionnaire (SQ-FFQ), that had already been tested for validity and reliability (Cronbach-α=0.6). Blood β-carotene concentrations were analysed using High Performance Liquid Chromatography (HPLC) at SEAMEO RECFON laboratory, Jakarta.

Model specification

The model specification of this study was determined based on its objectives, i.e. to find out the association between variables (independent and dependent variables) (Ingranti et al., 2012). The independent variable was eating culture, while the dependent variables were skin quality perception, intake of β-carotene, and blood β-concentration. The equation for this analysis is as follows:

$$Y_1 = a + bX_1 \dots\dots\dots\dots\dots (1)$$
$$Y_2 = a + bX_1 \dots\dots\dots\dots\dots (2)$$
$$Y_3 = a + bX_1 \dots\dots\dots\dots\dots (3)$$

Where X_1 is the independent variable (eating culture), a is a constant, b is the slope of the line, and Y_1, Y_2, and Y_3 are dependent variables (skin quality perception, intake of β-carotene, and blood β-concentration).

Processing and analysis of data

Eating culture of *Lalapan* and skin quality perception were assessed in the questionnaire before being analysed. The five indicators to assess the eating culture of *Lalapan* were 1) *Lalapan* habit passed on from the parent, 2) *Lalapan* habit passed on to the children, 3) *Lalapan* consumed for the past 20 years, 4) *Lalapan* usually consumed at least three times a week, 5) *Lalapan* consumed with other foods (rice, side dishes, and sambal (chilli sauce)). The indicators for assessing skin quality perception were those perceived by the respondents, namely perception of skin appearance (smoothness and brightness) and perception of skin moisture. The indicators were measured using a value that ranged from 5 (yes/100%) to 0. β-carotene levels in food were obtained from the Indonesian Food Composition Table 2018, ASEAN Food Composition Database, USDA National Nutrition Database for Standard Reference 2018, and other scientific journals. If there was no data on β-carotene levels for a food item consumed by the subject, it was estimated by using data on β-carotene levels for a similar food item. If this was not possible, β-carotene levels were estimated by calculating conversion from vitamin A, with Retinol Activity Equivalents (RAE μg) = 12 μg β-carotene. The association between eating culture of *Lalapan*, skin quality perceptions, β-carotene intake from *Lalapan*, daily β-carotene intake, and blood β-carotene concentrations were analysed using Chi-square.

Results and discussion

Most of the Sundanese subjects were between 30-39 years old (63.3%) and most of them were housewives (96.7%) (Table 1). The majority had studied only to elementary level (81.7%) and about 46.7% had a monthly income of between IDR 1,000,000 and IDR 2,000,000, equal to approx. USD 70-140 per month.

Lalapan has been defined as fresh tender coloured leaves, cucumber, and stinky beans that are consumed with sambal (chilli sauce) (KBBI, 2018). Based on the results of this study, the Sundanese themselves define *Lalapan* not only as vegetables that are consumed in fresh condition (raw), but also as vegetables that are processed by briefly boiling them (blanching) with or without the addition of salt.

The top ten leaves and fruits consumed by subjects as *Lalapan* are given in Table 2. The leaves and fruit most consumed in fresh and processed condition are cabbage (71.7%) and cassava leaves (76.7%), and cucumber (96.7%) and string beans (33.3%) respectively. In addition, other ingredients in *Lalapan* often consumed by the subjects were chayote, carrots, banana bud, and several others. The food issues that influence consumers include educating others, exerting their choice as consumers, or growing their own food (Gray, 2017). *Lalapan* consumed in fresh (raw) conditions or slightly processed

Table 1: Subjects' characteristics

Characteristics	Total subjects* n (%)
Age (years)	
30-39	38 (63.3)
40-49	22 (36.7)
Occupation	
Housewife	58 (96.7)
Others	2 (3.3)
Education level	
Elementary school	49 (81.7)
Junior high school	3 (5.0)
Senior high school	7 (11.7)
College	1 (1.7)
Income (IDR/month)	
<1,000,000 (<$ 70)	17 (28.3)
1,000,000-2,000,000 ($ 70-140)	28 (46.7)
>2,000,000 (>$ 140)	15 (25.0)
Nutritional Status	
Normal	37 (61.7)
Overweight	15 (25.0)
Obesity	8 (13.3)

Note: *n=60 subjects; 1 IDR=0.000075 USD

has several advantages, such as preventing a decrease of nutrients, especially heat-sensitive nutrients such as vitamins A and C, preventing enzyme damage in vegetables (Link & Potter, 2004), reducing potential of Maillard reactions that can change colour and taste (O'Brien & Morrissey, 1989), preventing a decrease of folate and fibre content (McKillop, 2002; Fabbri & Crosby 2016), and containing higher levels of polyphenols and total antioxidants than cooked vegetables (Sengül et al., 2014). In addition, consumption of *Lalapan* for a sustained period has several health benefits, such as reducing risk of cancer (Link & Potter, 2004), decreasing blood LDL and triglycerides concentrations (Koebnick et al., 2005), and increasing blood β-carotene, α-carotene, and lycopene concentration levels (Garcia et al., 2007). Even so, consumption of *Lalapan* in fresh (raw) conditions also has several disadvantages, such as having residual and bacterial potential that can endanger health (Schattenberg

et al., 1996), lower bioavailability of nutrients compared to cooked vegetables (Link & Potter, 2004), and enabling the presence of non-nutritive components in vegetables (Fabbri & Crosby, 2016).

Based on the results of the study, the subjects were divided into two groups (of 30 subjects each) according to their β-carotene intake from *Lalapan* (µg/day). Table 3 shows that about 63.3% of subjects' parents had passed to them the habit of consuming *Lalapan*, while 71.7% passed the habit on to their children. These results indicate that parents have an important role in teaching the eating culture of *Lalapan* to their children. Parents choose foods to be included in the family diet, and thus act as models for their children and encourage their children to learn and adapt eating patterns and behaviours that are appropriate within their culture (Savage et al., 2007). Stajcic (2013, p.6) says that "culture is created,

Table 2: Type of *Lalapan* mostly consumed by subjects

Type of *Lalapan*	Scientific name	Local name	n (%)
Leaves			
Fresh *Lalapan*			
Cabbage	Brassica oleracea	Kubis/kol/engkol	43 (71.7)
Poh-pohan	Pilea melastomoides	Poh-pohan	41 (68.3)
Basil	Ocimum basilicum	Kemangi/surawung	34 (56.7)
Lettuce	Lactuca sativa	Selada/salada	17 (28.3)
Rane	Selaginella doederleinii	Rane/cakar ayam	12 (20.0)
Gandaria	Bouea macrophylla	Gandaria/jatake	11 (18.3)
Jotang	Spilanthes iabadicensis	Jotang/getang	10 (16.7)
Processed *Lalapan*			
Cassava	Manihot esculenta	Singkong/sampeu	46 (76.7)
Papaya	Carica papaya	Pepaya/gedang	38 (63.3)
Mustard green	Brassica juncea	Sawi	11 (18.3)
Fruits			
Fresh *Lalapan*			
Cucumber	Cucumis sativus	Ketimun/bonteng	58 (96.7)
Long beans	Vigna unguiculata	Kacang panjang	47 (78.3)
Stinky beans	Parkia speciosa	Petai/peteuy	41 (68.3)
Tomato	Lycopersicon esculentum	Tomat	38 (63.3)
Leunca	Solanum americanum	Leunca	37 (61.7)
Green eggplant	Solanum melongena	Terong hijau/hejo	22 (36.7)
Gandaria	Bouea macrophylla	Gandaria/jatake	16 (26.7)
Takokak	Solanum torvum	Takokak/tekokak	13 (21.7)
Processed *Lalapan*			
String beans	Phaseolus vulgaris	Buncis	20 (33.3)
Dogfruit	Archidendron Jiringa	Jengkol	11 (18.3)

Note: *n=60 subjects

formed, delivered, and obtained through the communication". Parents are teachers for children in the family and their interactions create an understanding of the eating culture, including the eating culture of *Lalapan*. Food that has been introduced since childhood will have a connection with culture and if it continues to be managed, it can create strong bonds with lifelong eating habits (Wansink et al., 2003). Childhood experiences about food are very important in shaping preferences and eating habits for the future (Wansink, 2002). Food as a culture is not formed rapidly, but through a long process. The eating culture of *Lalapan* has been around since the 10th century AD and is referred to in the Taji Inscriptions of 901 AD (Hendariningrum, 2018). The results show that 70.0% of subjects had consumed *Lalapan* for the past 20 years. This shows that the eating culture of *Lalapan* is not new.

Eating culture is also formed because it is often repeatedly, so that it becomes habitual and carried out routinely. One concept of habits and routines is that these actions are carried out repeatedly and have been shared across whole communities or social groups (Southerton, 2012). According to the results of this study, about 60.0% of subjects consume *Lalapan* at least three times a week. Several factors could affect habits and frequency of *Lalapan* consumption, such as environment, accessibility, and availability (Dean & Sparkey, 2011). Table 3 shows that all subjects consumed *Lalapan* alongside other dishes (rice, side dishes, and chilli sauce). According to

Table 3: Eating culture of *Lalapan* and skin quality perception indicators

Indicators	High intake of β-carotene n** (%)	Low intake of β-carotene n** (%)	Total n (%)	p*
Eating culture of *Lalapan* indicators				
Passed from parent	23 (76.7)	15 (50.0)	38 (63.3)	0.032
Passed to children	26 (86.7)	17 (73.3)	43 (71.7)	0.011
Consumed since 20 years	32 (76.7)	20 (66.7)	43 (71.7)	0.394
Consumed three times a week	24 (80.0)	12 (40.0)	36 (60.0)	0.002
Complemented by other dishes	30 (100.0)	30 (100.0)	60 (100.0)	>0.05
Eating culture of *Lalapan* categories				
Good (score ≥20)	23 (76.7)	13 (43.3)	36 (60.0)	0.009
Less (score <20)	7 (23.3)	17 (56.7)	24 (40.0)	
Perception of benefits on the skin				
Brighter	8 (26.7)	2 (6.7)	10 (16.7)	0.039
Smoother	12 (40.0)	6 (20.0)	18 (30.0)	0.094
More moist	5 (16.7)	6 (20.0)	11 (18.3)	0.741
No effect	10 (33.3)	19 (63.3)	29 (48.3)	0.021
Skin quality perception categories				
Good (score ≥5)	20 (66.7)	11 (36.7)	31 (51.7)	0.021
Less (score <5)	10 (33.3)	19 (63.3)	29 (48.3)	

Note: *Mann Whitney test, significant at $p<0.05$; **n=30 subjects for each groups

Hendariningrum (2018), *Lalapan* and chilli sauce is the food menu that must be present every mealtime. *Lalapan* consumption complemented by other dishes, especially foods that contain enough oil or fat, can increase the absorption of nutrients in *Lalapan* such as β-carotene (Gopper et al., 2009).

Table 3 shows that 51.7% of subjects feel that eating *Lalapan* is beneficial to their skin. Previous studies have shown that vegetable consumption habits can improve skin quality, brighten skin tone, and increase facial attractiveness (Tan et al., 2015; Appleton et al., 2018). Vegetable consumption including *Lalapan* can improve skin quality because vegetables contain high levels of carotenoids (Whitehead et al., 2012). Therefore maintaining this good eating culture of *Lalapan* seems necessary to increase the nutrition and health of the community. Community perception plays an essential role in social-ecological arrangements. For example, public perception of water quality is seen as a necessary condition for the development of a more integrated system to sustain ecology in Mashavera River Basin, Georgia (Withanachchi et al., 2018). Modern media could be used to highlight and strengthen the eating culture of *Lalapan*.

There are also significant differences between the eating culture of *Lalapan* and skin quality perception by high and low intake groups of β-carotene (p=0.009 and p=0.021) (Table 3). The result shows that the high intake group of β-carotene had a higher score of eating culture of *Lalapan* and skin quality perception compared to the lower group.

Cultural context and practices are one of the important factors that can influence food choices (Roudsari et al., 2017; Preedy et al., 2011). Culture, especially food eating culture might play an important role in human nutrition intake, and food beliefs might give beneficial or detrimental effects on human health status (Reddy & Anitha, 2015). Table 4 shows that the eating culture of *Lalapan* has a positive association with skin quality perception (p=0.000). The eating culture of *Lalapan* influences the food choice of subjects, increasing the consumption of vegetables and having a positive effect on the health of the body including skin quality. Table 4 also shows that consumption of *Lalapan* has a positive association with vegetables consumption (p=0.025), which indicates that the eating culture of *Lalapan* could increase vegetable consumption. Urbanization, evolution of agriculture, environmental characteristics of food, income, availability of food, and access to food all influence vegetable consumption including consumption of *Lalapan* (Caspi et al., 2012).

One type of carotenoid that is widely found in vegetables, blood, and human tissue is β-carotene (Rodriguez-Amaya et al., 2008; Schagen et al., 2012). β-carotene has a role in regulating skin quality (Schagen et al., 2012). β-carotene consumed from *Lalapan* and other resources is absorbed through the intestine and then transported through the bloodstream to various target tissues (Mayne et al., 2010). β-carotene concentration in the blood could reflect the amount of food consumed from β-carotene sources such as fruit and vegetables, including fresh vegetables (Block et al., 2001). The results of this study show that the eating culture of *Lalapan* has a positive association with β-carotene intake from *Lalapan* (p=0.008), daily intake of β-carotene (p=0.035), and blood β-carotene concentrations (p=0.031).

Lalapan consumption increases daily intake of β-carotene and blood β-carotene concentrations, which in turn are thought to cause subjects to feel skin quality benefits. Previous research has shown that β-carotene can increase the brightness of skin colour (Whitehead et al., 2012; Pezdirc et al., 2016), prevent skin damage caused by sun light (Köpcke & Krutmann, 2008), reduce erythema caused by UV exposure (Stahl et al., 2000), reduce mitochondrial damage to fibroblasts in the skin layer after UV exposure (Eicker et al., 2003), and prevent ageing (Cho et al., 2010). In addition, long-term consumption of raw vegetables could increase levels of β-carotene (Garcia et al., 2007). The limitation of this study is that eating culture is only measured using five indicators, even though there are many other influencing factors such as availability, environment, and motivation to consume *Lalapan*.

Conclusion

The eating culture of *Lalapan*, which contains nutrients including β-carotene which is beneficial for health and skin, likely increases vegetable consumption and the perception of good skin quality. In turn this positive perception seems to spur an increase in *Lalapan* intake. This is reflected in the high level of blood β-carotene concentrations, which is very important to support and protect human health. This positive community perception on skin quality and vegetable consumption suggests a potential communication media for improving people's eating quality and health at the community level. Maintaining the good eating culture of *Lalapan*, therefore, should be an urgent priority by all interested in increasing the nutrition and health of the community.

Acknowledgements

Conflict of Interests

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

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Biological control in pest management in Turkey: Comparison of the attributes of participant and non-participant greenhouse farmers in government-subsidized biological control practices

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Abstract

The adoption of biological control methods is increasing in crop production due to concerns and awareness of consumers about food safety and pesticide residue conundrum. Biological control methods are a key component in pest management practices as they minimize the usage of pesticides, hence create less environmental and health problems. Biological control practices have been supported in Turkey since the year 2010 to ensure economical greenhouse production and to reduce the consumption of pesticides for sustainable agricultural production. This solved the pesticide residue conundrum in fresh fruits and vegetables both domestically consumed and exported. The main objective of this study was to compare the attributes of the participant and non-participant farmers in government-subsidized biological control practices for pest management in greenhouse pepper cultivation. The data used in this study were collected from 84 greenhouse growers by using a face-to-face interview in Kaş district, Antalya province, in the Mediterranean coastal region of Turkey. The results show a statistically highly significant (p<0.05) relationship between the government-subsidized biological control implemented farms and non-implemented farms with respect to age of farmers, educational level, retirement status of farmers, number of workers, use of agricultural credit, greenhouse working experience, pepper yield, type of greenhouse covering, type of greenhouse ventilation, crop production system, internet usage, farmers association membership, and so on. The results also show that farmers believe biological control practices improve crop quality and yield as well as improve the environment and human health. The agricultural extension agencies and government subsidy policy played an important role in motivating farmers to intensify biological control practices on their farms.

Introduction

Greenhouse production of vegetables is an important part of the agricultural sector and crop production in Turkey and continues to show a promising pace of development. The total greenhouse vegetable production realised was 7.3 million tonnes cultivated on 73717 ha of land. According to TURKSTAT, (2017) about 6.43% of the total greenhouse vegetable produced in Turkey was sweet pepper in 2016. Antalya province is one of the most important crop production areas. It is the centre of greenhouse vegetable production in Turkey. The total greenhouse sweet pepper production was 3.6 million tonnes in Antalya province making it 48.88 % of the total greenhouse sweet pepper production in Turkey (TURKSTAT, 2017). Greenhouse vegetable production is very

Figure 1: Location of Kaş, Antalya

important economic venture in Antalya province. It contributes significantly to income, employment and export opportunities. Tomato and pepper production dominate in the total greenhouse vegetable production.

Increased environmental consciousness by consumers has led to the need for sustainable agricultural production systems with essential components including Good Agricultural Practices (GAP) and Integrated Pest Management (IPM) (Pretty and Bharucha, 2015). Concerns about quality and safety of food consumers have compelled both public regulation authorities/bodies to put stringent standards on pesticide residues in foods. Ahangama and Gilstrap (2007) opined that although IPM is a sustainable and effective method of pest control, pesticides should be used only as a last resort in other to ensure food safety and access to international market. One of the major components of IPM is biological pest control. In biological pest control, natural enemies of the pest are introduced to the population density of the pest to feed on them. The natural enemies used in biological pest control are mostly predatory insects or nematodes (Bale et al. 2018). Public worry about the safety of food and issues associated with pesticide residues in food has made the concept of IPM in general a biological pest control more importantly from both economic and ecological viewpoints (Erkılıc and Demirbas, 2007).

Biological control of pest as an industry has not seen the needed growth and development although it is one of the oldest methods of pest control. Nevertheless, it is of late being considered as a primary pest control method in several crops production and managed ecosystems (Sharma et al. 2013). Biological control of pest is a key component of pest management. Biological practices in greenhouse production are a solution to the challenge of sustainable and safe food production. Meeting food safety requirements using current agricultural production techniques cannot be achieved. For this reason, biological control and organic production is recommended as a solution to the challenge of sustainable food production with less or no pesticide residues and lower use of inputs (Ciccarese and Silli, 2016). IPM practice was first introduced in Turkey in 1970 with cotton production and later was applied in apple, hazelnut, wheat, vines and production of other such crops (Isin and Yildirım, 2007). Biological control application initially began by trials carried out on 10 ha of pepper grown in greenhouses in 2002 in Antalya Province of Turkey. Amblyseius swirskii Athias-Henriot, Orius laevigatus Fieber, Aphidius colemani Viereck, and Phytoseiulus persimilis Athias-Henriot have been used in practice for biological control of pests in pepper production. (Topakcı and Kececi, 2017). However, the usage biological control method for pepper production at the greenhouse has not been effective due to obsolete greenhouses and more so the insignificant result it's able to achieve (EC, 2013). Biological control applications in greenhouse crop production result in maximum economic returns and sustainable pest control leading to no harmful effects on human health and the environment (FAO, 2017). To realize this, supportive and enabling policies together with institutions are required. For this reason, the Ministry of Agriculture and Forestry (MAF) in Turkey has provided an area-based support to greenhouse growers. The ministry subsidy for growers introducing biological control agents in greenhouse production is 3 500 TL and those using sticky traps and pheromones in greenhouses is 1 100 TL per hectare (1US dollar was equal to 3.65 Turkish Lira as at 2017) (TOJ, 2017). Growers who are not registered to

Table 1: The result of the chi-square test analysis according to selected personal characteristics of the growers and their information-seeking behavior

Characteristics	Biological control implemented farms		Biological control non-implemented farms	
	Mean	**S.D**	**Mean**	**S.D**
Age of grower (years)	43.76	7.65	53.24	10.08
Level of education (years)	8.07	3.17	6.12	0.72
Greenhouse growing experience (years)	22.07	7.35	30.93	10.03
Biological control experience(years)	4.10	1.28	-	-
Household size	4.50	0.83	4.55	1.09
Number of employees worker	4.00	1.72	3.67	1.56
The rate of farm association membership	97.62	-	47.62	-
The rate of grower working non-agricultural	11.90	-	21.43	-
The rate of agricultural credit use	11.90	-	2.38	-
The rate of internet use	76.19	-	38.10	-
Size of the greenhouse (hectare)	0.61	0.35	0.37	0.18
Number of greenhouses	3.50	1.49	2.95	1.03
Pepper production (tons/farm)	78.06	53.61	34.24	19.36
Pepper yield (ton/hectare)	131.70	20.04	93.60	15.10

Greenhouse Registration System (GRS) cannot apply for the support of biological control. Biological controlled areas have increased after government subsidy of the biological control expenditures of growers; these areas reached 1 270.1 ha in 2015. Currently, biological control fields constitute about 5% of the total protected areas in Antalya.

The aim of this study was to compare the attributes of participant and non-participant greenhouse farmers in government-subsidized biological control practices in pest management of greenhouse pepper cultivation for sustainable food production in the Mediterranean coastal region of Turkey.

Materials and Methods

Experimental site: The study area was confined to Kaş district of Antalya province in the Mediterranean Coastal Region of Turkey. Antalya province is one of the most important greenhouse production regions in Turkey. Kaş district was purposively selected for the study because it has the largest number of greenhouse sweet pepper growers, and the government supported biological control project was first introduced in Kaş. It is situated in the westernmost part of Antalya province between mountains and the Mediterranean Sea (Figure 1). The climate is warm and temperate. The winter months are much rainier than the summer months. Annual average temperature and total rainfall are 18.3 °C and 909mm, respectively. The driest month is August, with an average of just 2mm precipitation. Most of the precipitation falls in January, averaging 221 mm. With an average of 26.5 °C, July is the warmest month. January is the coldest month, with temperatures averaging 11.0 °C. The population shows a remarkable demographical increase in recent years. District centre population increases while village populations are constant. Kaş population of around 7 000 inhabitants and increases to about 20 000 people during the summer season. The economy in

the district of Kaş is dominated by greenhouse production, tourism and fishing. Greenhouse production strikes as the main occupation of the local workforce thus the main revenue-generating activity for local livelihoods. The production is mainly characterized by out of season vegetables and especially green peppers. In 2017 total green pepper production was 32 430 tonnes produced on 324.3 ha in greenhouse pepper area in Kaş district. The green pepper produced in Kaş district meets 14.6 % of Antalya's province total production. (TURKSTAT, 2017).

Data Collection: Purposive sampling technique was used for the sample selection of this study. The main goal of purposive sampling was to focus on the characteristics of a population that were of interest and best enable the answering of the research questions. A well-structured questionnaire was developed and administered to farmers via face-to-face interview. Simple random sampling method was used to determine the sample size of the research (Yamane, 2001) Sampling size was determined using Eq. 1. According to calculations, the sample size was determined as 84 growers, the sample size representing the area;

$$n = \frac{N * S^2 * t^2}{(N-1) * d^2 + S^2 * t^2} \qquad \text{(Eq 1)}$$

Where, n= Sample size; s= Standard deviation; t= t value with 95% confidence interval (1.96), N= Total number of farms in the sample population and, D= Acceptable error (5% deviation).

Data Analysis

All data collected from the study were analysed using SPSS (version 19) software. Moreover, descriptive statistics (frequencies, percentages, means, and standard deviations) were used for data analysis to accomplish the objectives of the study. Also, the chi-square test was used to ascertain the relationship between participant and non-participant farmers in the biological control practices. The differences between the groups depending on the normality of the data and selected variables were also to establish. The chi-square ($χ2$) test statistics is given in formula (Eq.2) (Koseoglu and Yamak, 2008).

$$\chi^2 = \Sigma_{ij} \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \qquad \text{(Eq 2)}$$

Where:

X^2 = calculated chi-square value
O_{ij} = observed frequency value
E_{ij} = expected frequency value

Results and Discussion

General characteristics of the farms

The mean age of the growers in biological control implemented farms is 43.8 years and non-implemented farms 53.2 years. This confirms what is commonly said that the age of the growers in biological control implemented farms is younger compared to the non-implemented farms. With respect to experience in greenhouse growing, the participants had, on average, 22.1 years of experience in biological control implemented farms and non-implemented farms are 30.9 years. Also, the participants had, on average, 4.1 years of experience in biological control. The size of the greenhouse in biological control implemented farms was 0.61 ha, higher than (0.37 ha) in the non-implemented farms. The educational level of growers in the biological control implemented farms was higher compared to non-implemented farms. The rate of internet use of growers in biological control implemented farms was 76.2%, higher than the rate (38.1%) in the non-implemented farms. The yield of pepper in biological control implemented farms (131.7 t ha-1) is higher compared to that grown the non-implemented farms (93.6 t ha-1). The rate of farmer uses agricultural credit in biological control implemented farms was 11.9%, higher than the rate (2.4%) in the non-implemented farms.

Personal characteristics of the farmers: Result of the chi-square test

Table (2) shows that chi-square ($χ2$) test revealed a relationship between the two groups and by selected personal characteristics of the farmers and their information-seeking behaviour in greenhouse cultivation. With respect to the farmers age ($p ≤ 0.01$), educational level ($p ≤ 0.05$), retirement status ($p ≤ 0.10$), greenhouse farming experience ($p ≤ 0.01$), engagement in agricultural extension activities ($p ≤ 0.05$), internet use ($p ≤ 0.01$), farmers association membership ($p ≤ 0.01$) and agricultural credit use by farmers ($p ≤ 0.10$), the result of the statistical analyses showed a significant relationship between the growers who applied the biological control practices and those who did not.

The above personal characteristics of the farmers also showed an increase in farmers' participation in government-subsidised biological control practices. This was an indication that the personal characteristics of the farmers influenced the farmers quest participate in the government sponsored biological control practices.

Table 2: Results of chi-square showing relationships between groups by selected personal characteristics

Characteristics	Biological control implemented farms		Biological control non-implemented farms		Total	
	N	%	N	%	N	%
Personal characteristics						
Age of the grower						
Younger than 45	22	52.38	10	23.81	32	38.10
45 and older	20	47.62	32	76.19	52	61.90
χ2 =7.269 , p ≤ 0.01						
Educational level						
Primary school	19	45.24	34	80.95	53	63.10
Middle school	8	19.05	2	4.76	10	11.90
High school or university	15	35.71	6	14.29	21	25.00
χ2 =3.896 , p ≤ 0.05						
Family population (person)						
1-5	20	47.62	20	47.62	40	47.62
5 and over	22	52.38	22	52.38	44	52.38
χ2 = 0.000 , p = 1.000						
Retirement status of grower						
Yes	1	2.38	5	11.90	6	7.14
No	41	97.62	37	88.10	78	92.86
χ2 = 2.872 p ≤ 0.10						
Status non-agricultural income of growers						
Yes	5	11.90	9	21.43	14	16.67
No	37	88.10	33	78.57	70	83.33
χ2 = 1.371 , p =0.242						
Greenhouse growing experience (year)						
Less than 25	23	54.76	11	26.19	34	40.48
25 and over	19	45.24	31	73.81	50	59.52
χ2 = 7.115 , p ≤ 0.01						
Farm Association Membership						
Yes	41	97.62	20	47.62	61	72.62
No	1	2.38	22	52.38	23	27.38
χ2 =26.403 , p ≤ 0.01						
Farm records keep						
Yes	32	76.19	30	71.43	62	73.81
No	10	23.81	12	28.57	22	26.19
χ2 =0.246 , p =0.620						
Agricultural credit use						
Yes	5	11.90	1	2.38	6	7.14
No	37	88.10	41	97.62	78	92.86
χ2 =2.872 , p ≤ 0.10						
Information-seeking Behavior						
Participation to agricultural extension						
Yes	6	14.29	1	2.38	7	8.33
No	36	85.71	41	97.62	77	91.67
χ2 =3.896 , p ≤ 0.05						
Internet use						
Yes	32	76.19	16	38.10	48	57.14
No	10	23.81	26	61.90	36	42.86
χ2 = 12.444 , p ≤ 0.01						
The aim of Internet use						
Agricultural	9	28.13	8	50.00	17	35.42
Agricultural and social media	23	71.88	8	50.00	31	64.58
χ2 =2.231 , p =0.135						

Table 3: Results of chi-square showing relationships between groups by selected personal characteristics

Characteristics	Biological control implemented farms		Biological control non-implemented farms		Total	
	N	%	N	%	N	%
Greenhouse size (hectare)						
0.1-0.4	19	45.24	22	52.38	41	48.81
0.4 and over	23	54.76	20	47.62	43	51.19
$\chi 2 = 0.429$, p =0.513						
Pepper yield (ton/hectare)						
1-120	7	16.67	38	90.48	45	53.57
120 and over	35	83.33	4	9.52	39	46.43
$\chi 2 = 45.997$, p ≤ 0.01						
Type of greenhouse covering						
Glass and plastic	6	14.29	1	2.38	7	8.33
Plastic	36	85.71	41	97.62	77	91.67
$\chi 2 = 3.896$, p ≤ 0.05						
Number of greenhouses						
1-3	13	30.95	15	35.71	28	33.33
3 and over	29	69.05	27	64.29	56	66.67
$\chi 2 = 0.214$, p =0.643						
Type of greenhouse ventilation						
Side and roof ventilation	38	90.48	27	64.29	65	77.38
Side ventilation	4	9.52	15	35.71	19	22.62
$\chi 2 = 8.230$, p ≤ 0.01						
Status of greenhouse insurance						
Yes	4	9.52	3	7.14	7	8.33
No	38	90.48	39	92.86	77	91.67
$\chi 2 = 0.156$, p =0.693						
Number of employees worker						
1-3	39	92.86	31	73.81	70	83.33
3 and over	3	7.14	11	26.19	14	16.67
$\chi 2 = 5.486$, p ≤ 0.01						
Crop production systems						
Double	21	50.00	7	16.67	28	33.33
Single	21	50.00	35	83.33	56	66.67
$\chi 2 = 10.500$, p ≤ 0.01						
Situation soil testing made by growers						
Yes	10	23.81	18	42.86	28	33.33
No	32	76.19	24	57.14	56	66.67
$\chi 2 = 3.429$ p ≤ 0.10						
Type of crop sell						
to trader	38	90.48	34	80.95	72	85.71
to exporter	4	9.52	8	19.05	12	14.29
$\chi 2 = 1.556$, p =0.212						

Characteristics of the farms: Result of the chi-square test

The table (3) shows the chi-square ($\chi 2$) test results relationship between the two groups (with and without biological control practices) and by selected characteristics of the farms in greenhouse production. The empirical evidence revealed that there was a significant relationship between the growers who applied biological control practices and those who did not in terms of yield of pepper (p ≤ 0.01), type of greenhouse covering (p ≤ 0.05), type of greenhouse ventilation (p ≤ 0.01), number of workers (p ≤ 0.01), crop production systems (p ≤ 0.01) and condition of soil tested by growers (p ≤ 0.10). This was an indication that farms in greenhouses with better condition and basic facilities was favourable for

Table 4: Analysis of growers' beliefs and opinions about the application of biological control

Statements	Mean
Reduce pesticide use	4.83
Useful for human health	4.72
Better quality products are produced	4.32
Increase crop productivity	3.69
Products are more easily marketed	3.57
Useful for the environment and natural enemies of pests	3.52
Reduce production costs	3.22
Products are sold at a higher price	2.71

Likert scale: 1 = strongly disagree, 5 = strongly agrees

the success of biological control practices subsidised by the government. This result also attests to the challenges faced by the ministry of agriculture and forestry that used to financially support biological pest control practices in the study area but was not successful as a result of the poor nature of the greenhouses which were used (EC, 2013).

Growers' opinion and perception on biological control
Biological pest control practice is economical as compared to other methods of pest management however, its adoption and implementation in a new environment is slow (Bale et al, 2008). This could be because of many reasons of which this study revealed an economic reason. Nonetheless biological pest control practice is the prospect of pest management due to its sustainability, economical and ecologically friendliness (Sharma et al, 2013). Table (4) presents the results of questions asked the growers concerning their beliefs and opinions on the application of biological control practices in greenhouse production. Using Likert scale results, the study found out those growers had positive opinions about the application of biological control practices in greenhouse production. Most of the growers believed that application of biological control practices in greenhouse pepper production was beneficial economically (better quality products are produced, increase crop productivity, products are more easily marketed and reduction in production costs) and to the environment and human health (reduce pesticide use, useful for human health, useful for the environment and natural enemies of pests). The statistical analyses showed that contrary to the expectations, growers that had adapted biologi-

cal pest control practices could not sell their pepper at a higher price (mean: 2.71).

Conclusions

The biological control can play an important role in achieving the goal of sustainable agriculture in research area. Biological pest control method is an accepted innovation among greenhouse farmers in Kaş district even with its shortcomings. However, creating more awareness to farmers in greenhouse production and lots of government investment in biological control practices is significant for food safety, sustainable agriculture, easy access to international market, minimum risk to human health and favourable environment. To achieve this, more research is needed in terms of the effects of government supported policies implementation and its practicality to influence the full acceptance of biological pest control by farmers in Turkey. Also, growers must be educated on the importance of biological control practices of pest management and sustainable greenhouse production practices. The training should be focused on minimizing environmental risks, safe food production, the use of sustainable farming techniques, maximizing the effects of beneficial organisms and identification of natural enemies in biological pest control practices. Agricultural extension agencies and subsidy policy of governments are needed in motivating the growers if the expansion of biological control practices is to be realised.

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Conflict of Interests

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Structural modelling of rice fields-buffalo livestock based integrated agricultural systems in the context of regional development in Humbang Hasundutan, Indonesia

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Abstract

This study analyses the influence of external and internal agriculture conditions on rice fields-buffalo livestock-based integrated agricultural systems in the context of regional development in the Humbang Hasundutan District. The method of analyzing data in research is structural equation modeling (SEM) with IBM SPSS® Amos 22 device. The results indicate that both external and internal agricultural conditions have a significant, positive influence on both rice field-buffalo livestock integrated agricultural systems and regional development. Furthermore, rice fields-buffalo livestock integrated agricultural systems have a significant positive influence on regional development. The direct influence of external agriculture conditions on regional development is 0,26. The indirect influence of external agriculture conditions on regional development by the intermediate of integrated agriculture systems is 0,32 and total influence is 0,58. Furthermore, the indirect influence of internal agriculture conditions on regional development is 0,24. The indirect influence of internal agriculture conditions on regional development by the intermediate of integrated agriculture systems is 0,28, with a total influence is 0,52. Based on the conclusion it is suggested that the government; a) provide guidance to improve farmers' knowledge of integrated agricultural systems; b) improve farmers' ability to develop their farms so as to have an impact on increasing incomes; c) establish agricultural development programmes for the longer-term increase of production, which will have an impact on regional economic growth; d) assist farmers by providing access to capital for agricultural development ensure the stability of output prices of agricultural products.

Introduction

Regional development is the cumulative effect of a complex system of interacting development process influenced or controlled by governmental and non-governmental interventions and by collective and individual decisions made at the local, the central, and the intermediate level (Ahmad, & Bajwa, 2005). Regional development is achieved through gradual specialisation of selected products, competitive on the foreign markets (Szajnowska, & Wysocka, 2009).

Wantu, Moonti, and Wantu (2018) said one of the triggers of stagnant regional development that can reduce

the poverty line and can create people welfare and prosperity. Conceptually, regional development is a series of efforts to realize integration in the use of various resources, increasing harmony between regions, integrating between sectors through a spatial planning process to achieve sustainable development goals. In pursuing these economic development projections, the challenge facing local governments is to increase employment opportunities, especially those that are labour-intensive (Wantu, Moonti, & Wantu, 2018).

Regional development is an effort in spurring socio-economic development, reducing disparity between regions, maintaining environmental preservation of a region. In addition, development of rural areas may contribute to the preservation of the rural landscape, the protection of indigenous cultures and traditions while rural societies could serve as a social buffer for the poor (Anríquez, & Stamoulis, 2007). Regional development can be started from rural development. Withanachchi, Kopke, and Frettsome (2013) said rural development is tied to programmes which connect rural society. An alternative political culture for rural development will consider rural people asa the centre of development according development goals. Thus rural development is considered an integral part of state development.

Regional development strategies should be based on the sound assessment of regional business potentials and on opportunities to develop the defined potentials in order to form competitive advantage (Harmaakorpi, & Pekkarinen, 2003, August, 27-31). Agriculture sector as competitive advantage in a region, can be developed to spur of regional development as said Rich, Rich, and Dizyee (2018) public policies were also promulgated to accelerate the development of agriculture. Regional development strongly bound to the institutional set-up of a region and can, therefore, be a useful tool in exploring existing potentials in manifold regional resource configurations (Harmaakorpi, 2006), becaused regional development, it is still only pursuing more dominant economic growth level (Wantu, Moonti, & Wantu, 2018).

Regional development is a process intended to make changes toward better development of society, by employing various resources such as agricultural sector (Borisov, 2015; Nainggolan et al., 2017, October 25). Regional government policy should re-activate agricultural development sector, that not only refers to te regional economic activity, but also create workplace, particularly in the rural area (Wantu, Moonti, & Wantu, 2018). Therefore, development of the agricultural sector is a priority in Indonesia. Agriculture as one of the important sectors in development, because this sector is a food producer,

raw material for production which is very important in encouraging development (Perdinan, Dewi, & Dharma, 2018). Future agricultural development must be well planned to improve the welfare of farmers and must encourage the realization of regional economic development through high competitive productive activities.

Mohammed (2016); Wahyudi, Priyarsono, and Rifin (2014) also said that the agricultural sector has an important and strategic role in regional and national development. The agricultural sector not only plays a role in regional food security, but also affects gross regional domestic income (GRDP) of the region and has the role of providing employment for the community. In line with that, the agricultural sector has an important role for Humbang Hasundutan District, even this sector is able to contribute 52.79% in 2012, and 53.6% in 2014 to the gross regional domestic product (GRDP) of this region, with an average growth rate of 3.83% in 2009–2014 (The Central Bureau of Statistic, Humbang Hasundutan in Figures, 2016). However, the productivity of farming in Humbang Hasundutan Regency is not optimal.

The Central Bureau of Statistics Humbang Hasundutan District (2016) pointed out that the growth rate of rice productivity in Humbang Hasundutan District fluctuated in 2009-2012. In 2009 with 1.0% productivity growth rate, it increased to 1.48% in 2010 and decreased to 0.10% in 2011 and then increased by 0.60% in 2012, with an average growth rate of 0.80% and smaller compared to the average growth rate of North Sumatra's rice productivity of 2.14% (The Central Bureau of Statistics North Sumatra, 2016). Thus efforts are needed to improve agricultural development in this region. Agricultural development can be done through intensification, extensification, diversification and integrated farming systems to increase farmer income and regional income.

The development of the agricultural sector must be in accordance with physical conditions that are external and internal, namely; land use, land management, fertilization, seeds, plant cultivation, plant protection. Then socio-economic conditions that are external and internal, such as; labour, farmer education level, institutional, capital, farmer family income, inflation, and external development variables such as; road and irrigation or irrigation facilities (Nainggolan et al., 2019). Utilization of agricultural land as an external physical variable, if not in accordance with its potential will result in a decrease in productivity, and cause degradation of agricultural land, so that sustainable planning is needed, including by analysing economic, social and environmental aspects (Niemmanee, Kaveeta, & Potchanasin, 2015, February 05-07).

Pedrosa, and López (2012 state that the physical external conditions of agriculture consist of; types of agriculture, land suitability, soil fertility, land topography, land use, landscape quality, climate and agricultural structure. Social variables in the form of; management and forms of activities that can affect farm productivity are also external conditions that affect farming production.

Agricultural business is managed in accordance with the concept of agricultural integration between rice fields (are also called paddy fields or rice paddies) farming as core business and buffalo livestock. This system is a farming managed by hereditary as local wisdom. The Central Bureau of Statistic, Humbang Hasundutan in Figures, (2016) indicated that farmers who work on rice fields integrated with buffalo livestock amount to 8,937 families or 21.91% of 40,783 families spread over 10 sub-districts. Ugwumba et al., (2010) said that one of the efforts to increase agricultural production is through an integrated farming systems which is a system for managing plants, livestock and fish with their environment to produce an optimal product. This systems has a significant positive impact and meets the requirements and criteria for sustainable agricultural development because it is developed based on organic and local resources so that external inputs are low (Tullo, Finzi, & Guarino, 2019).

Soni, Katoch, and Ladohia (2014) also said that integrated farming systems are management systems that integrate agricultural components, such as; plants, animals and fish in a unified whole. The farming system must be fully integrated in order to optimize the use of locally available alternative resources. The system of integrating livestock plants is an agricultural systems characterized by a close link between the components of plants and livestock in a farm in an area. This linkage is a trigger factor in driving farmers' income growth, regional economic growth in a sustainable manner (Tullo, Finzi , & Guarino, 2019). Based on this background, this study aims to analyse the influence of external and internal agricultural conditions towards a rice field-buffalo livestock integrated agricultural systems in the context of regional development in Humbang Hasundutan District.

Literature Review
Regional Development

The concept of sustainable development is based on three dimensions mentioned above. Regions 'development is usually defined as the integral community development (social, economic, environmental and healthcare, technological, cultural and recreational) on

a particular territory (Jovovic et al., 2017). Region's development must be based on their optimal expansion constituents (social, natural and economic development aspects) aimed at certain life's level maintenance and quality improvement through the mentioned constituents.

Regional development encompasses not only traditional policy on a concrete territory, but also socioeconomic process organized in the specific political and cultural context (Spangenberg, 2002). Besides the cultural context, Reinbott (2013) said that the concept of empowerment is part of regional development by strengthening the capacity of groups or individuals to increase their political, economic and social participation in development.

Regional development in today's context is at a critical juncture, with multiple crises (financial, food and energy) forcing us to re-assess the economic paradigm of our time and to evaluate how to better address the unfulfilled promises that we are currently leaving to future generations in the areas of employment, social progress, quality of life and respect for nature (Jovovic et al., 2017).

Regional development related to administrative areas, integrated economic functions and socio-cultural identity, which form a competitive advantage of a region. In social theory related to regional development, there is a concept of territorial competitiveness that is used for regional development and is closely related to environmental, social and cultural sustainability in a region (Janković , 2012).

According to Susilo (2006) the concept of regional development in Indonesia, in terms of its application is based on several theories, including; First is Walter Isard as a pioneer of regional science that examines the causal relationship of the main factors forming regional space in the form of external conditions, namely physical, socio-economic and cultural factors. The second is Miyrdal in the 1950s era with his theory which explained the relationship between developed regions and their back regions by using the term backwash spread effect. The third is Friedman in the era of 1960s which emphasized the formation of a hierarchy, in order to facilitate the development of a development system which became known as the theory of the centre of growth. And the fourth is Douglass in the 1970s who introduced rural-urban linkages in regional development.

Regional development policies are needed because of differences in the geographical (Eberhardt, & Vollrath, 2016), social, economic and cultural conditions of the

community between regions, so that the establishment of regional development policies must be adjusted to the conditions, potentials and problems in the region concerned. Thus regional development can be said as a process intended to make changes towards a better development of society, by utilizing various resources such as the agricultural sector (Resosudarmo et al., 2012; Sertoglu, Ugural, & Bekun, 2017).

Integrated Agricultural Systems

Sertoglu, Ugural, and Bekun (2017) said the agricultural sector is a potential resource and has a strategic role in regional development because this sector acts as an absorber of labour, a producer of basic foodstuffs, a driver of exports, a source of raw materials for the manufacturing industry and a source of livelihoods (Simamora, Sirojuzilam, & Supriadi, 2013). This is in line with Budiman et al., (2016) who stated that in accordance with climatic conditions in Indonesia, the government's priority development sector, is the development of energy, food and maritime. Agricultural development can be done through intensification, extensification, diversification and integrated farming systems to be able to increase farmer income and regional income.

Ugwumba et al., (2010), said that an integrated farming system is a system for managing plants, livestock and fish with their environment to produce an optimal product and its nature is closed to external inputs. This system has a significant positive impact that meets the requirements and criteria for sustainable agricultural development because it is developed based on organic and local potential (local resources). So the purpose of implementing an integrated farming system is to suppress minimum input from the outside (low input) and be sustainable (Bijttebier et al., 2017).

The development of the agricultural sector carried out with various approaches certainly has links with various things, such as physical variables, namely; land use, land management, fertilization, seeds, plant cultivation, plant protection. Then the social variables are; farmer education level and culture and institutions, economic variables in the form of; capital, farm input and output prices, farmer family income, inflation and development variables in the form of; road and irrigation or irrigation facilities. Utilization of land resources must be adapted to the agroecological conditions, so that agricultural businesses can be sustainable (Niemmanee, Kaveeta, & Potchanasin, 2015, February 05-07). Furthermore Pedrosa, and Lopez (2012) stated that the physical environment is in the form of; land suitability class, soil fertility, land topography, land use, landscape quality, climate and even

social variables in the form of; management and forms of farming activities also influence farm productivity.

Nuraeni et al., (2013) said that external agricultural conditions are external factors that influence farming activities which are difficult to intervene including, culture, social capital, market access, access to capital, input prices and output prices. Furthermore, Nuraeni et al., (2013) stated that external factors that influence the activities of the community that manage forest resources are social, economic, cultural and market conditions, such as; input prices and production output, that internal conditions are factors that influence farming activities internally, including the knowledge, attitudes and skills of farmers to apply environmental conservation techniques.

Future agricultural development must be well planned to improve the welfare of farmers and must encourage the realization of regional economic development through high competitive productive activities. The agricultural sector is a potential resource and has a strategic role in the process of economic development because the agricultural sector acts as an absorber of labour, a staple food producer, agricultural development as a driver of exports and agricultural commodities as a manufacturing industry, a source of livelihood and a driver of regional development (Simamora, Sirojuzilam, & Supriadi, 2013). Even the development of the agricultural sector is a strategy to spur economic growth, thus providing a multiplier effect on other sectors. Besides that, the agricultural sector also has an important role for the regional economy because it contributes to the GRDP of a region (Sertoglu, Ugural, & Bekun, 2017).

Methodology

Research Location

The research was conducted in the Humbang Hasundutan District as purposively determined, in which area is potential for agricultural sector development with an integrated systems. The research population was 8,937 families, consisted of rice farmer-buffalo breeder in household-scale spread over 10 sub-districts, i.e. Sub-district of Pakkat (1,663 families), Onan Ganjang (708 families), Sijamapolang (233 families), Doloksanggul (1,456 families), Lintong Nihuta (1,150 families), Paranginan (560 families), Baktiraja (152 families), Pollung (1,242 families), Parlilitan (1,342 families) and Tarabintang (428 families) (The Central Bureau of Statistics Humbang Hasundutan District, 2016). The sample was determined by the following Slovin formula;

$$n_c = \frac{N}{1 + Ne^2}, (1)$$

which; nc = sample size, e = error interval (0,1), N = total population.

The number of obtained samples of 99.98 was rounded into 100 samples. The samples interviewed by each sub-district were determined proportionally, i.e. Sub-district of Pakkat (19 respondents), Onan Ganjang (8 respondents), Sijamapolang (3 respondents), Doloksanggul (16 respondents), Lintong Nihuta (13 respondents), Paranginan (6 respondents), Baktiraja (2 respondents), Pollung (14 respondents), Parlilitan (15 respondents) and Tarabintang (5 respondents).

Type and Data Sources

The applied data in this study was primary data obtained from the field through interviews with respondents by using questionnaires. Secondary data were obtained from publications; Central Bureau of Statistics-North Sumatra Province, Central Bureau of Statistics Humbang Hasundutan District, research, journals and other official publications.

Variables and Data analysis method

In order to analyse the influence of external and internal agricultural conditions on an integrated agricultural systems of rice field-buffalo livestock and regional development in Humbang Hasundutan District, we used Structural Equation Modelling (SEM) using IBM® SPSS® Amos 22 software, with the following formula. The latent variable model for the hypothetical model by using the equation:

$$Y1 = γ1·X1 + γ2·X2 + f1, (2)$$
$$Y2 = γ3·X1 + γ4·X2 + β·Y1 + f2, (3)$$

In this study, γ1 represents the direct influence of X1 on γ1, γ2 represents the direct influence of X2 on γ1, γ3 represents the direct influence of X1 on γ2, and γ4 represents the direct influence of X2 on Y2. The structural parameter β represents the direct influence of γ1 on γ2. In the hypothesized model X1 and X2 does not only have a direct influence on γ2 but also have an indirect influence mediated by γ1. The indirect influence of X1 to γ2 is equal to γ3 + γ1. β and the indirect influence of X2 to Y2 equals to γ4 + γ2. β. Random errors of f1 and f2 are assumed to have zero-expected values and independent homoscedastic variance (both are non-autocorrelated) and are not correlated with X1 and X2.

An exogenous latent variable of external agricultural condition (X1) has 7 indicators or measurable variables according to research Pedroza and Lopez (2012); Nuraeni et al., (2013) i.e. guidance (X11); culture (X12); social capital (X13); market access (X14); capital access (X15); input price (X16); and output price (X17). Exogenous latent variables internal agricultural condition (X2) has 5 indicators or measurable variables according to research Pedroza and Lopez (2012); Nuraeni et al., (2013) i.e. land area (X21); topography (X22); land use (X23); road facilities (X24); and farming experience (X25). An endogenous latent variable of the integrated agricultural systems (γ1) has 3 indicators or measurable variables i.e. raised income (γ11); increased food security (γ12); and cultural preservation (Y13).

An endogenous latent variable of regional development (γ2) has 4 indicators or measurable variables-according to research Pedroza and Lopez (2012); Nuraeni et al., (2013) i.e. the provision of the conducive environment (γ21); environmental impact reduction (γ22); poverty reduction (γ23); and increased market access (γ24). The measurement model for the exogenous variable of X1 (external agricultural condition) with the following equation:

$$X11 = λ1·X1 + e1, (4)$$
$$X12 = λ2·X1 + e2, (5)$$
$$X13 = λ3·X1 + e3, (6)$$
$$X14 = λ4·X1 + e4, (7)$$
$$X15 = λ5·X1 + e5, (8)$$
$$X16 = λ6·X1 + e6, (9)$$
$$X17 = λ7·X1 + e7, (10)$$

The measurement model for the exogenous variable of X2 (internal agricultural condition) with the following equation:

$$X21 = λ8·X2 + e8, (11)$$
$$X22 = λ9·X2 + e9, (12)$$
$$X23 = λ10·X2 + e10, (13)$$
$$X24 = λ11·X2 + e11, (14)$$
$$X25 = λ12·X2 + e12, (15)$$

The measurement model for intervening endogen variable of γ1 (integrated agricultural systems) of rice field-buffalo livestock with the following equation:

$$Y11 = λ13·Y1 + e13, (16)$$
$$Y12 = λ14·Y1 + e14, (17)$$
$$Y13 = λ15·Y1 + e15, (18)$$

The measurement model for the dependent endogenous variable of γ2 (regional development) with the fol-

Table 1: Compatibility criteria of measurement model and structural model

Indicator	Definition	Acceptable compatibility level	Remark
Chi-Square		Smaller (p-value ≥ 0,05)	Better
RMR	Root mean square residual	RMR ≤ 0.05	Good
GFI	Goodness of fit index	GFI ≥ 0.90 0.80 ≤ GFI < 0.90	Good Quite good
NFI	Normed fit index	NFI ≥ 0.90 0.80 ≤ NFI < 0.90	Good Quite good
CFI	Comparative fit index	NFI ≥ 0.90	Good
NCP	Non-centrality parameter (fixed parameter associated with DF)	Smaller	Better
RMSEA	Root mean square error of approximation	RMSEA ≤ 0.01 0.01 < RMSEA ≤ 0.05 0.05 < RMSEA ≤ 0.08	Very good Good Quite good

Source: Processing, 2018

lowing equation:

$$Y_{21} = \lambda_{16} \cdot Y_2 + e_{16}, \quad (19)$$
$$Y_{22} = \lambda_{17} \cdot Y_2 + e_{17}, \quad (20)$$
$$Y_{23} = \lambda_{18} \cdot Y_2 + e_{18}, \quad (21)$$
$$Y_{24} = \lambda_{19} \cdot Y_2 + e_{19}, \quad (22)$$

The equations (4) to (22) are linear in their variables and parameters. The structural parameter of λ_i, (i = 1, 2,......., 17) represents the expected change in the ith measured variable referring to a single unit of increase in the corresponding latent variable. The error rates e_j, (j = 1, 2,......, 12) are measurement errors for X_j and e_k, (k = 13, 14, ..., 19) are measurement errors for Y_k. It is assumed that these measurement errors have zero-expected values and also independent homoscedastic variance (non-autocorrelated), non-correlated with latent variables of X1, X2, γ1, and γ2, and non-correlated with a latent error of f1 and f2.

Structural modelling process was conducted through several steps (Shek, & Yu, 2014) i.e. 1) Model specifications by establishing models based on empirical evidence; 2) Model identification, for endogenous variables, error rates were made by regression weights; 3) Model estimation (part 1). Analyse each measurement mod-

el. Modification of the initial model takes into account model compatibility and modification index. 4) Model estimation (part 2). An overall analysis of the structural model; 5) Model evaluation. Goodness-of-fit evaluation of the whole model. 6) The model modification is based on model compatibility and hypothetical model is based on model compatibility index. In this study used an assessment of the compatibility of the whole model i.e. compatibility criteria of measurement model and structural model in Table 1.

If the model has not met the compatibility criteria with the data, the model goes through respecification in post-rock. The path in the model is insignificant (p>0.05) indicating the incorrect factor load. The next stage examines the correlation between the external agricultural conditions, the integrated agricultural systems of rice field-buffalo livestock and regional development in Humbang Hasundutan District.

Direct influence will be seen based on the standard regression weight (path coefficient) between the latent variables. Direct influence is significant if the probability value of the standard regression weight (p <0.05) with 95% confidence interval. Indirect influence is expressed by summing independent variable --> intermediate vari-

Table 2: Full Model Regression Weight SEM

			Estimation	S.E.	C.R.	P
Integrated_ agricultural_ systems	←	External_ag-ricultural_ condition	0.333	0.076	4.389	***
Integrated_ agricultural_ systems	←	Internal_ag-ricultural _condition	0.130	0.059	2.203	0.028
Regional_de-velopment	←	Integrat_ag-ricultural _systems	0.423	0.059	7.221	***
Regional_de-velopment	←	External_ agricultural _condition	0.217	0.058	3.74	***
Regional_de-velopment	←	Internal_ agricultural_ condition	0.133	0.059	2.204	0.029

able --> dependent variable. Standard regression weight values for both paths are multiplied (value of the independent variable and intermediate variable x value of the intermediate variable and the dependent variable). The probability value review is done after calculating the multiplication of standard regression weight of independent variable and intermediate variable along with the standard regression weight of intermediate variable and independent variable. The influence of mediation is significant if the probability value of each standard regression weight is significant (p <0.05) with 95% confidence interval.

Results and discussion

The Influence of External and Internal Agricultural Condition on Integrated Agricultural Systems of Rice Field-Buffalo Livestock

TBased on the result of data analysis through structural equation modelling (SEM), in order to observe the influence of external and internal agricultural condition to the integrated agricultural systems of rice field-buffalo livestock and regional development in Humbang Hasundutan District, we obtained full model regression weight SEM in Table 2.

Table 2 shows the probability of obtaining critical ratio value of the integrated agricultural systems of rice field – buffalo livestock and regional development in absolute value is less than 0.01, which means regression weight for external and internal agricultural conditions in predicting integrated agricultural systems in the context of regional development at the 0.01 level (two-tailed). If ex-

ternal and internal agricultural conditions increase by 1 standard deviation, the integrated agricultural systems and regional development will increase by the estimated standard deviation value in Table 3.

Based on the result of data analysis with structural equation model (SEM) represents of path coefficient of external agricultural condition to integrated agricultural systems of rice field – buffalo livestock by 0,61 with CR value of 4,389 > 1,96 and p (** *) < 0.01 (Table 2). This indicates that external agricultural conditions significantly have positive influence on the integrated agricultural systems of rice field-buffalo livestock in Humbang Hasundutan. Based on the data analysis results it can be seen that path coefficient values are visually shown through the structural model in Figure 1.

Figure 1 shows that indicator variables of external agricultural conditions i.e. guidance, culture, social capital, market access, capital access, input price and output price are statistically significant with standard regression weight (p) of each indicator, p <0.01. Indicator variable of the integrated agricultural systems of rice field – buffalo livestock i.e. raised income, increased food security and cultural preservation are also statistically significant with standard regression weight (p) of each indicator, p <0.01.

The results of the research defined that guidance factor is one predictor of external agricultural condition that significantly contributes to the perception of farmers to the integrated agricultural systems of rice field – buffalo livestock. This is in accordance with research by Indran-ingsih (2011) that one of the factors affecting farmers

Table 3: Standard Deviation Value

Variable		Variable	Estimation
Integrated_agricultural_systems	⬅	External_ agricultural condition	0.612
Integrated_agricultural_systems	⬅	Internal_ agricultural_condition	0.524
Regional_development	⬅	Integrated_agricultural_systems	0.533
Regional_development	⬅	External_agricultural_ condition	0.265
Regional_development	⬅	Internal_agricultural_ condition	0.244

in Garut District to adopt agricultural technology is the perception of farmers towards the guidance.

Cultural factors of hereditary farming on Humbang Hasundutan community influence perceptions of farmers in the integrated agricultural systems. This is in accordance with research by Ejembi and Obekpa (2017); Diwyanto, Priyanti, and Saptati (2007) that community culture becomes an important consideration in the integrated agricultural systems. In addition, social capital significantly contributes to the perception of farmers on integrated agricultural systems. This finding was supported by research by Wibisono and Darwanto (2016) and than Dewi et al., (2017) that social capital has a positive and significant influence on agricultural productivity and determinant of the success of the integrated agricultural systems in Klungkung District. The results of data analysis indicate that some factors such as market access, capital access, input price, and output price contribute to perceptions of farmers to the integrated farming systems in Humbang Hasundutan District. This is in line with the research of Giroh, Umar, & Yakub (2010) and Kizito (2011) that lack of facilities and infrastructure, access to capital and access to market information will cause farmers unable to control price increase, that the price changes at consumer level are not transmitted to farmers level (Waroko et al., 2008).

The result of data analysis by using structural equation modelling (SEM) shows path coefficient of internal agricultural condition to the integrated agricultural systems of rice field – buffalo livestock at 0,52 with CR value of 2.203 > 1.96 and p (0.028) < 0.05 (Table 2). This represents that internal agricultural conditions significantly (α = 5%) have a positive influence on the integrated agricultural systems. Based on the result of data analysis, it is known that path coefficient values are visually shown through the structure model in Figure 1.

The result of data analysis is shown in Figure 1 in which variable of internal agricultural condition i.e farming experience, road facilities, land use, topography and land area are statistically significant with standard regression weight (p) of each indicator, p <0.01. Indicator variable of the integrated agricultural systems i.e. raised income, increased food security and cultural preservation are also statistically significant with standard regression weight (p) of each indicator, p <0.01. The farming experience is one of the predictors of the internal agricultural condition, contributing significantly to the perception of farmers to integrated agricultural systems of rice field – buffalo livestock.

The results of this study are in line with the findings of Aryana, Budhi, and Yuliarmi (2016) stated that the higher the farmer's experience, the easier it is to increase production in order to achieve maximum profit. Ainembabazi and Mugisha (2014) conveyed one of the main indicators of the reflector of farmer-breeder quality variables is the farming experience that affects the application of cattle and food crops business.

The results also represent that road facilities and land area significantly contribute to perceptions of farmers to integrated agricultural systems in Humbang Hasundutan District. This is in line with Suroyo and Handayani (2014) study indicating the welfare level of Kulonprogo farmers is below average due to unavailability of upstream-downstream agribusiness facilities and infrastructure and Mahananto, Sutrisno, & Ananda (2009) defined factor of cultivated land area, experience of farmers in agricultural business has a significant influence on increasing rice production.

The Influence of External and Internal Agricultural Condition on Development

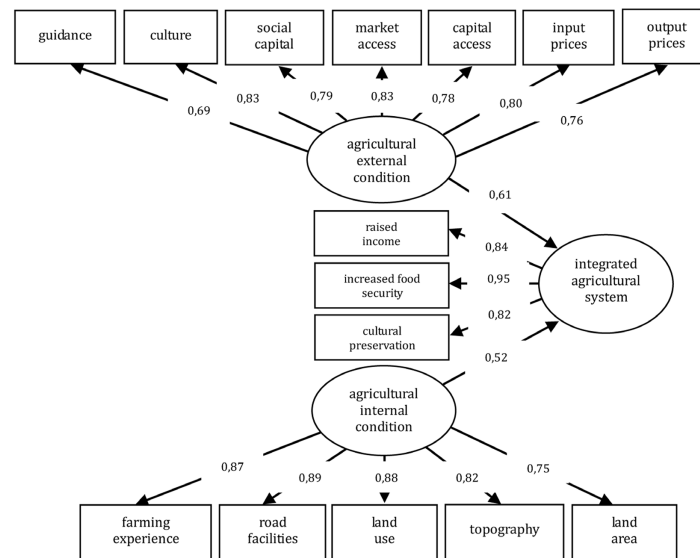The result of data analysis by using structural equation

Figure 1: Structural model of direct influence of external and internal agricultural condition on integrated agricultural systems of rice field – buffalo livestock
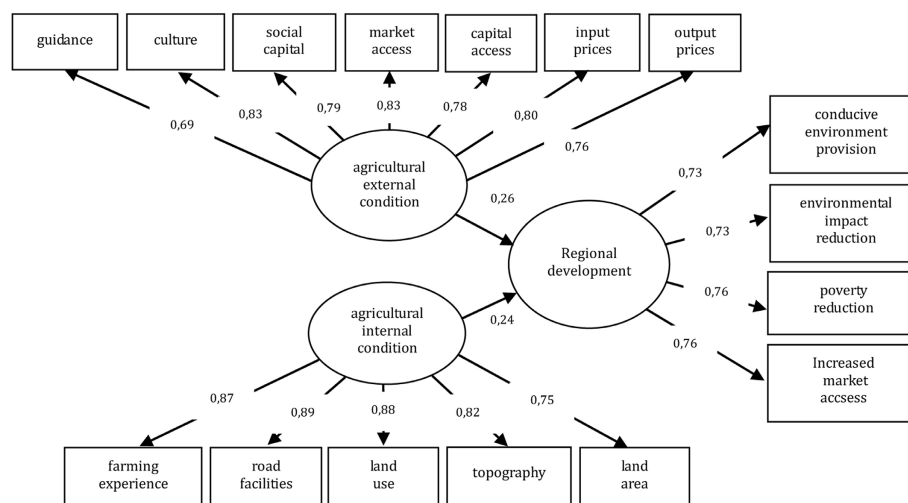

Figure 2: Structural model of the influence of external and internal agricultural condition on regional development

modelling (SEM) exhibits path coefficient of external agricultural condition to the regional development equal to 0,26 with a value of CR 3,740 > 1,96 and p (***) <0.01 (Table 2). It indicates that agricultural external conditions significantly (α = 5%) have a positive influence on the regional development and is visually shown through the structural model in Figure 2.

The result of data analysis as shown in Figure 2 exhibits that indicator variables of the external agricultural condition i.e. guidance, culture, social capital, market access,

capital access, input price and output price are statistically significant with the standard regression weight (p) of each indicator, p < 0.01. Indicator variable of regional development is the provision of a conducive environment, environmental impact reduction, poverty reduction and increased market access that is also statistically significant with the standard regression weight (p) of each indicator, p <0.01.

The results of the study point out guidance as a predictor of the external agricultural conditions have con-

tributed to the regional development in the Humbang Hasundutan District. This is in line with the research of Mangkuprawira (2010) that agricultural guidance is required in regional development. In the long term, the guidance aims to improve the community lives. Indraningsih (2011) defined the purpose of agricultural guidance to increase food production, stimulate economic growth, and improve the welfare of farmers.

The regional development contains socio-cultural aspects that must be maintained and preserved, as Sultani (2016) defined that the regional development should be raised internally by involving local wisdom. The results represent that there is a close relationship between culture and environment that is greatly obvious to the community in Humbang Hasundutan District. They have spiritual, cultural, social and economic relation with their traditional territories in the form of customary laws, including the responsibility for preserving their territory for the needs of future generations. An important element of successful rural development is social capital. Sultani (2016) stated that regional development by involving social capital will foster a sense of responsibility towards implementation of the development. Sunarsih et al., (2014) also suggested that social capital rooted in tradition, which includes socialization in agriculture plays a role in maintaining the relation between human, human and nature, and human and the community.

The result of data analysis using structural equation modelling (SEM) exhibits direct influence of internal agricultural condition to the regional development with path coefficient of 0,24 and CR value of 2,204 > 1,96 and p (0,025) < 0.05 (Table 2). It shows that internal agricultural conditions have significant influence ($\alpha = 5\%$) to the regional development as visually represented by the structural model in Figure 2.

Figure 2 represents indicator variable of the internal agricultural condition i.e. farming experience, road facilities, land use, topography and land area that are statistically significant with standard regression weight (p) of each indicator, p < 0.01. Indicator variable of the regional development i.e. provision of a conducive environment, environmental impact reduction, poverty reduction and increased market access are also statistically significant with the standard regression weight (p) of each indicator, p < 0.01. The results of the research indicate that infrastructure facility is a locomotive to drive economic development and is a determinant of the smooth flow of goods, services, people, and information in Humbang Hasundutan District. This is in line with the research of Srinivasu and Rao (2013); stating that the quality of road infrastructure positively affects the marketing system

of agricultural products. The better the quality of infrastructure, more smoothly the farmers market their agricultural products to the market or consumers.

In relation to regional development, the results exhibit that agricultural land has economic value as a food support and ecological function. Snieska and Simkunaite (2009); Rudiarto and Doppler (2013) stated if the benefits of agricultural land are not maintained, it will disrupt the ecosystem that leads to socio-economic changes and tend to harm and reduce farmers' income.

The pace of development as triggered by the increase in population leads to a change in land use. Agricultural land becomes a residential and industrial area (Prabowo, Bachri, & Wiwoho, 2017). The interaction between space and time dimension with biophysical and human dimensions is also the cause of change in land use, including economic activity and transportation can change land use (Koomen et al., 2007; Wu et al., 2006).

The development of a region can change land use patterns in rural characteristic areas (Kim, Hong, & Ha, 2003) such as Humbang Hasundutan District. Changes in land use in this area indicate the negative impact on the environment, i.e. the emergence of degraded land due to deforestation and environmental vulnerability issues such as; the occurrence of erosion and landslides. In line with that, Sinurat, Munibah, and Baskoro (2015) with the CLUE-S Model (the Conversion of Land Use and its Effects at Small region extents) exhibits that there has been a change in land use in Humbang Hasundutan District covering 5,362 ha in the period (2003-2013). This study even shows that a change in land use based on the rate of natural change indicates the area of forest land use in 2033 was only left by 27.5% of the total area of Humbang Hasundutan District, this shows that land use for the development process due to population growth can cause a decline in farming production which in turn also affects economic growth, in line with the findings of Wang, Chai, and Li (2016); Tali, Divya, & Murthy (2013) which states that population growth will affect the decline in agricultural land area, which can cause a decrease in farm production.

The Influence of Integrated Farming Systems of Paddy Rice-Paddy Rice to Regional Development

Based on the result of structural equation modelling (SEM) analysis, it is known that the direct influence of the integrated agricultural systems of rice field – buffalo livestock to the regional development in Humbang Hasundutan District with a path coefficient of 0,53 and CR value of 7,221 > 1,96 and p (***) < 0.01. This suggests
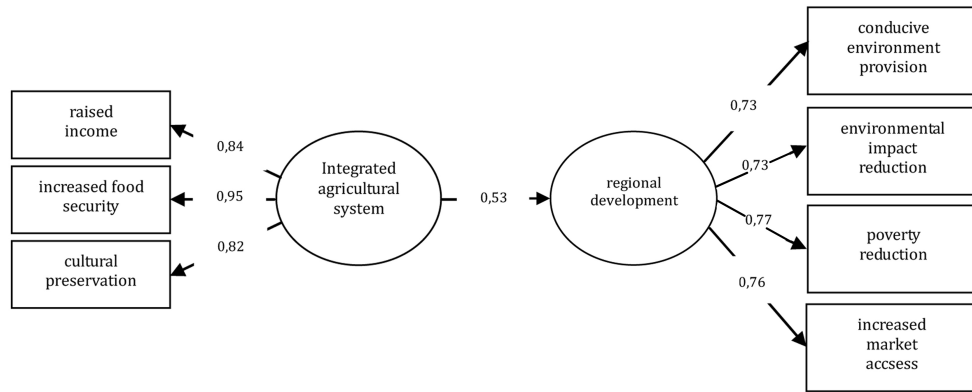
Figure 3: Structural model of the influence of integrated agricultural systems of rice field–buffalo livestock to regional development
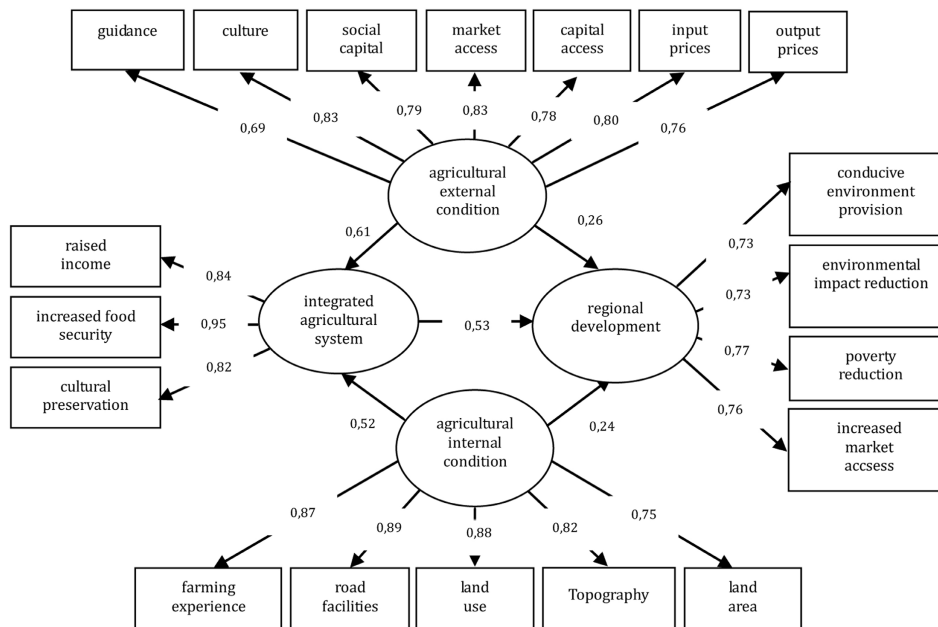

Figure 4: Structural model of the influence of external and internal agricultural condition to the regional development through integrated agricultural systems of rice field–buffalo livestock

that integrated agricultural systems have a positive and significant impact on the regional development as visually shown by the structural model in Figure 3.

Figure 3 represents indicator variables of the integrated agricultural systems i.e. raised income, increased food security and cultural preservation was statistically significant with standard regression weight (p) of each indicator, p <0.01. Indicator variable of regional development i.e. the provision of conducive environment, environmental impact reduction, poverty reduction and increased market access that are also statistically significant with the standard regression weight (p) of each indicator, p < 0.01, thus integrated agricultural systems significantly have a positive effect on the regional devel-

opment in Humbang Hasundutan District.

The result of data analysis as shown in Figure 3 exhibits the cultural preservation as a predictor of an integrated farming systems that gives a real contribution to regional development. Indigenous peoples in Humbang Hasundutan District have been familiar with farming and livestock customs, utilizing rice crops as a source of food, buffalo as farming aids, and horses as a means of transportation. Crops cultivation and livestock development of the integrated systems in the eco-friendly agricultural system is a strategy in reducing environmental impacts as well as actualizing the welfare of farmers and rural communities. This is in line with research by Diwyanto, Priyanti, and Saptati (2007) that the pattern

of crop-livestock integration systems makes serious efforts to improve soil structure and microbiology and improve farm productivity, income, and farmers' welfare. In line with the notion of James C. Scott in Willmore (2017) the integrated agricultural system is a good agricultural model to apply in the rural areas of Humbang Hasundutan District.

Soni, Katoch, & Ladohia, (2014) defined an integrated agricultural system that is a business management to integrate agricultural components, such as plants, animals, and fishes in a unified whole. Integrated farming systems, involving crops (rice fields, wheat) and livestock (dairy animals, poultry, fish, rabbits and honey bees), proved more profitable than crops alone in terms of net returns. Further, integrated systems resulted in better utilization of land, water input and human resources. The crop-livestock integration system is characterized by a close association between crop and livestock components in agricultural business in the region. This linkage is a factor to encourage the growth of farmers' incomes and regional economic development in a sustainable way.

The Influence of External and Internal Agricultural Conditions on Regional Development through Integrated Agricultural Systems of Rice Field–Buffalo Livestock

From the result of data analysis with structural equation modelling (SEM) is known as indirect influence of external agricultural condition to regional development through an integrated agricultural systems of rice field – buffalo livestock showed by the structural model in Figure 4.

Figure 4 exhibits the direct influence of external agricultural conditions on the regional development of 0.26. The indirect influence of external agricultural conditions on the regional development through integrated agricultural systems of rice field-buffalo livestock is $0.61 \times 0.53 = 0.32$. Total influence of external agricultural conditions on regional development is $(0.32) + (0.26) = 0.58$. Thus the external agricultural conditions have a positive and significant influence on the regional development through an integrated agricultural systems of rice field – buffalo livestock.

The results of data analysis represented an increase in the predictors of external agricultural conditions that determine the success of integrated agricultural systems will be able to increase regional development. Agricultural guidance as a predictor of external agricultural conditions plays a role in alleviating poverty, in which the success of guidance is related to increasing productivity

and income in the agricultural sector.

Social capital contributes to regional development in Humbang Hasundutan District. The farmers have a low quality of social capital that it will result in lack of access to information, as they have not done maximally in accessing information due to the domination of market opportunities by the middlemen.

Thus the adoption of knowledge and technology in agriculture is influenced by socio-cultural problems, thus it takes time and energy to convince and change the habits of farmers. Therefore, it requires good guidance program that farmers have no obstacles in Humbang Hasundutan District in developing their business due to limited capital and lack of accessibility to the source of capital.

The result of data analysis with structural equation model (SEM) is known as indirect influence from the internal agricultural condition to regional development through an integrated agricultural systems of rice field – buffalo livestock, as visually shown by the structural model in Figure 4.

Figure 4 represents the direct influence of internal agricultural conditions on the regional development in Humbang Hasundutan District of 0.264. The indirect influence of the internal agricultural conditions on the regional development through integrated agricultural systems of rice field – buffalo livestock is $0.52 \times 0.53 = 0.28$. Total influence of internal agricultural conditions on regional development is $(0.28) + (0.24) = 0.52$. It can be said that the internal agricultural conditions have a positive but insignificant influence on the development of Humbang Hasundutan District by an integrated agricultural systems of rice field – buffalo livestock.

The results of the data analysis indicate that although the improvements were made to the predictors of internal agricultural conditions which are the determinants of integrated agricultural systems, it insignificantly improve regional development. The diverse topography of Humbang Hasundutan District from flat land to hilly and mountainous terrain does not contribute significantly to perceptions of farmers to regional development by integrated agricultural systems. This is because the farmers consider that diverse land topography cannot be employed as agricultural land. They assume that the hillside is a factor required to consider, from land preparation, planting and process of collecting products.

The results of data analysis also indicate that road facilities significantly contribute to perceptions of farmers to

integrated agricultural systems, as it turned out that it did not significantly contribute indirectly to regional development. Prowse and Chimhowu (2007) argued that infrastructure is a key factor in supporting rural poverty reduction programs. Having observed in other countries such as in Vietnam, the rapid decline in poverty is inseparable from high investment for the irrigation and roads construction in the agriculture area. Similarly, in India and Ethiopia, which suffered from food and hunger crises in the mid-1980s, the infrastructure improvements of rural roads are a means of increasing market access for farmers in order to increase the farmers' welfare.

Therefore, in order to attract investors into the agricultural sector, it is required to facilitate the accessibility and distribution of agricultural production and output facilities, as it requires adequate infrastructure. Due to the low level of government investment in infrastructure, there are a lot of damaged farm roads, production roads, and irrigation networks. It is necessary for the development and rehabilitation of farm roads, production roads, irrigation networks, shallow ground irrigation, absorption wells, ponds, reservoirs, in order to support the development of integrated agriculture in Humbang Hasundutan District.

Conclusion and Suggestions

Based on the result of the research, it can be concluded that: a) External and internal agricultural conditions have a significant positive influence on integrated agricultural systems of rice field-buffalo livestock, b) External and internal Agricultural conditions have a significant positive influence on the regional development, c) Integrated agriculture systems of rice field-buffalo livestock has a positive and significant influence directly on the regional development, d) Direct influence of external agriculture conditions to regional development is 0,26. Indirect influence of external agriculture conditions on regional development by intermediate of integrated agriculture systems is 0,32 and total influence is 0,58, e) Direct influence of internal agriculture conditions to regional development is 0,24. Indirect influence of internal agriculture conditions on regional development by intermediate of integrated agriculture systems is 0,28, with a total influence is 0,52.

In accordance with the conclusions, it is suggested that; a) the government must be educate farmers to improve their knowledge of integrated agricultural systems, in addition, the role of government is necessary to ensure capital access and market access to facilitate marketing process of farmers' agricultural production, b) the government conducts education and training to improve the ability of farmers to manage and develop their farms so as to have an impact on the increase of farmers' income, c) the government must be creates agricultural development programs for longer-term purposes to obtain higher quality agriculture in order to increase agricultural production that impact on regional economic growth, d) the government will help farmers to obtain agricultural business capital or access to more flexible capital access and can ensure the agricultural output price stability, e) the government builds road facilities to agricultural centres, irrigation canals, reservoirs and absorption wells in order to support agricultural development.

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Conflict of Interests

The authors hereby declare that there are no conflicts of interest.

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The 11th Annual Horizon Scan of Emerging Opportunities and Threats of Biodiversity 2020

The Horizon Scan of Emerging Global Biological Conservation Issues for 2020 presented fifteen issues the constitute threats to and opportunities for biodiversity. Scientists and conservation professionals narrowed down a list of 89 issues to 38 issue first, then to fifteen issues that are the most emerging effects on global biological conservation as published in the journal *Trends in Ecology & Evolution*.

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We list some of the top picks that highlighted important positive and negative issues identified in 11th annual horizon scan.

Cellulose as good product with bad outcomes
Cellulose helps with removing carbon dioxide and reducing the demand for environment-harming plastics. Its use in packaging and construction raised the demand to 18% per year. This higher demand for cellulose may threaten the biodiversity of forests and disturb habitat.

Wood as an alternative fuel
After the European Union classified wood as a renewable energy, the import of timber from several countries into Europe has increased. Such higher demand may no longer be satisfied by current exporters which could promote the the intensification of European forestry. This would accelerate the loss of primary forest and have a dramatical effects the climate change and biodiversity.

Sunflowers as nutritious plants of bees
Perils such as pesticides and diseases decimate the population of bees and other pollinators. A research published in US reported that sunflowers pollen reduces gut infections in bumblebees, which negatively impact the productive process of the pollinators. These results may lead to a massive planting of sunflowers. As sunflowers are considered less nutritious to other bees apart from bumblebees, the mass planting of sunflower could negatively affect other bee species, which depend on alternative plants for more nutritional values.

Kelp forests are disappearing

Kelp is well known for its important benefits such as protecting shores from erosion and providing shelter to a numerous maritime species in addition to commercially important fishstock. The raise in ocean temperature in addition to pollution and other factors lead to a dramatical decline in kelp forests. This decline compromises ocean ecosystems and may results in an economic loss of billions of dollars.

Antarctic ice: Serious consequences

The rise in the atmospheric temperatures contributes to the retreat of polar ice. Scientists are trying to understand how reducing the ozone hole is contributing to the melting of Antarctic ice. The consequences of the vanishing of large parts of polar ice are obvious: Sea levels would rise significantly, threatening the existence of coastal communities and heavily disturbing littoral species.

Overall, horizon scanning aims to improve the robustness of policies and to provide new insights, opening up potentials for a more sustainable future of global biodiversity.

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Annex:

UN Convention on Biological Diversity's science body provides advice critical for next year's UN

Biodiversity Conference (*PDF on Pages 5-7 of this News section*)

COP25: The annual United Nations' climate talk

In 2015, the Paris climate summit took place with representatives of almost 200 countries. The agreement's long-term goal was to limit global warming to no more than 2°C. However, pledges to limit carbon emission seem to be out of reach as a new peak of greenhouse gas emissions has been recorded in 2018, which meant that emissions are continuing to raise.

An annual United Nations' climate talk, COP25, took place in Madrid 5-13 December 2019, focused on the international carbon emissions trading which could reduce the cost of climate change mitigation. Article 6 of Paris agreement, encouraging voluntary collaboration between nations, was on the table for discussion.

The participating nations had over the last years succeeded in introducing rules for emissions tracking. This year, they failed to agree on rules regarding carbon trading. Carbon trading is a scheme which allows buying and selling permits to emit carbon dioxide. It enables countries with high emission and countries with relatively low emissions to satisfy their respective carbon emission requirements.

The parties to the COP also argued over the voluntary offsetting scheme which promotes certain services to be ''carbon neutral''. Many countries criticized this offsetting scheme, as they see that economically advanced countries may use it to avoid their responsibilities in achieving the required goal of emission reduction. Unplanned offsetting schemes could prevent the required goal of global emission to be reached, as efforts to reduce the emissions could be simply avoided and moved between the countries.

As the climate-protest movement is rapidly growing, this year's meeting also faced intensifying public pressure. Moreover, the United States' official withdrawal from the Paris agreement affected this year's talk. However, the US will continue as a member of Kyoto Protocol and the Paris agreement, and the UN Framework Convention on Climate Change. Yet they will no longer take part in any future COP meetings, except for the next year's meeting, unless it revokes the decision to withdraw from the Paris agreement.

The world leaderships are focusing efforts to reduce the disturbance of Earth's climate by greenhouse gas. New hopes to reduce emissions are being represented by the 'climate and environmental emergency', a move on which the European Parliament voted to promote the EU countries to curb emissions by 55% by 2030, and to achieve net-zero emissions by 2050.

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An avoidable health risk: Air pollution reduction leads to prompt remarkable health benefits

Air pollution is a hazard that can lead to harmful health impact on humans, animals, and plants. Emissions from factories, cars, and planes are among the main causes of air pollution. Fortunately, by reducing air pollution, these mischievous impacts are not only possible to be avoided, but health can also enhanced in a matter of short period.

A report revealed by the Environmental Committee of the Forum of International Respiratory Societies (FIRS) addresses the prompt and spectacular improvements in health-outcomes promptly after reducing air pollution. The report examines the outcomes of different interventions conducted by several countries in order to reduce air pollution.

The smoking ban in Ireland was one of the distinctive mentioned examples. Starting at week one, the ban brought astonishing health benefits foremost among non-smokers, such as a decrease of all-cause mortality with 13%, a 32 % reduction in stroke and a 26% reduction in ischemic heart disease.

In Utah, the United States, a closure of a steel mill for 13 months yielded a 40% decrease in school absenteeism. More importantly, hospitalizations for pneumonia, pleurisy, bronchitis and asthma were reduced by half.

Prompt health benefits were also noteworthy following the restrictions applied on transportation by each of Georgian and Chinese governments during the Olympics. In a matter of weeks, hospitalizations for asthma cases dropped remarkably.

In addition to city-level regulations, individuals' actions could also contribute in air pollution reduction within the home. Statistics of pregnant Nigerian women who used clean cook stoves that helps with indoor reduction of air pollution had reported higher birth weights, greater gestational age at delivery, and less perinatal mortality.

On an economical level, the enactment of the Clean Air Act in US resulted in 2 trillion dollars of savings in 25 years. This environmental policy was announced as one of the most effective public health policies of all time in the United States.

The report concludes that air pollution is avoidable and can result in fundamental and, most importantly, immediate health gains. Thus, Dr. Dean Schraufnagel, lead author of the report, emphasizes the critical rule of governments in immediate adopting and enforcing of WHO guidelines for air pollution. Moreover, he suggests sweeping policies and local programs that contribute in a better air pollution reduction.

Reference

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UN Convention on Biological Diversity's science body provides advice critical for next year's UN Biodiversity Conference

- *Governments identified key elements of the scientific base needed to build post-2020 global biodiversity framework.*
- *New ecologically or biologically significant marine areas in the North-East Atlantic catalogued.*
- *Parties recognized urgency of tackling biodiversity loss and climate change through ecosystem-based approaches to climate change adaptation, mitigation and disaster risk reduction.*

1 December 2019 – The Convention on Biological Diversity's (CBD) subsidiary body on science suggested elements of the science base that will be used at next year's biennial UN Biodiversity Conference[1] in Kunming, China that will include discussions on an ambitious, transformative and effective post-2020 global biodiversity framework.

Some 673 delegates representing 118 countries convened in Montreal for the twenty-third meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA-23), held from 25-29 November. The agreed recommendations include decisions suggested to be adopted at the UN Biodiversity Conference.

"The results of SBSTTA-23 illustrated the critical role this scientific body of the Convention plays in ensuring that all work under it is underpinned by sound science," said Elizabeth Maruma Mrema, Acting Executive Secretary. "To that end, Parties have identified key elements of the scientific base for the development of the post-2020 global biodiversity framework. While much work remains to be done, we are well on our way to achieve a framework that is both ambitious and effective."

In late 2020, the 196 Parties to the Convention will adopt the post-2020 global biodiversity framework. This global agreement will offer an unparalleled opportunity to advance progress on the conservation, restoration, and sustainable use of biodiversity, while strengthening interlinkages between biodiversity, climate change and sustainable development agendas.

Development of this framework is based on an open and transparent consultative process, engaging all Parties and stakeholders in a meaningful and integrated manner. The process is informed by best available science and evidence base learning also from relevant global and other assessments., such as the IPBES Global Assessment.

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[1] Fifteenth meeting of the Conference of the Parties to the Convention on Biological Diversity; Tenth meeting of the Conference of the Parties serving as the meeting of the Parties to the Cartagena Protocol on Biosafety; Fourth meeting of the Conference of the Parties serving as the meeting of the Parties to the Nagoya Protocol on Access and Benefit-sharing; Kunming, China, October 2020.

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At SBSTTA-23, governments agreed on the following recommendations:

Informing the Scientific and Technical Evidence Base for the Post-2020 Global Biodiversity Framework: Parties stressed the need for action to address indirect and direct drivers of biodiversity loss, and to tackle climate change and land degradation in an integrated manner. This includes scaling up existing measures and initiating steps to achieve transformative change. Parties further recognized that to achieve the 2050 vision of the CBD: 'living in harmony with nature,' changes are needed in finance and economics that support pathways to sustainability.

Biodiversity and Climate Change: Parties recognized that biodiversity loss, climate change, desertification and land degradation are inseparable, interdependent challenges of "unprecedented severity." Parties noted that limiting the global average temperature increase to 1.5°C above pre-industrial levels is not sufficient to halt biodiversity loss but would significantly reduce it. Parties noted that nature-based solutions provide approximately 37 per cent of climate change mitigation needed by 2030 to keep warming below 1.5°C . Ecosystem-based approaches to climate change adaptation, mitigation and disaster risk reduction are indispensable to achieving multiple globally agreed goals, including the Paris Agreement and the sustainable development agenda.

Possible Elements of Work on the Links Between Nature and Culture in the Post-2020 Biodiversity Framework: The Scientific Body built on the results of the previous eleventh meeting of the Convention's Working Group on Traditional Knowledge and Indigenous Peoples and Local Communities. Parties considered increased interagency cooperation bringing together the CBD, United Nations Educational, Scientific and Cultural Organization, IUCN and indigenous peoples and local communities, and other partners to integrate biological and cultural diversity - Nature and Culture - in the development of the post-2020 framework.

Sustainable Wildlife Management: Parties recognized the importance of the sustainable use of biodiversity in wildlife management, including the contribution of indigenous peoples and local communities. They agreed to strengthen collaboration among multilateral environment agreements and international organizations to tackle illegal and unsustainable use and trade of wildlife trade. Additional work is still required to implement decisions on sustainable wildlife management, and voluntary guidance for a sustainable wild meat sector.

Technical and Scientific Cooperation: Parties recognized the importance of technical and scientific cooperation to implement the post-2020 framework. Such cooperation will need to extend across a wide range of fields and disciplines to support the mainstreaming of biodiversity. SBSTTA asked for additional views and suggestions for matters such as technology horizon scanning, assessment and monitoring, and examples of effective institutional mechanisms, partnerships, networks, and regional and subregional institutional arrangements.

Results of The Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas in the North-East Atlantic Ocean: Parties considered the outputs of a regional workshop that described 17 areas meeting the criteria for ecologically or biologically significant marine areas (EBSAs) in the North-East Atlantic Ocean and adjacent areas. These results fill an important geographical gap in the work under the Convention to describe EBSAs globally. Parties also acknowledged the collaboration of the Convention for the Protection of the Marine Environment of the North-East Atlantic and the North-East Atlantic Fisheries Commission and their pioneering work related to EBSAs in the North-East Atlantic Ocean. Parties encouraged continued efforts to describe EBSAs using the best available science and emphasized that EBSAs can inform the development of the post-2020 global biodiversity framework.

New and emerging issues: Parties deferred consideration of whether synthetic biology would be classified as a new and emerging issue to its twenty-fourth meeting, and recommended that pending the outcome of that meeting, the Conference of the Parties not to add new and emerging issues to the SBSTTA agenda in the coming biennium.

NOTES TO EDITORS

The Subsidiary Body on Scientific, Technical and Technological Advice, the intergovernmental body responsible for providing scientific, technical and technological advice related to the implementation of the Convention, plays a key role in assessing the current status of the world's biodiversity, identifying solutions and in bringing emerging issues related to the conservation and sustainable use of biodiversity to the attention of the global community.

Meeting documents: www.cbd.int/conferences/sbstta23-8j11/sbstta-23/documents

Convention on Biological Diversity (CBD)
Opened for signature at the Earth Summit in Rio de Janeiro in 1992, and entering into force in December 1993, the Convention on Biological Diversity is an international treaty for the conservation of biodiversity, the sustainable use of the components of biodiversity and the equitable sharing of the benefits derived from the use of genetic resources. With 196 Parties, the Convention has near universal participation among countries. The Convention seeks to address all threats to biodiversity and ecosystem services, including threats from climate change, through scientific assessments, the development of tools, incentives and processes, the transfer of technologies and good practices and the full and active involvement of relevant stakeholders including indigenous and local communities, youth, NGOs, women and the business community. The Cartagena Protocol on Biosafety and the Nagoya Protocol on Access and Benefit Sharing are supplementary agreements to the Convention. The Cartagena Protocol, which entered into force on 11 September 2003, seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. To date, 172 Parties have ratified the Cartagena Protocol. The Nagoya Protocol aims at sharing the benefits arising from the utilization of genetic resources in a fair and equitable way, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies. It entered into force on 12 October 2014 and to date has been ratified by 123 Parties.

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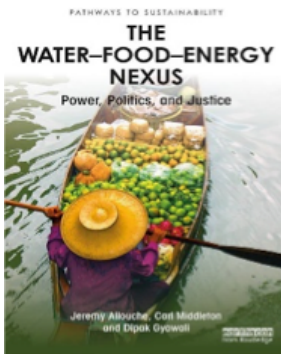
The Water-Food-Energy Nexus:
Power, Politics and Justice

A Review by Saniya Ramzan

The Water-Food-Energy Nexus (hereafter referred to as the nexus) is the relationship between the systems of food, energy, water and the environment that are somehow manipulated by power and governance. There is a need for justice for the proper distribution and utilization of these resources in a sustainable way. There is no straight forward solution, and no single body can solve the problems alone. Rather different bodies including those comprising politicians, bureaucrats, policymakers, technicians, scientists and locals have to think together about different nexuses. This book of eight chapters discusses how such nexus thinking is needed across the globe to bring social justice to the food, water and energy sectors by removing barriers including power, politics and injustice.

Chapter one introduces and discusses the nexus approach in the context of the different actors in society. Green economy usually aims to push interventions that conserve resources and bring sustainability in many dimensions regardless of conventional politics. Similarly, policy and decision makers should consider water crises and energy resources during policy making. The physical scarcity of a resource is not only due to geographic reasons but can be man-made or socially constructed by bureaucrats and market controllers. A single nexus approach is insufficient therefore multiple nexuses that highlight their interconnections should be utilized to resolve resource scarcity problems. Proposed nexus based strategies include either resources shifted to large scale production systems or green policy that leads to sustainable utilization of resources.

Mismanagement of nexuses among water, food, energy and climate are causing drastic effects across the globe. So, current global policy making should consider stability and durability that leads to sustainability among these nexuses. The scarcity of resources is one of the factors that limits the sustainability of the nexus concept and its systems for resource utilization. Some crises are demand led such as high food and oil prices while others are driven by climatic changes, such as food insecurity. These lead to emergency policy making when scarcity of land and water is the result of improper nexus management. Oil crises and fuel shocks can cause environ-mental damage, geopolitical conflicts and socio-political instability.

The World Economic Forum (WEF), German Federal Government (GFG) and Food and Agriculture Organization (FAO) have played key roles in a new global policy initiative on the nexus and its relation with the Sustainable Development Goals (SDGs). The 17 SDGs referred to in policy domains are however still rather random in the sense that their interconnections are insufficiently elaborated. There is a need for green growth to prevent the further erosion of natural capital. Local nexuses are conceptualized differently by various actors: the nexus thinking of professionals is different to that of rural communities. Static rather than dynamic thinking often leads to failed outcomes. Thus for a wide overview of dynamic security, both ecological and cultural theories must be taken into consideration.

Moreover the book focuses on resource management starting from the 1990s to the present. Today's conceptualisation of nexus is based on the idea of IWRM: coordinated development and management of water, land and related resources without compromising sustainability. Integration attempts from the past including IWRM, Integrated Natural Resource Management (INRM), Tennessee Valley Authority (TVA) and watershed management have been important but such nexus approaches have also faced criticism. IWRM is one of the focal points for international water policy as 80 percent of the world's countries have incorporated it into their water laws. Integration is a political process to allocate water use priorities and trade-offs for various sectors. Who is doing the integration, for whom and how, are the major questions that arise. The new nexus concept presents more novelty and a wider range of resource management coverage than IWRM but both approaches share the ultimate goal of sustainable resource usage. The nexus approach basically helps the shifting of resource management from the state level to the system (global) level.

The proposed nexus is a multidimensional approach that reveals nonlinear and complex linkages among food, energy, water, climate and society. The interdisciplinary methodology focuses on the connections, nature of connections and boundary issues related to the nexus but, according to the authors, data challenges remain. Most of the methods used are based on quantitative methods that are specific or irreproducible, confined to disciplinary silos and lack sufficient conceptualisation of the interaction among resources. Social science contributions are also lacking. Chapter four gives an insight of nexus specific methods that include environmental, technical and social challenges. Knowledge nexus is one transdisciplinary approach that brings up changes among organizations, infrastructure, governance behaviour, markets and cultures by broadening the analysis, connecting theory and methodology to apply it practically to the question of global sustainability. Trans-disciplinarity (final stage of inter-disciplinarity with thorough coordination of knowledge from researcher, practitioners and local persons) is more vast than multi-disciplinarity and inter-disciplinarity but ultimately nexus trans-disciplinary research gets stuck when trying to find tools, procedures and frameworks in regard to policy making owing to barriers in communication and collaboration, decision making, social and cultural dimensions, responses, power and force in academic research. For radical diversity of nexus related methods and capabilities, cultural theoretical concepts like egalitarianism, humility, pluralism and reflexivity can be considered.

According to studies, rather than scarcity, the main problem is the lack of political will to implement long-lasting measures for sustainable resource management. For a sounder nexus based approach, the main problem to be brought to the table of policy makers is consideration of local resource users.

Governmental approaches to redistribution or taxation of resource usage need to be reconsidered, e.g. to transform resource usage from luxurious to justified. Knowledge politics helps to shape nexus governance such as in the cited case of Lake Tana of Ethiopia. For on the ground results, the Kulekhani Hydro-electric Power station and Melamchi basin water supply in Kathmandu are cited as the best examples of single aim approaches. Chapter five focuses on hegemonic official nexus policy and local people's understanding of nexus based approaches with the help of case studies.

Justice and rights have been neglected in the water-food-energy nexus in terms of small holders that have multiple livelihoods. In many countries there has been a mismanagement of multi-scaled and cross-sectoral interlinkage of nexuses. But today there is awareness and recognition of linkages between human rights and natural resources. Chapter six places emphasis on the increased demand of nexus-thinking, fair decision-making and justified outcomes that include local users. Arguments about exploring individual injustice i.e., issues related to just access and control over natural resources are covered in this section. Environmental justice is fair in understanding law, policy and decision making but weak in explaining intersectoral linkages. With the help of case studies from Southeast Asia it is shown that national and local civil society have paid less attention to utilize nexus framing for human rights and justice.

The book further discusses the new nexus approaches that explicitly involve ethics. Ethical thinking conjoined with the nexus approach brings up all the voices of a society to propose innovative solutions to problems. Ethics makes people think what needs to be done and how it can be done. Value judgement and ethics engagement are unavoidable in nexus approaches. Ethical studies of the major religions, i.e. Christianity,

Islam, and Hinduism, make clear that their ethical principles play a vital role in nexus approach formation and implementation to better define the interlinkages of the various sectors. Water, energy, food and environmental ethics for different parts of societies vary, so the nexus approach should be adaptable for them.

The last chapter, chapter eight, summarizes the content of the book. Today's need is to re-conceptualize nexus thinking because current policies reflect specific framing of problems. Nexus policies that do not take seriously the inequalities and injustice of current resources distribution are unlikely to result in sustainable and just outcomes. The main argument is that a shift is needed from bureaucratic integrated management to policy that has social styles like hierarchism, individualism and egalitarianism. In nexus approaches, global priorities can be better connected to local needs by developing nexus ethics (normative positioning of nexus). Multiple nexuses intersect with one another, so a precise and critical rethinking of democracy and its practice is needed. There is a global need to make people aware about these nexuses.

This book is recommended because it covers all the possible factors that can affect the nexus based approach for food, water, energy and climate and their possible solutions. The case studies mentioned in the book help the reader to better understand the complexity of nexus based systems and their implementation.

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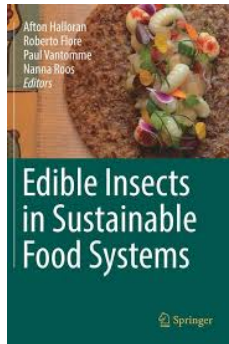
Edible Insects in Sustainable Food Systems

A Review by Varsha V. Prabhu

In this book, the authors give a detailed explanation of insects for food and feed which would interest anyone who is dealing with the topic of edible insects in sustainable food systems. The inputs in this book were provided by numerous authors from 20 different nations including public, academic, governmental and private sectors, with a focus on clarifying the role of insects in the sustainable food system. This book covers various topics such as entomology, agricultural economics, human nutrition, environmental science, fisheries and many more. It is about 500 pages, divided into 8 parts and 30 chapters.

The book starts with some basic information on the biology of insects, insect structure, gut functions followed by its growth and development. It then specifies on light traps, soil digging, and pheromone traps etc. as some methods to collect particular insects and finally concludes with the importance of understanding the insect biology to consider it as a food and feed.

The book further divulges on the uses of insects in Adi-tribe, North-East India. It specifies the role of insects in weather-forecast, myths and belief, and entertainment etc. In addition, it accounts certain historic practices regarding consumption of certain insects by Inuits in the Arctic and the indigenous uses of insects in North America.

The next part of the book addresses the health benefits of incorporating insects in the diet. This is explained by comparing the nutritional composition of the insects with meat and fish, in particular protein, fats, vitamins and minerals. The books also accentuates nutritional insecurity in East-Africa and the ability of the insects to mitigate it. Further, it delves into the harvesting and processing of insects and their contribution towards food and nutrition security in East Africa. Along with this it also gives a brief analysis of the food safety aspects specifically biological and chemical hazards related to insect consumption.

The book further apprises the readers on the exotic foods using insects, developed by chefs. Some foods mentioned are charred avocado tartare with ant larva, pineapple dessert with leaf cutter ant etc. In addition, the book sheds some light on the attitudes of future chefs towards insects as food. This was justified from the experiment conducted in the university by the chefs.

The second chapter proceeds further with Casu Marzu as an example of insect application in production and processing in Italy. The final chapter discusses a case study on the current use of edible insects in Korea and its innovations in gastronomy.

Environmental impact of Insect production is lower than livestock production. The next part of the book revolves around this concept. It compares insect production with livestock production in terms of land usage, water footprint, and carbon footprint etc. and thus concludes insect production as sustainable source of food when compared to the livestock production. Insects need specific harvesting methods when compared to normal food. The book therefore encloses the traditional methods of harvesting insects in Sub-Saharan Africa.

After focussing on the insects as food and their impact on the health and the environment, the book directs the readers on insects as animal and marine feed. The first chapter compares between the small scale productions of black soldier fly (Hermetia illucens) and house fly (Musca domestica) as a feed. The comparison is concerning per-formance, user-friendliness, safety and sus-tainability. It further draws attention towards the safety regulations of the feed. The follow-ing chapter sheds light on the DESIRABLE project funded by the French national research agency. The project evaluates the performance of larvae mealworm (T. Moliter) for feeding fish and poultry. In short, this chapter deals with new insect value chain and explains the insect rearing and processing. Production of insects in small scales can improve the livelihood of small scale farmers as well as mitigate the dependency on the marketed animal feed thus improving the small scale economies as well as the sustainable development of their regions. Hence the next chapter centres on the need for insects in small scale production and the use of these insects as animal feed in low-income countries. The last chapter highlights the production of mealworm in the feed as well as food.

After discussing on the insects as a feed, the book furthermore focuses on the importance of consumer's preferences and acceptability. It focuses on the consumer's attitudes towards insects in Europe, USA and Kenya.

The last part deals with policies and legislation on the use of insects as food and feed. There are five chapters in this section. The first chapter highlights the PROteINSECT research project which provides details on the application of insects as feed. The other chap-ters mainly focus on the legislation of insects harvesting, processing and growing in Thailand, Africa and the Global South.

Overall, the book delves into multiple topics and also provides detailed information on each topic. The book uses a simple and clear language. The reader gets to learn something new in every chapter but might tend to lose interest due to repeated information in certain chapters. All in all, the book is a good read to get comprehensive knowledge and tweak the reader's interest in the intended direction.

About the author: *Varsha V. Prabhu is a student pursuing her masters in International food business and consumer studies at Kassel University. She is a food technologist by profession and is always curious about recent trends in food product development.*