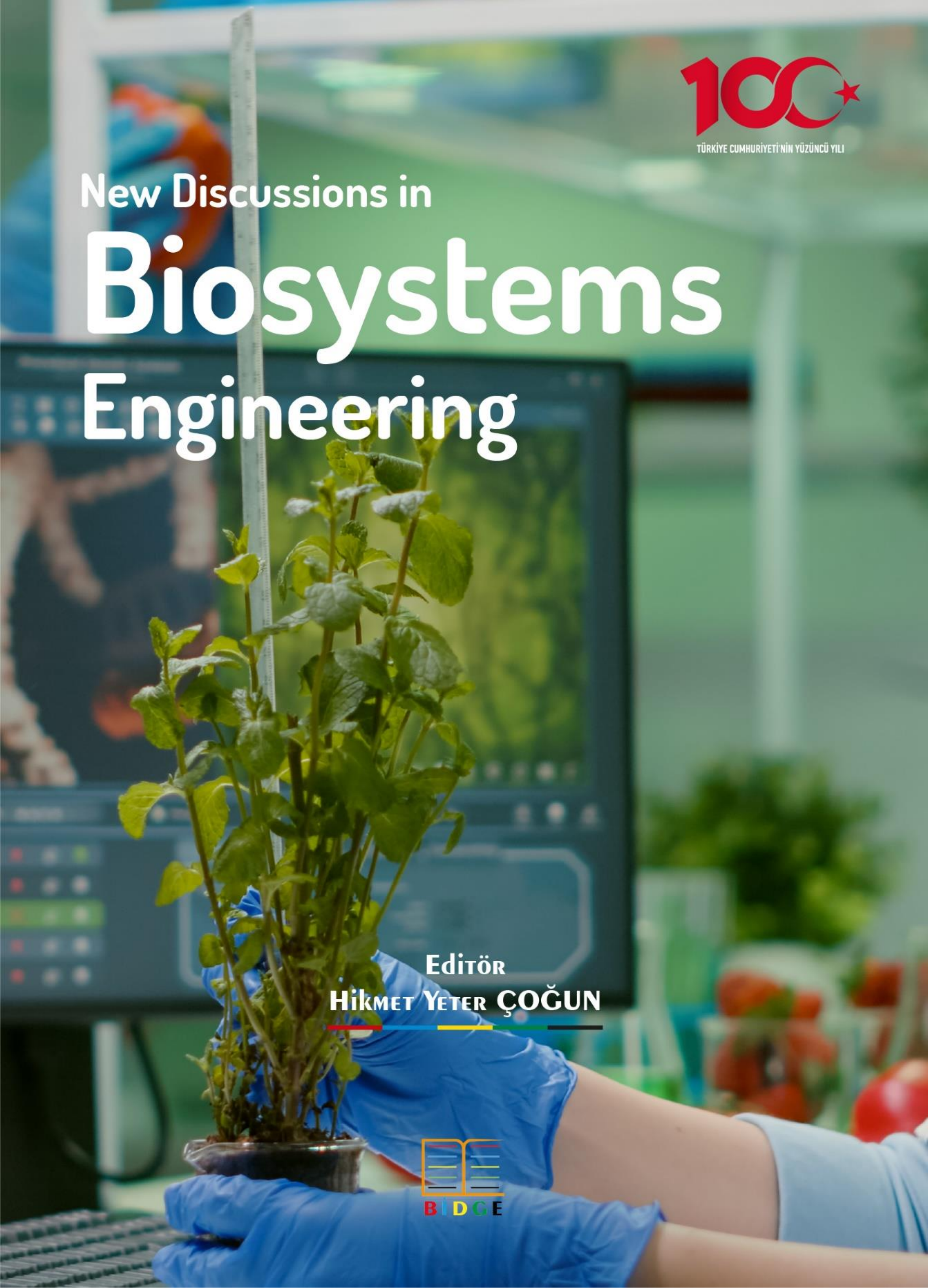

TÜRKİYE CUMHURİYETİ'NİN YÜZÜNCÜ YILI

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PREFACE

The rapid increase in population has significant effects on the environment and natural resources. As the population increases, more resources are consumed and more waste is produced, which leads to a decrease in the quality of life of both humans and other living creatures. The purpose of the New Discussions in Biosystems Engineering book is; Some of the features and importance of biosystem engineering are to be a source of up-to-date information in the light of theoretical knowledge. In this context, New Discussions in Biosystems Engineering book chapters will be an important course resource.

Editor

Hikmet Yeter Çoğun

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CHAPTER I

Women’s Entrepreneurship in Rural Areas: The Case Study in Cumalıkızık, Turkey

Müge KİRMİKİL[1]

1. Introduction

Entrepreneurship is considered an important undertaking by which to alleviate poverty (Agu & Nwachukwu 2020; Igwe & al. 2020; Obunike 2016). Schumpeter (1911) has defined an entrepreneur as a creative and determined individual who finds “new combinations of production” to develop a new product, capture a new market (Kim & Lim 2022), or design a new technology. Women’s entrepreneurship is important for three reasons. First, as noted by Schumpeter (1911), entrepreneurship plays an important role in the development process, and recognizing only male entrepreneurs means neglecting the economic growth potential of one-half of the population. Second, women-led micro- and small

[1] Doç.Dr. Bursa Uludağ Üniversitesi Ziraat Fakültesi Biyosistem Mühendisliği Bölümü

businesses may have a more significant impact on overall household welfare and consumption than those led by males. Female entrepreneurs and heads of households tend to spend more money on household health, nutrition, and education than males. Third, women's entrepreneurship is important for promoting sexual equality in the labor market. Increasing female entrepreneurship increases both the number of female employers and female employees in the labor market because female entrepreneurs tend to employ proportionally more women than male-run companies (Nichter & Goldmark 2009); however, significantly fewer women than men worldwide own and run businesses (Georgellis & Wall 2005; Minniti & Naude 2010).

Although the number of female entrepreneurs has increased significantly in recent years (De Bruin & al. 2006), empirical evidence has shown that the number of male entrepreneurs remains significantly higher than that of females, and these differences are consistent across countries (Minniti & al. 2005). Several international organizations and nongovernmental organizations, notably the World Bank, have begun to support women's entrepreneurship in sectors that use innovation, research and development, digitalization, and advanced technologies and that generate higher incomes (Ökten 2013). Thus, they attempt to overcome sectorial discrimination between men and women, increase women's active participation in the economy, and support the states' patents, research and development, technological development, and innovation policies (Anonymous 2018).

Entrepreneurs are one of the most important key factors in structuring economic activities by creating employment areas within different stages of production activities. Entrepreneurship, which has rapidly developed since the 1980s, has increasingly appealed to women (Türkten & Demiryürek 2015). Their increased participation in entrepreneurship activities can be attributed to changes in the sociocultural structure, sex-based difficulties in working life, perception of entrepreneurship as a job guarantee, and increasing number of successful women entrepreneurs (Soysal 2013); therefore, this increasing trend in women's entrepreneurship has been emphasized and studied in recent years (Yürük & Engindeniz 2020).

Female workers constitute approximately 51% of the agricultural employees in Turkey; however, women's labor and production potential in rural areas are not considered an economic input, and they are defined as an "unpaid family worker"; therefore, their role in the traditional economic structure tends to be invisible and disregarded (Asan & al. 2012; Ilter & al. 2019; Koutsou & al. 2009) even though rural women contribute to their family's economic well-being by producing goods and services for family consumption and the market economy and ensure the sustainability of agricultural production and thus rural development. Women should be considered a target audience in the rural development process and their active participation in this process should be enhanced (Erdoğan 2021).

Until the industrial revolution, women generally performed household chores or handicraft works; however, their place in society changed in the years that followed (Milliken & al. 1998), and it has become very important for women entrepreneurs to take on economic roles. Their entrepreneurship has positively contributed to employment and increased their status in society, enabling them to become independent and create a better society by becoming self-confident individuals (Özyılmaz 2016).

Women participate in working life at various levels within many different areas of urban life. They also contribute to family income in rural areas by doing household chores; engaging in various activities, such as agriculture and animal husbandry; and selling their surplus products in the marketplace (Şahan & al. 2014).

Rural areas are small settlements with a low population density that are separated from cities by their various social, economic, and geographic differences (Özensel 2015). After the declaration of the republic in Turkey in 1923, 25% of the population lived in cities and 75% in rural areas. These rates have somewhat reversed since the 2000s, and the proportion of those living in rural areas constitute ~35% of the total population. According to 2020 data of TURKSTAT (2020), 92.3% of the total population live in provincial and district centers and 7.7% in villages and towns.

The main problems of women entrepreneurs in rural areas are their low level of education, lack of knowledge about the business they have established and difficulties in work-family balance. Lashgarara & al. (2011) stated in their study that women who started a new business in rural areas were quite inexperienced in obtaining information about work and supportive systems. At the same time, women in new ventures do not have investment and savings education and knowledge, sales, marketing and management knowledge and experience. The patriarchy of the rural lifestyle is another problem. In patriarchal societies, men often perceive financing women's enterprises as a significant risk. Women generally have a low risk-taking attitude. Instead of applying to banks or other credit institutions, they obtain financing by using their savings or borrowing from their close family, relatives and friends. In addition, low literacy and education levels cause them to be ignorant or inadequate about the use of new technologies (Paluri & Mehra 2016).

The aim of the present study was to determine some of the factors that affect women in rural areas in their ability to consider themselves as entrepreneurs.

2. Materials and Methods

The main methods used in the present study comprised face-to-face surveys with women living in Cumalıkızık Village of Yıldırım District in Bursa, Turkey. The data gathered were age, educational level, marital status, annual family income, home ownership status, number of people in the household, social-security status, frequency of travel to city centers, entrepreneurship information sources, status of project application to support entrepreneurship, barriers they faced in entrepreneurship, and whether they considered themselves to be entrepreneurs.

Cumalıkızık is an important cultural heritage area where houses are examples of original civil architecture, shaped by traditional Ottoman architecture, and integrated with organic street texture and monumental structures. Cumalıkızık is somewhat of an open-air museum with houses in which people live, was entered onto the UNESCO World Heritage temporary list in 2000, and was registered as a World Heritage Site in 2014 together with the Khans Area–Sultan Complexes of Bursa (Anonymous 2021).

Cumalıkızık, one of the most magnificent village settlements representing Ottoman rural architecture, is a 700-year-old foundation village that was established on the southern slopes of Uludağ Mountain. It is located 3 km along the provincial road that branches 10 km from the Bursa-Ankara Highway to the south, and has been established within an area of approximately 10 ha. Cumalıkızık is a very rich neighborhood in terms of rural tourism because of its proximity to Bursa; its cool weather, especially in summer; and its natural beauty.

2.1. Data collection

The data were collected in 2021 using face-to-face surveys of women in Cumalıkızık. The number of women to be surveyed was determined using the proportional sampling method according to the following formula (Karaturhan 2017; Miran 2003; Newbold 1995; Özdemir & al. 2017; Yüzbaşıoğlu, 2022):

$$n = \frac{Np(1-p)}{(N-1)\sigma_{p_x}^2 + p(1-p)}$$

(1),

where, n = Sample size, N = total number of women, p = ratio of women and σ_(p_x)^2= variance of the ratio.

Considering the TURKSTAT (2020) data on the female population in Cumalıkızık and using Eq. (1), the sample size was determined to be 134 women, assuming a 90% confidence interval and 10% margin of error. For the questionnaire applied within the scope of this article, approval was obtained from Bursa Uludağ

University Research and Publication Ethics Committee (Social and Human Sciences Research and Publication Ethics Committee) with the decision of the session number 2020-09, dated 27.11.2020. The article has been prepared in accordance with research and publication ethics.

2.2. Data analyses

The data gathered from the surveys were analyzed using SPSS ver. 23 (IBM Corp., Armonk, NY, USA) and tables were created from these data using the cross-tabbing method and calculating the averages and percentages. One-way analysis of variance (ANOVA), post-hoc analysis, and the paired-samples t test were used to determine the parameters that affected women's entrepreneurship. Pallant (2001) emphasizes that when the flatness and skewness coefficients of the dimensions that are seen to be not normal are examined, the flatness and skewness coefficient between +2 and -2 show a normal distribution. According to the analyzes made on whether the scale provides the assumptions of normality and homogeneity, it was seen that homogeneity (Levene Test $F=.488$, $p>0.05$) was achieved. The assumption of normality was found to be Skewness =-.328 and the coefficient of flatness (Kurtosis =-1.298) between +2 and -2, and from this point it was assumed that it was normally distributed.

3. Research Results and Discussion

Table 1 presents the women's demographic characteristics. More than one-half (76.9%) of those surveyed were middle-aged or older. Table 2 provides the descriptive statistical results of their ages. Of the women surveyed, 44.8% were primary-school graduates, 40.3% were middle-school graduates, 13.4% were high-school graduates, 0.7% were university graduates, and 0.7% did not attend school but were not illiterate.

More than one-half of the women were married (73.9%), 12.7% were single, and 13.4% were widowed or divorced. When those married were asked about how they were married, 72.4% had an arranged marriage, 19.4% had a marriage to a loved one, and 8.2% did not give an answer. Unfortunately, the marriage age is low in the villages, and those surveyed were also asked about their age at first marriage. Of the respondents, 15.7% reported that they were married at from 13 through 15 years old, 53% at from 16 through 18 years old, 15.7% at from 19 through 21, and 2.9% at ≥22 years old; 12.7% did not give an answer.

In addition, 85.9% of the women surveyed had a total annual income between 3000 and 15000 TRY, 13.4% between 15001 and 30000 TRY, and only one >30000 TRY. As of January 1, 2020, the monthly minimum wage in Turkey was 2324.70 TRY. Those families with an annual income between 3000 and 15000 TRY were considered to be low-income residents.

Table 1. *Distribution of women's demographic characteristics (%)*

		Number of people	%
Age	20-30	31	23.1
	31-45	48	35.8
	46<	55	41.1
Education	primary-school graduate	60	44.8
	middle-school graduate	54	40.3
	high-school graduate	18	13.4
	university graduate	1	0.7
	did not attend school	1	0.7
	not literate	0	0
Marital status	single	17	12.7
	married	99	73.9
	widowed or divorced	18	13.4
Deciding on Spouse Choices	arranged marriage	97	72.4
	marriage to a loved one	26	19.4
	unresponsive	11	8.2
First marriage age	13-15	21	15.7
	16-18	71	53
	19-21	21	15.7

	22-24	3	2.2
	25<	1	0.7
	unresponsive	17	12.7
Annual Income	3000-15000	115	85.9
	15001-30000	18	13.4
	30001<	1	0.7
Household	2 people	47	35.1
	3 people	37	27.6
	4 people	34	25.4
	5 people and above	16	11.9
Living house	Rent	17	12.7
	property owner	117	87.3
Frequency of travel to Bursa	least once a week	73	54.5
	every month	50	37.3
	less frequently	11	8.2
Social Security Status	no social security	33	24.6
	fathers	12	9.0
	husbands	87	64.9
	private life insurance	2	1.5

Of those surveyed, 87.3% reported to be property owners of their homes and 12.7% to be tenants. Within the household, 35.1% lived with two other people, 27.6% with three people, 25.4% with four people, and 11.9% with more than five people.

Cumalıkızık is an advantageous settlement because of its proximity to the center of Bursa. When the women were asked about their frequency of travel to Bursa, 54.5% reported that they travel to Bursa center at least once a week. 37.3% every month, and 8.3% less frequently.

In addition, 64.9% of the women received social security through their husbands and 9% through their fathers; 24.6% had no social security and 1.5% had private life insurance.

As seen in Table 2, the highest arithmetic mean (0.95) belongs to those aged ≥45 years old and the lowest (0.73) to those from 31 through 44 years old. The arithmetic mean of those from 20 through 30 years old was relatively close to those from 31 through

45 years old ($\bar{X}$ = 0.77). The general arithmetic mean of these three age groups was 0.83.

Table 2. *Descriptive statistical age analysis*

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Min.	Max.	Between-Component Variance
20-30		31	.77	.425	.076	.62	.93	0	1	
31-45		48	.73	.449	.065	.60	.86	0	1	
46<		55	.95	.229	.031	.88	1.01	0	1	
Total		134	.83	.378	.033	.76	.89	0	1	
Model	Fixed Effects			.368	.032	.77	.89			
	Random Effects				.072	.52	1.14			.012

The aim of the present study was to determine the factors that affect rural women's perceptions of being an entrepreneur (Table 3) (no = 0, yes = 1). The statistically significant factors are provided. Table 3 presents the distribution of women according to their perceptions of being an entrepreneur. Of those interviewed, 82.84% considered themselves to be entrepreneurs and 17.16% did not.

Table 3. *Distribution of considering oneself as an entrepreneur by age*

		Entrepreneur		
		0	1	Total
Age	20-30	7	23	30
	31-45	13	35	48
	46<	3	53	56
Total		23	111	134

After the basic descriptive information provided in Table 2 regarding the average and distribution characteristics by age classification, one-way ANOVA was conducted to check whether there was a significant difference between those who considered themselves to be an entrepreneur and those who did not based on the age variable (Table 4).

Table 4. *Results of the one-way analysis of variance of the relationship between age and entrepreneurship*

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.317	2	.659	4.865	.009
Within Groups	17.735	131	.135		
Total	19.052	133			

As seen in Table 4, there was a statistically significant difference among the age groups ($df[2–131] = 4.865$; $p < 0.01$). The post-hoc test was conducted to determine the source of this difference among the age groups; the results are provided in Table 5.

Table 5. *Source of the Difference between age groups*

(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
20-30	31-45	.045	.085	1.000	-.16	.25
	46<	-.171	.083	.121	-.37	.03
31-45	20-30	-.045	.085	1.000	-.25	.16
	46<	-.216*	.073	.010	-.39	-.04
46<	20-30	.171	.083	.121	-.03	.37
	31-45	.216*	.073	.010	.04	.39

*. The mean difference is significant at the 0.05 level.

Table 5 presents the multiple comparison test results of three age groups. According to the results of Bonferroni multiple comparison test, there was no statistically significant difference among those from 20 through 30 years old, those from 31 through 45 years old, and those ≥46 years old (df[2–131] = 4.865; $p > 0.01$). In addition, there was a significant difference between the average values of those from 31 through 45 years old and those >46 years old (df[2–131] = 4.865; $p < 0.01$).

Likewise, a statistically significant difference was found between the average values of those >46 years old and those from 31 through 45 years old (df[2–131] = 4.865; $p < 0.01$), and there was no significant difference between the average values of those >46 years old and those from 20 through 30 years old (df[2–131] = 4.865; $p > 0.01$).

The paired-samples t test was applied to determine the effect of education level and marital status on the women's perception of being an entrepreneur; the results are provided in Table 6.

Accordingly, the women's marital status (t0.05:133 = 22.791) and education level (t0.05:133 = 11.110) were found to affect their perception of being an entrepreneur. Chitsike (2000) has stated that in the absence of cultural constraints, women move away from entrepreneurship because of their inadequate education (Türkten & Demiryürek 2015). Çolakoğlu & al. 2022 said that for the development of women's entrepreneurship in rural areas, women and men should have equal educational rights, and that well-educated women can easily carry out entrepreneurial activities and thus solve their economic problems more easily. For this reason, when making rural development plans, it would be a correct approach to focus on trainings such as entrepreneurship training for women.

Table 6. *Results of the paired samples t test based on education level and marital status*

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	marital status-entrepreneur	1.179	.599	.052	1.077	1.281	22.791	133	.000
Pair 2	Education-entrepreneur	.903	.941	.081	.742	1.064	11.110	133	.000

Marangoz & al. (2016) have divided entrepreneurship into subdimensions comprising self-confidence, innovation, need to succeed, locus of control, risk taking, opportunity orientation, leadership, future orientation, individual power, and creativity and have found a statistically significant relationship between education level and creativity. They have also concluded that the difference between education groups in terms of creativity is the results of the differences between the groups who attended only primary school and those who attended a university.

In Turkey, the Agriculture and Rural Development Support Institution provides several financial grants and incentives and ensures the most rational use of all possibilities to be obtained artificially using existing natural and financial resources to increase the income level of people living in rural areas and those involved in the general agricultural sector, improve income distribution, preserve natural resources, and reflect natural wealth to all people. In the present study, 92.5% of the women interviewed had applied for a support project. The women stated that the most important factor in applying to these projects is to earn an additional income (51.5%) and to become a business woman (26.1%) (Table 7).

Table 7. *Factors in applying for a support Project*

	Number of people	%
Evaluating the agricultural and handicraft products produced	5	3.7
Earning additional income	69	51.5
Develop their skills	25	18.7
Become a business woman	35	26.1

Access to information has become easier with today's technology and the women interviewed in the present study were asked about their sources of information on entrepreneurship. Of all respondents, 58.2% reported to have obtained information from their acquaintances, 35.8% from the electronic media in their villages, and 6% from television. Their inability to obtain information online may have been because of the lack of computer use or Internet access in their villages (Table 8). Onay Özkaya (2009) has conducted face-to-face interviews with 25 women entrepreneurs who are members of the "Women Entrepreneurs Board" established under the leadership of the Union of Chambers and Commodity Exchanges of Turkey (TOBB) TOBB in Manisa and affiliated with the Chamber of Commerce and Industry, and have determined that the 50% of women first approach spouse, relatives, and family members, 42.85% approach informed people, and 7.15% approach educational institutions for support and information channels.

***Table 8**. Women's sources of information on entrepreneurship*

	Number of people	%
Television	8	6.0
Education - meeting	48	35.8
Acquaintances	78	58.2
İnternet	0	0

In the present study, the women were asked about the obstacles they faced in becoming an entrepreneur; the results are provided in Table 9. Nearly one-half (44%) of the women reported insufficient financial support as the major obstacle, followed by lack of knowledge/experience (33.6%), and sex discrimination (13.4%).

***Table 9.** Obstacles women faced in becoming an entrepreneur*

	Number of people	%
Education level	4	3.0
Insufficient financial support	59	44.0
Lack of knowledge/experience	45	33.6
Economic uncertainty	5	3.8
Sex discrimination	18	13.4
Family problems	3	2.2

Minniti & Arenius (2003) and Philips (2005) have conducted studies on women's entrepreneurship and have found the factors affecting women's entrepreneurship are as follows: demographic environment and family structure, literacy and education, socioeconomic environment, workforce and employment, sex and organizational norms, financial support, lack of information, and sectorial employment and economic development (Soysal 2013). Mwangi (2012) have stated that lack of management and marketing information, difficulty in accessing financial resources, competition from the domestic informal sector in foreign markets, sex discrimination, insufficient protection of intellectual property rights, and cultural diversity have an effect on women entrepreneurship. Mehta & Mehta (2011) have listed the obstacles that women entrepreneurs face as follows: a male-dominated culture, low literacy rates, low skills and lack of knowledge, lack of infrastructure, and lack of financial resources. Studies conducted in Turkey have found that the factors preventing women's entrepreneurial activities in rural areas are as follows: low level of education, introversion, socially accepted prejudices, suppressed women's behaviors, psychological inability to see oneself as an entrepreneur, disorganization, home–work incompatibility, inability to access credit resources, low income level, inability to provide collateral, lack of corporate information, insensitivity of public institutions and organizations and local governments, and sex discrimination (Can & Karataş 2007; Fidan & Nam 2012; Kulak 2011; Soysal 2013).

Conclusion

Women's entrepreneurship is as an important field of employment in both developed and developing countries. In Turkey, economic and social life has become more effective with the active role of women in recent years with entrepreneurial qualities in business life. Women's entrepreneurship has increased their economic independence, self-confidence, and social status. Because women entrepreneurs are more emotional than male entrepreneurs, women must be prepared for ordinary and extraordinary problems occurring both during business establishment and operations and arising from being a woman. Determining problems faced by women entrepreneurs, who have a potential to stimulate the economy through different entrepreneurship policies, reveals a need for comprehensive studies on how to cope with these problems more effectively. It would also be beneficial for new women entrepreneurs to provide the reasons for them becoming involved in business life, the negative encounters they face during this process, and the problems they face in starting and running a business. In this regard, the present study examined the demographic characteristics and entrepreneurship status of women entrepreneurs in Cumalıkızık Village of Yıldırım District in Bursa, Turkey, and determined the factors that affected their entrepreneurship and the problems they have encountered during this process in conjunction with their views on entrepreneurship.

In the present study, more than one-half of the women were middle-aged and above. Young populations in villages leave rural areas and migrate to metropolitan cities to seek better living conditions, receive a higher education, and work in nonagricultural sectors. Rural migration will decrease if the socioeconomic concerns of people living in those settlements are eliminated and better regulations are introduced within their working conditions.

The present study found that age, education level, and marital status have an important and positive effect on women's entrepreneurship. Financial, managerial, organizational, and educational supports should be increased and sex discriminatory barriers should be removed for women to be more successful in entrepreneurship activities. In addition, for women to be more productive and innovative in entrepreneurship activities, a higher number of regional studies should be conducted on women's entrepreneurship, and the ability for women to obtain and share up-to-date information should be facilitated.

The physical and structural situation of each region, needs, problems, priorities, customs and traditions vary. These differences also affect women entrepreneurship. Therefore, regional differences should also be taken into account when developing programs and agricultural policies especially for women living in rural areas.

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CHAPTER II

Uses of Leaf Water Potential (LWP) in Agriculture for Planning Irrigation Programs

Uğur KEKEÇ

1. Introduction

The main purpose of irrigation is to provide water to the plant as and when it is needed. Therefore, monitoring the plant is a more accurate method of determining the irrigation time. Since the plant responds to the environment (soil-water-atmosphere) and also the plant is located between the soil, which is the water source, and the atmosphere, using the internal water state of the plant for irrigation programming is much healthier and more reliable than traditional irrigation programming based on soil water observations. Water scarcity situation in the world; It is linked to the need for food and climate change. Global warming due to the greenhouse effect creates unpredictable results in the distribution of water. This means that imbalances occur in the distribution of precipitation, which reveals that countries with low irrigation water will experience water problems. It is normal to reduce the negative effects of water shortage predictions on production by researching and sustaining new solutions. Under these conditions, it is important to know the plant's water needs in detail, use water effectively and determine the irrigation program in the most accurate way. It is generally accepted that plant development is related to the water balance in its tissues. Shortage of water affects the physiological processes in plants, first the growth of the plant, and then the productivity. The water balance in the tissues determines the amount of water absorbed into the atmosphere by plants (Tekinel & Kanber, 1978). Acceptable assessment of irrigation water requirement should be based on the observed changes in the growth of plants if they are affected by the lack of water.

Irrigation water should be provided as needed by the plant to prevent or minimize deviations from optimum growth. To achieve this goal, many methods have been developed to determine the water status in plants. Some of the methods mentioned are based on the soil and the environment, and some on the plant. Herbal Since it combines its entire environment consisting of soil and atmosphere, neither the soil water condition nor the atmospheric demand truly reflect the plant water condition. Therefore, physiological approaches to the determination of plant water status are gaining more and more weight. An evaluation of the general condition of the plant can be made with the technique of measuring appropriate vegetative parameters and irrigation can be decided using this information. Until now, many studies have been conducted on the indirect or direct measurement of the water status of plants and the signs of water stress in plants and many methods have been introduced (Denmead & Shaw, 1962; Ehlig & Gardner, 1964; Namken et al., 1969). It can be classified as techniques that measure the potential of water, water content methods, and methods that detect visual stress symptoms in plants. however, most of the mentioned methods are limited in their usability for irrigation scheduling beyond physiological studies (Stegma et al., 1986).

Leaf Water Potential Measurements

Leaf water potential is a physiological criterion frequently used in irrigation programming. Leaf water potential (LWP), which defines the energy state of the water in the plant, in other words, a driving force for water movement in plants; It is a negative value, expressed as "bar" (0.987 atm=0.1 MPa), showing how much the energy state of the water in the leaves is less than the energy state of pure water at the same temperature. The variation of the specified value according to the transpirational flow and the water content of the soil shows the importance of the leaf water potential in the evaluation of the plant-water relationship. Leaf water potential is a parameter that defines the internal state of the plant and can be easily measured, and in recent years, parallel to the developments in technology, it has been widely used in irrigation programming of high income crops. When this method is used together with micro-irrigation (such as drip, mini-sprink) methods that can apply water more efficiently and with high uniformity, significant savings in irrigation water are achieved and water usage efficiency is maximized. Leaf water potential (LWP) is widely used to describe the water status of plants (Hsiao, 1990). LWP is a very accurate indicator of crop water status, helping to estimate the effect of water deficit on crop yield. Small changes in water content in leaf cells correspond to large changes in leaf water potential (Hsiao et al., 1976; Kramer & Boyer, 1995).

Even though the daily variation in the leaf water potential can make it difficult to determine the correct time to measure LWP, on a sunny day LWP is partly constant at noon for several hours and reaches a minimum level (Kramer& Boyer, 1995) in most fruit tree cultivars. Some researchers argue that the PWP is more persuasive than the LWP as a plant water level indicator. There is, however, a large body of scientific evidence to the contrary. Irrigation plays an important role in the world’s fruit-growing regions, particularly in arid or semi arid climates. For instance, the Mediterranean region, where citrus fruits are grown, is characterized by hot and dry summers. Irrigation plays a key role in the production of high-quality products. Kekec. U & Özekici.B, (2020) found in their study that the use of soil water at plant root depth (Field Capacity-Available Soil Water) together with leaf water potential (LWP) measurements in grapefruit trees is a good indicator for irrigation of trees in different parts of the garden and they concluded that both the irrigation time and the amount of water to be applied can be predicted, and they determined that a grapefruit orchard or different parts of the same garden can be irrigated when the LWP value is 25-26 Bar or the soil water use is 60-66% (Figure 1).

Goldhamer et al., (1985) explained that water losses from plants through transpiration are controlled by stomata in the leaves. (Goldhamer et al., 1986) measured the leaf water potential value as -3.59 MPa in unirrigated subjects and -1.54 MPa in fully irrigated subjects in their LWP measurements at different irrigation levels in young and newly emerging Pistachio trees (11 years old). Monastra et al., (1997) explained that pistachio leaves are highly resistant to drought due to stomata on both sides and the opening and closing of stomata is controlled by the relative humidity in the external environment. In the findings of the study, with the increase in the relative humidity of the air during the hot hours of the day, the stomata close and the leaf water potential value starts to decrease again in the negative direction. Steinberg et al., (1989), examined the effects of leaves of different maturity on LWP osmotic potential, turgor potential and stomatal conductivity in old peach trees; young leaves have a higher leaf water potential of -2.4 bar than old leaves under different soil moisture content conditions. In plants irrigated at different levels of available water, differences of approximately 5 bar in young leaves and 4 bar in old leaves of plants irrigated at the highest and lowest humidity levels were determined.

Figure 1. *The LWP measueremnts and the LWP equipment.*

Kaynaş, (1994) investigated the effects of different irrigation levels on leaf water potential in peach and nectar varieties; He determined that there were daily and seasonal changes in LWP values and stated that in seasonal measurements made in the middle of the day in all plants, the LWP values decreased over time and the decreases increased as the amount of water given to the plant was limited. In the daily leaf water potential changes, it was determined that the LWP, which was maximum before sunrise, increased again after reaching the minimum level in the middle of the day. Özmen, (2002) reported that the lowest LWP values were measured as -3.2 MPa and -2.9 MPa, respectively, in fully and incompletely irrigated subjects in his study on pistachio trees at the yield age. Aydın, (2004), in his study in which different irrigation water and nitrogen levels were used in pistachio, made leaf water potential measurements on the subjects that were fully irrigated and the most nitrogen was given and the subjects that were not irrigated. Leaf water potential values in irrigated subjects reach approximately -2.5 MPa in the middle of the irrigation period; After this value, stomata close and tend to prevent transpiration. In the non-irrigated subject, the aforementioned value was measured as -3.68 MPa. A continuous decrease (negative increase) was observed in irrigated subjects compared to non-irrigated subjects (Takahiro et al., 2006).

Mid-day leaf water potential is used in irrigation programming, and this parameter remains at a fairly stable level from the beginning of maturation in the vineyards. Quality criteria such as yield, grain size and homogeneity and must composition are of great importance in non-wine grape varieties. Optimizing the irrigation application in terms of irrigation time and amount of water in these varieties plays a very important role in terms of yield and quality. Determining the reflections of irrigation time and level on these features is of great importance especially for the Mediterranean Region, where the potential for early table grape cultivation is high. Leaf Water Potential The amount of usable water indirectly affects vegetative development as a result of physiological events such as leaf water potential, photosynthesis and transpiration. In conclusion, irrigation management successfully controls vigor and growth in vines, which are sensitive to water stress (Loveys et al., 1998) (Matthews et al. 1987) stated that the mid-day leaf water potential value decreased during the early development periods regardless of whether it was watered daily or weekly. It has been reported that the mid-day leaf water potential value decreases to -0.4 MPa before flowering and -1.0 to -1.2 MPa during the fall period under good irrigation conditions, and after this period, the leaf water potential remains at a constant value. After the veraison period, the indicated value decreased rapidly to -1.6 MPa under the conditions of no irrigation. Williams & Araujo , (2002) stated in their study conducted in California that the midday leaf water potential was not more negative than -10 bar (-1.0 MPa) in fully irrigated subjects, and in general, when irrigating at this value of the leaf water potential, high quality product was obtained. In his study on thompson seedless variety, it was reported that the leaf water potential did not decrease to -10 bar (-1.0 MPa) until flowering and the first irrigation could only be done during the flowering period.

They determined that 80% of the actual plant water consumption in irrigation was applied and the reduction did not affect the fruit grain size. (Girona et al., 2005), in their study on a 12-year-old Pinot-noir vineyard variety in Spain, started irrigation at three different values of the midday leaf water potential and applied 4-6 mm of water daily with the drop method. From the awakening of the buds until mid-June (until the veraison period), the yield per vine was 10.82 kg/grape planted in the witness subject where the leaf water potential was -0.6 MPa and after the veraison period -0.8 MPa; From the awakening of the buds to mid-June (veraison), the yield reduction was 43% (6.12 kg/grape plant) in the subject irrigated at -1.0 MPa of LWP. From bud awakening to mid-June (until the veraison period) leaf water potential is -0.6 MPa; In the next period, the yield was determined as -1.2 MPa and 9.21 kg/grape plant for moderate stress under irrigation.

Santesteban & Royo, (2006) investigated the effects of leaf water potential, leaf area and yield load on grain size and sugar concentration in Tempranillo grape variety in Southern Spain vineyards and found close relationships between grain size and leaf water potential and sugar content. It was stated that grain size at harvest depends on many factors, especially environmental factors, fertilization, leaf area and leaf water potential. (Rana et al., 2004), as a result of the study carried out in 3 different (thin, plastic and uncovered) covered areas in the vineyard; Leaf water potential decreased in the uncovered vineyard and decreased to its lowest level in time.

Grimes & Yamada, (1982a) irrigated cotton according to the leaf water potential values they measured with the pressure chamber technique in their study. Researchers have recommended irrigation when the leaf water potential decreases to -16 bar at the beginning of the growing season, to -18 to -20 bar in the middle of the season, and to -18 bar during the peak flowering period. Takahiro et al, (2006) They carried out a study to demonstrate the suitability of using LWP as an irrigation time indicator in wheat plants in the Mediterranean climate. According to the researchers; There are 3 important factors affecting the leaf water potential: soil water conditions, nighttime weather conditions and soil surface conditions. As a result, it is not recommended to use only LWP as an irrigation time indicator. They attributed this to the fact that it caused reductions in the product. The researchers decided to create an appropriate irrigation indicator by examining other characteristics of the air (such as daily temperature ranges, humidity values) in future studies. They attributed this to the reduction in yield. Researchers decided to create an appropriate irrigation indicator by examining other characteristics of the air (such as daily temperature ranges, humidity values) in future studies.

Sato & Sakuratani, (2005) used leaf water potential measurements at dawn to determine the irrigation time by experimenting with three different irrigation programs on five different wheat cultivars in northern Syria conditions. They investigated the relationships between soil water potential, atmospheric vapor pressure gap, root density and LWP. They determined that LWP alone could not be used to determine irrigation time and correlated LWP with soil water potential, atmospheric vapor pressure deficit and root density.

The water status in plants at any given time was defined by Cowan, (1965) as the ratio between the plant's water loss and uptake. Accordingly, the water potential does not remain constant when loss and uptake are equal. In sunny weather, water loss will increase as the vapor pressure of the atmosphere increases. Irrigation time can be determined depending on the plant water content. The plant cell water state can be characterized by chemical potential or water potential (Kramer & Boyer, 1975).

Leaf water potential at noon is usually taken into account, as it best indicates the water condition in the plant. Many researchers have shown that there is a close relationship between LWP and plant water parameters. Some plant-related parameters such as available water in the soil (Stricevic & Caki, 1997), evapotranspiration (Meyer & Green, 1980), proportional transpiration (Valancogne et al., 1997), leaf age and photosynthesis (Turner et al., 1986) were explained with LWP.

Conclusion

One of the major issues in irrigated orchards is the lack of feasible techniques for determining irrigation water amount and frequency (Kanber et al., 1999; Assaf et al., 1982). The irrigation schedule is especially significant because net revenue for fruit crops is typically higher than for other crops (Fereres, 1997; Pereira & Villa Nova, 2009; Al-Yahyai, 2012). Fruit tree growers have to overcome terrestrial and seasonal variations in soil and microclimate that impact plant growth. Furthermore, because of recent climate change, farmers of 8–30 year old orchards are facing high levels of uncertainty regarding output and quality. Regarding consistent and long-term yields, the effects of fertilization and irrigation practices in orchards are critical. Reliable data and information are needed to optimize the irrigation program. From an engineering point of view, a conceptual basis is needed for deciding an irrigation program. Within the mentioned conceptual basis, yield and quality are considered as an interconnected feedback. From an engineering point of view, a conceptual basis is needed for deciding the irrigation program. Within the mentioned conceptual basis, yield and quality are considered as an interconnected feedback. Numerous techniques are used to determine the water requirements of fruit trees. Tree irrigation water requirements have long been estimated using direct or indirect observations of soil, water, and climate. However, because fruit trees have different anatomical and morphological characteristics and are more compatible with soil water levels, the measurements indicated are more appropriate for herbaceous plants than trees (Al-Yahyai, 2012). Tree water use is particularly dependent on weather conditions, leaf area forming an effective transpiration surface, and tree phenology (Pereira & Villa Nova, 2009).

Among a variety of physiological variables, measurements of leaf water potential are most commonly employed as a tree water status indicator (Hsiao, 1990, Al-Yahyai et al., 2005). Utilizing plant and soil characteristics while determining the irrigation schedule is frequently advantageous. In order to ascertain the characteristics of the soil, including plant type, cover width, rooting depth and width, plant density, and leaf water potential, this method involves soil analyses. Fruit trees' physiological processes, such as gas exchange and water potential, are extremely sensitive to variations in the water content of the soil (Al-Yahyai et al., 2005; Naor & Cohen, 2003). The right amount of water to give the orchard depends on the soil water content, which should be associated with the physiological variables growth and fruit set, in this case. Water tension develops in the plant when the amount of water lost from the leaves exceeds the amount of water received from the soil (Currier, 1967). Numerous physiological formations, including leaf growth and other plant functions, are impacted by the plant's decreased water level. Many plants are extremely sensitive to water shortages, and even brief periods of dryness can have a detrimental impact on yields (Hsiao et al., 1976).

Irrigation can be planned according to LWP values in clear sky conditions and in conditions where measurements made at midday are sufficient. While LWP is between -16 bar and -18 bar in cotton plant, an increase in yield can be expected when irrigation time is determined. The importance of optimizing water use in grape varieties can be better understood when considering the gradual decrease in the amount of water allocated for irrigation in arid and semi-arid regions due to global climate change. In the light of the results obtained from this study, in which the effects of different irrigation strategies created according to different threshold values of midday leaf water potential in the Mediterranean climate zone on yield, yield components, WUE, must quality in Italia and Flame Seedless varieties for three years, the following suggestions can be made. In Flame Seedless variety, when the midday leaf water potential reaches Ψl = -1.0 to -1.3 MPa (-10 bar); Italia variety, on the other hand, has the highest yield with Ψl = -1.3 MPa (-13 bar) irrigation. In irrigation, the missing moisture in the root zone should be brought to the field capacity. Considering that the mid-day leaf water potential reaches Ψl = -1.0 MPa (-10 bar) in 7-8 days in May in general, and 3-6 days in June and July, the watering intervals are between 3-8 days for Flame Seedless variety. implementation is recommended. In the Italia variety, the irrigation intervals are 12-15 days for May; It can be applied for 7-10 days in June and July. (Bozkurt, 2010).

Since the water-yield relations are very dynamic in the fields where crop production is made, irrigation programs to be planned according to the leaf water potential should be carried out according to the regions. It may be preferable to use the leaf water potential as an irrigation time indicator in the planning of irrigation programs according to the plants. Leaf water potential is a very accurate indicator of plant water status for estimating the effects of water shortage on plant yield, so it can be widely used to characterize plant water status. In addition, when planning irrigation programs in crop production, leaf water potential measurements can be used in terms of water savings and efficiency.

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CHAPTER III

Enhancing Collagen Bundle Structure Analysis: A Robust Approach through Crossing Density Analysis with Orientable Filters

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1. Introduction

The cornea is a transparent avascular connective tissue that covers the front part of the eye and functions as the primary infectious and structural barrier and protector of the eye. Along with the overlying tear film, it provides a proper anterior refractive surface for the eye. The human cornea is a highly organized tissue composed of five layers: three cellular (epithelium, stroma, endothelium) and two interfaces (Bowman membrane, Descemet

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membrane) [1]. The primary structural element of the cornea is collagen, which is the most prominent protein in the human body. Using quantitative methods, it is possible to distinguish the structural differences between collagen fibers of normal and diseased tissues due to the remodeling of the extracellular matrix during the infection cycle. Corneal diseases can be broadly classified into three categories: inflammatory, dystrophic, and degenerative. The corneal shape and curvature are highly conserved by the regular packing of the highly ordered hierarchical organized tiny collagen fibrils. Any alteration in the conformation of the collagen fibrils caused by damage will alter the corneal transparency and physical properties [2]. There are many common conditions that affect the cornea such as injuries, allergies, keratitis, dry eye, and corneal dystrophies. According to the World Health Organization (WHO), it is estimated that there are 45 million human beings around the world who are bilaterally blind and another 135 million that have gravely impaired vision in both eyes. Diseases that occur in the cornea are the main reason for causing blindness worldwide [3].

Clinical examination findings and topographic imaging methods are used in the diagnosis of these diseases. These diagnostic methods usually work in the later periods after the disease is established since they are based on anatomical changes. However, these methods have limitations such as low sensitivity and specificity. The basis of anatomical changes is in the collagen structure, which forms 90% of the cornea. Although the collagen structure in the cornea is of such importance, it is a great handicap that cannot be analyzed with the current clinical diagnostic methods [4]. In this context, 2-photon microscopy, which has started to be used clinically in the last few years, is a significant development with the potential to meet the present deficit. Unlike the standard microscopic examination methods, the ability of non-invasive imaging of collagen fibers in tissue by 2-photon microscopy provides a new perspective in this field. The multiphoton microscopy is divided into two types of microscopes: two photon excitation fluorescence (TPEF) and Second harmonic generation

(SHG). The traditional cornea topographic methods have many disadvantages such as small degree of malformation of the corneal shape not easy to be identified, limited depth of focus and subtle abnormalities cannot be detected [4-5]. On the other hand, multiphoton microscopy has proven to be worthy since it can show subcellular spatial resolution and the allowance to utilize different modalities to accumulate large amount of graphical data. This large amount of graphical data with high resolution and depth can be used in quantitative analysis of the collagen structure since, the disorganization of collagen 3D structure can be used as a biological marker of certain diseases [6].

SHG is a non-linear mechanism that two lower energy photons are up converted to twice the incident frequency of an excitation laser that is utilized for thick tissue imaging because the excitation utilizes near-infrared wavelengths, that permits excellent depth penetration [7]. Moreover, SHG provides several advantages for imaging tissue or live cell. Because the SHG working principle does not include the excitation of molecules and because of that the molecules will not be affected by phototoxicity effects or photobleaching and those effects can limit the usefulness of fluorescence. Also, many intrinsic structures do not need to be labelled with exogenous molecular probes because those structures can produce strong SHG [8]. However, there are several disadvantages to SHG imaging and one of them is the limited capability of imaging highly scattering tissue [9].

1.1. Methods for quantitative analysis of collagen bundles

Different approaches exist for identifying and analyzing the patterns within textures, particularly in regard to collagen morphology. One key aspect of images is texture, and it is often simpler to use in comparison to other spatial characteristics, such as shape and size. This is because it does not necessitate prior image segmentation and can be beneficial in certain situations. The methods that are commonly used for extracting textures are outlined below.

Spectral analysis techniques, such as Fourier, wavelet, and Gabor transforms, are widely used in the fields of image and signal processing for identifying textures and their visual properties. These methods involve the application of integral filters with specific parameters, which represent different spatial patterns within the texture, and then convolving the filtered image with the original image to produce a response. The similarity between the analyzed image fragment and the texture pattern can be assessed by calculating the value of the response [10-11]. While Fourier transform has been applied in collagen analysis, it has limitations in its ability to classify different morphological patterns based on the orderliness of collagen fibers. On the other hand, studies have shown that changes in collagen structure can serve as biomarkers for various diseases [12]. This highlights the importance of developing more sophisticated methods for analyzing collagen structures to better understand the relationship between collagen changes and disease development.

Statistical techniques in digital image processing refer to the utilization of mathematical models and algorithms that are based on probability theory and statistical principles to analyze, segment, and extract information from digital images. These techniques are applied in various tasks such as image categorization, separation of objects or regions, identification of unique features, removal of unwanted noise, and restoring images to their original form [13]. This method can be divided into first-order statistics-based method or second-order statistics-based method. First-order statistics methods provide a statistical illustration of gray-level distribution but neglect the spatial relationships between pixels in an image [14]. Second-order statistics methods calculate the likelihood of observing specific values of a pixel pair in the image, such as the Gray-scale Co-occurrence Method (GLCM) [15]. This statistical method analyzes the texture of a grayscale image by extracting second-order statistical texture features. The GLCM is a matrix of pixels where the number of rows and columns refers to the number of gray levels in the image [16]. The GLCM matrix element P(i, j - x, y) refers to the relative frequency of two pixels, separated by a pixel distance (x, y) within a given pixel neighborhood, where one has intensity 'i' and the other has intensity 'j'. The second-order statistical probability values for changes between gray level 'i' and 'j' at a certain displacement distance (d) and at a certain angle () contain the GLCM matrix element P(i, j - d,) [17]. The GLCM method computes how often pixel pairs with certain numerical values in a specific spatial relationship occur in the image. The spatial relationship, also known as offset, is the distance between a pixel and its neighboring pixels in a specific direction. The GLCM method creates a matrix, and from the matrix, features such as correlation, entropy, energy, and homogeneity can be extracted. Normally, the GLCM features are calculated along 0, 45, 90 and 135-degree angles .

The features that can be extracted using GLCM are contrast, homogeneity, correlation, and energy. Contrast provides information about the gray-level variation in a GLCM matrix. Correlation provides information about the correlation a pixel has with its neighboring pixels. Homogeneity is the measurement of the uniformity of non-zero pixels in the GLCM matrix, and energy refers to the texture uniformity of the target image (the pixel pairs repetitions) [18-19].

In structural methods, texture is defined by the presence of texture elements or primitives and the way they are arranged spatially. Mathematical morphology is an example of this approach and is used to analyze the geometric shape and generate descriptions. This method employs structuring elements to extract specific structures from an image, the shape of which is usually chosen based on prior knowledge of the desired and undesired image structures. The main parameters of binary morphology include the structuring element, erosion, dilation, opening, and closing. Dilation increases the size of pixels while erosion decreases it. Opening and closing are sequences of dilation and erosion where the former is erosion followed by dilation and the latter is dilation followed by erosion. However, structural methods are not appropriate for extracting oriented structures [20].

Fire algorithm is an automatic method which is used for the extraction of the geometric structure of 3D collagen images, and it calculates the length, number, and the curvature of the collagen fiber in the target image. As much as powerful this method looks, it has drawbacks such as the algorithm is not capable to extract the geometric structure when the collagen fibers are densely packed or when the target image quality is degraded and this is the case of the utilized dataset in this work [21]. Table 1 summarizes the limitations of the methods.

Table 1. Drawbacks of the literature utilized methods to analyse collagen bundles [10-21]

Method	***Limitations***
First-Order Statistics	Neglects spatial relationships between pixels in an image.
Second-Order Statistics (GLCM)	Limited to gray-scale images and may not capture all relevant information about collagen structure.
Fourier Transform	Cannot classify different morphological patterns such as linear, disordered or curved based on the orderliness of collagen fibers.
Fire Algorithm	Limited in its ability to capture the three-dimensional structure of collagen fibers, computationally intensive.

In this project, we proposed a quantitative analysis framework to measure distribution of collagen bundles SHG microscopy of human cornea. By utilizing the advantages of SHG, we aim to obtain high-resolution, deep graphical data of the collagen structure and use this data to differentiate between healthy and diseased corneas. Our proposed method will be based on the orientation information of each collagen bundle, and by combining crossing density intensity analysis of an image with a major orientation of bundles. This will allow us to differentiate between healthy and diseased corneas, and ultimately improve the early detection and diagnosis methods for corneal diseases.

In summary, this research aims to apply the newest technology of multiphoton microscopy, specifically Second harmonic generation (SHG), to the field of ophthalmology, and more specifically to the analysis of collagen bundles in the cornea. By providing a quantitative analysis of the collagen structure, we expect to improve the early detection and diagnosis of corneal diseases, and ultimately reduce the global burden of corneal blindness.

2. Methods

2.1. Image stack Slicing

The dataset images were in czi form, firstly these images imported to MATLAB. The imported images then downscaled in z-direction since the resolution was significantly high. Although high resolution improves the image analysis accuracy, the computational burden is significant in 3 dimensional images. Hence, by considering the computational expense, the input images were downscaled in z direction with factor 2.

2.2. Image Pre-Processing

The input images firstly pre-processed to increase the image quality. For that purpose, firstly images are filtered to increase image contrast. The SHG images of collagen structures have significantly low contrast. As it is seen in Fig. 2 the bundle boundaries are not even visible. Hence, an increased contrast is critical for the further thresholding and filtering based image analysis phase. For that purpose, contrast equalization was applied to adjust image contrast. The preprocessing step continues with image smoothing. Since the images are significantly noisy, to denoise the images anisotropic diffusion technique was applied. The anisotropic diffusion is one denoising method which could be aware of the edges, hence once smoothing the image preserve the edge information as much as possible.

2.3. Directional Filtering and Image segmentation

The preprocessed image is at the highest quality now for the further image analysis. Firstly, images are processed with orientable filters. These filters are used in literature for vessel-like object detection [22]. For that purpose, we used rectangular filters oriented uniformly distributed in 8 uniformly distributed orientations in xy plane. Filters are designed in rectangular shape and the sizes were determined as 20 pixels to 10 pixels as height and width. Although the images are in 3-dimensional space. Since the Z dimension has a relatively low resolution and considering the high computational burden of 3-dimensional analysis, application of 2-dimensional analysis was preferred. For that purpose, the 2D slices of volume analyzed individually with 2D orientable filters. However, considering the dataset and computational efficiency, instead of analyzing all slices, we randomly selected slices from the volume and then applied the proposed method to these slices individually. By random selection of enough number of slices would theoretically present a qualified estimation to the value showing the characteristic of all slices. After the images are filtered with the 8 oriented filters the maximum filtering responses are collected for each pixel. When the orientation of the filter matches with the local orientation of a pixel, the filtering response will be maximum. As a result, we observed one filtered image where each pixel intensity is determined as the maximum filtering response for that pixel based on 8 analysis orientation. This process highlights the anisotropic regions like collagen bundles.

The maximum filtering response image was then thresholded to determine the pattern of collagen bundles. The Adaptive thresholding method was selected to separate collagen bundles region from the background based on the difference in pixel intensities of each region in the image and for each depth a different sensitivity value based on the depth intensity.

2.4. Crossing-Density analysis

The crossing-density [23] of the images from different patient were analyzed by using ImageJ software. The crossing density was measured from 3 position at each image and then the average of those 3 crossing density peaks was taken to get one representative value. Also, eight images were randomly selected from different depths for each patient, then the average value of crossing density peak those 8 images was obtained in order to have one representative value.

3. Results

The proposed method is applied to a dataset of SHG images of human cornea. The dataset is formed by 20 volumes of 10 healthy and 10 diseased patients. **Fig 1** shows the complete flow diagram for our analysis. A representative output slices from a healthy and diseased samples can be seen in Fig.2 and Fig.3 respectively.

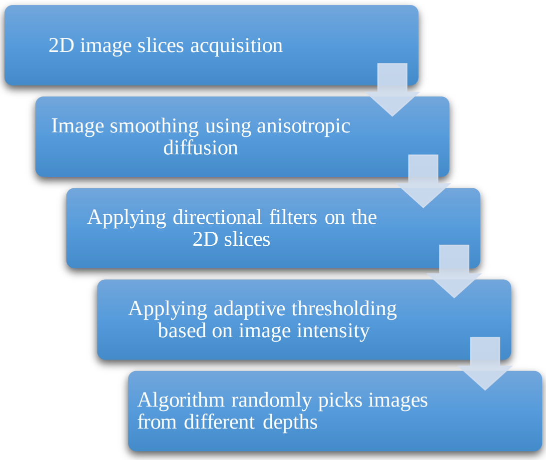

Fig. 1. Proposed Algorithm flow chart.

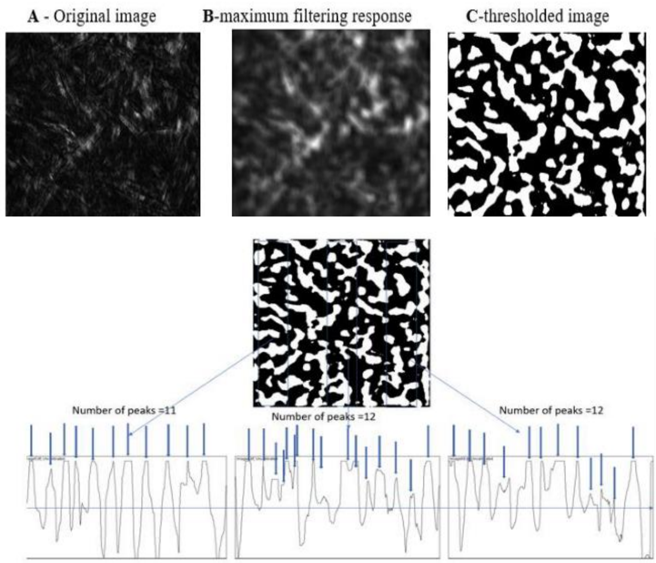

Fig. 2. (A) Original image, (B) maximum filtering response, (C) thresholded image. The bottom row shows extracting the crossing density for healthy cornea.

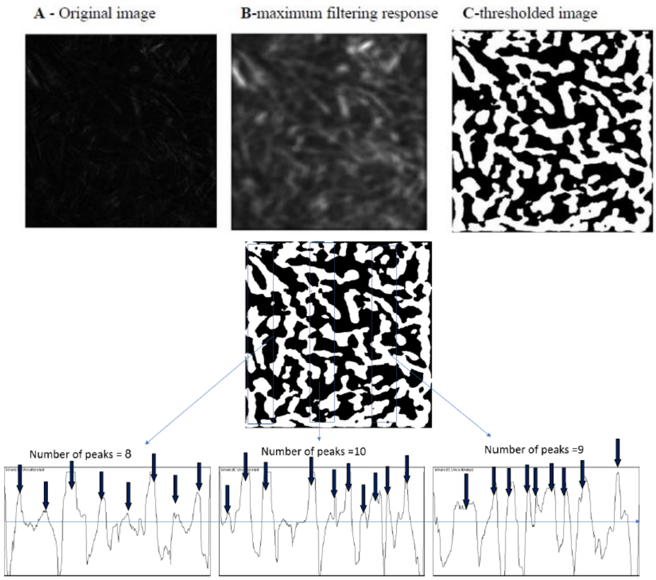

Fig. 3. A) Original image, (B) maximum filtering response, (C) thresholded image. The bottom row shows extracting the crossing density for diseased cornea.

The observed results can be seen in Table 2. It is observed that for the healthy samples the crossing-density always between 11-13 while for the diseased samples that value is around 9. That concludes that by considering the mean and standard deviation of crossing density values, there is no overlap between the distribution of the crossing density values. This can be justified as well with a confidence interval analysis (Fig. 4). The overall results show us that classification of the samples can be easily done only by measuring the crossing-density features.

Table 2. summarizes the obtained results

Patient	Healthy	Diseased
1	12	9
2	13	9
3	12	9
4	11	8
5	12	9
6	11	9
7	12	-
8	12	-
9	11	-
10	12	-
MEAN	12	9
STD	0.68	0.40

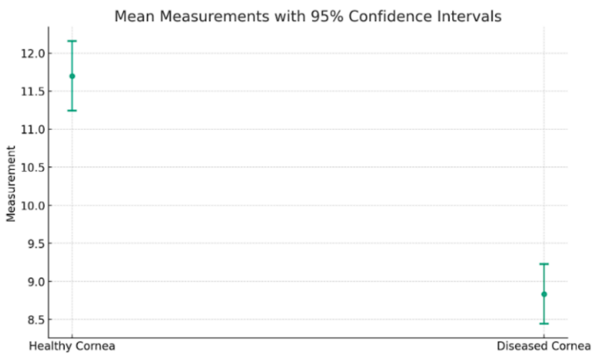

Fig.4. Mean Measurements of Healthy and Diseased Corneas with 95% Confidence Intervals.

Disscusion

The aim of this study was to analyse the morphology of collagen bundles in order to differentiate between healthy and diseased corneas. Cornea diseases are a leading cause of blindness worldwide, and early detection can greatly aid in selecting the appropriate treatment to decrease the risk of blindness. To achieve this goal, a thorough review of literature in the field was conducted to gain an understanding of the methods currently utilized. It was observed that, by considering the computational burden and the accuracy of the method at the same time, crossing-density analysis is one optimum approach to apply. However, this method is so sensitive to the high level of noise in the SHG images of cornea. To handle that, we utilized the crossing-density analysis with the maximum filtering response image with anisotropic orientable filters. The maximum filtering response with anisotropic filters helped us to highlight the anisotropic regions and surpass the noise and isotropic artifact regions. Hence, this combination was expected to be an efficient tool to distinguish distribution features of collagen bundles. This claim was proved with the obtained results.

It was found that the proposed technique yielded relatively constant values, regardless of the measurement area in the same image. Furthermore, when comparing the results from healthy and diseased cornea images, it was observed that the healthy cornea images had relatively constant values and the diseased cornea images had lower and less variable values. This indicates that the structure of healthy corneas is more organized and tightly packed, while the structure of diseased corneas is disrupted due to disorganization of collagen bundles and a looser structure.

Confidence interval histograms of both populations (diseased and healthy cornea images) were plotted in Fig. 4. As it is seen in the figure, there is no overlap between the regions and the extracted features to represent samples yield a perfect separation of diseased group from healthy one.

Conclusion

In conclusion, the use of maximum filtering response and crossing density peaks intensity measurement yielded significant results and can be effectively used to differentiate between healthy and diseased corneas. Further research can be conducted to refine and improve the methodology, and to investigate the potential clinical applications of this technique.

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BÖLÜM IV

Usage Possibilities of Geographic Information Systems In the Livestock Sector

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Introduction

The availability of new technology, such as the Global Positioning System (GPS), and advancements in computer science, remote sensing, and cartography have made spatial data more accessible and necessitated the use of specialized tools to handle it. In light of this, Geographic Information Systems (GIS) have been created since the 1980s with the express purpose of facilitating the management, visualization, and analysis of data with a geographical reference (i.e., coordinate information) (Sturaro & et al., 2011).

Many definitions of Geographic Information System (GIS) technology have been proposed due to its applications in various

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disciplines. "An organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information" is how one of the most general definitions of a GIS puts it (ESRI, 1990).

Numerous industries have been effected by the positive contributions of Geographic Information Systems (GIS), and the lives-tock industry is no exception. GIS provides a wealth of opportunities to monitor environmental effects, reduce disease outbreaks, and improve productivity by combining spatial data with livestock management techniques. In order to obtain knowledge and make wise decisions, geographic data must be collected, stored, analyzed, and visualized using GIS. GIS helps with resource allocation, precision farming, and land use optimization in agriculture. When used in the livestock industry, GIS proves to be an effective instrument for sustainable farm management.

Beyond the confines of conventional observation and data collection techniques, remote sensing is a technologies that includes drones, satellite imaging systems, and a variety of sensors. Livestock farmers are now able to monitor, analyze, and react to dynamic conditions within their operational ecosystems, thanks to this technological amalgamation. With their infrared sensors and high-resolution cameras, drones make it possible to conduct real-time aerial surveillance, which allows for the quick diagnosis of livestock health problems and the evaluation of pasture conditions. With their wide coverage and regular revisit cycles, satellite imaging systems aid in large-scale monitoring by providing information on regional patterns and trends. Simultaneously, sensors situated at ground level offer detailed information on microenvironmental elements, enabling a comprehensive comprehension of the interactions among livestock, terrain, and climate.

This transformative capacity of remote sensing not only augments the efficiency of routine livestock management practices but also establishes a foundation for sustainable agricultural approaches. The nuanced data acquired through remote sensing technologies allows for precise resource allocation, minimizing waste and maximizing the utilization of available resources. Moreover, the ability to anticipate and proactively address potential challenges, such as disease outbreaks or environmental stressors, positions livestock farmers at the vanguard of resilient and adaptive agricultural systems.

The livestock industry plays a pivotal role in global agriculture, contributing significantly to the economy and food supply. Geographic information systems have become a potent tool for solving these problems by offering analytical tools and spatial insights for wise decision-making.

With an emphasis on dairy barns, cattle barns, poultries, and sheep shelters, this article highlights the multifaceted advantages and applications of Geographic Information Systems (GIS) in the management of diverse facets of the livestock industry and discusses the status of livestock farms with other environmental sustainability factors. Also, this paper provides an analysis of the uses and benefits of GIS in managing different aspects of raising livestock.

Geographic Information Systems in Livestock Farms

Recently, there has been an increase in interest in the use of GIS in livestock science. Research is currently being conducted on a number of topics, primarily pertaining to the interactions between livestock and the environment, land use management, disease surveillance, biodiversity, and genetic conservation (Joost & et al., 2010; Sturaro & et al., 2011).

A primary consideration in contemporary agriculture is maintaining environmental sustainability. Farmers can evaluate how their livestock operations affect nearby ecosystems by using GIS. Farmers are better able to prevent overgrazing, soil erosion, and water pollution by mapping grazing areas, water sources, and vegetation. The identification of ideal grazing patterns is made easier by GIS-based analysis, protecting biodiversity and natural habitats.

The integration of Geographic Information Systems (GIS) in the livestock sector has emerged as a different tool in enhancing efficiency, sustainability and productivity. Livestock farmers can optimize resource allocation, disease control, environmental sustainability, and overall management strategies by utilizing GIS technology.

Moreover, by identifying sensitive areas like wetlands or important wildlife habitats, GIS helps farmers modify their operations to cause the least amount of disturbance to the environment.

A different of GIS-based applications have been choosed in livestock agriculture. In sheep and goats, they have been used to characterize their production systems (Malafant, 1998), to suggest pasture areas in regions where land has been divided (Kalivas & Apostolopoulos, 2005) and to examine the spatial link between indigenous breeds and areas of livestock usage (Bertaglia & et al., 2007; Lozano-Jaramillo & et al., 2019).

In cattle, sheep and buffaloes, GIS has been used to see the spatial structure of animal populations and to analyze the characteristics of disease transmission between farms (Cringoli & et al., 2007; Lozano-Jaramillo & et al., 2019).

Dairy farming is a crucial segment of the livestock sector. Applications of GIS in dairy barn management cover a wide range of topics, including waste disposal, feed management, environmental impact assessment, and site selection. Farmers can assess a piece of land's suitability for growing fodder, plan the best places for dairy barns, and effectively manage waste disposal to reduce its negative environmental effects by using GIS. When it comes to cattle farming, GIS makes pasture management easier by evaluating terrain, vegetation types, and land characteristics to maximize grazing areas. In order to maintain the health and productivity of cattle, GIS also helps with disease monitoring and management by mapping disease outbreaks, identifying high-risk zones, and putting in place targeted vaccination programs.

GIS technology is essential to the poultry farming industry because it helps with facility planning, which includes waste management, ventilation systems, and the best location for poultry houses. By mapping disease patterns, evaluating risk factors, and putting biosecurity measures in place to reduce outbreaks, GIS applications also help farmers monitor and manage the spread of diseases within chicken farms.

Proper management of the range and control of predators are essential to sheep farming. By mapping predator territories and creating safeguards to protect the flock, GIS helps with identifying appropriate grazing areas for sheep, analyzing vegetation patterns, and putting predator control strategies into practice.

Disease surveillance systems driven by GIS make it possible to take prompt action, like isolating impacted areas and launching focused immunization campaigns. Moreover, GIS makes it easier to track the spread of disease, which helps with the development of proactive measures to stop future transmission.

Livestock diseases are serious hazards to the productivity and well-being of animals. In the livestock industry, GIS is essential for disease management and monitoring. GIS aids in the early identification of disease outbreaks by combining real-time data on animal health, environmental conditions, and geographic patterns.

Geographic information systems (GIS) are crucial in the veterinary field because they can map a wide range of epidemiological data, including morbidity, mortality, prevalence, incidence, and geographic distribution of diseases. 1994 saw the introduction of GIS into veterinary medicine in response to the outbreak of foot and mouth disease (Sanson & et al., 1994; Tadesse & Amare, 2021). GIS provides different types of maps, especially for the spatial analysis, which assists epidemiologists and public health professionals in the veterinary sector in analyzing associations between various locations, environment, and disease pattern (Cringoli & et al., 2007; Sadkowska-Todys & Kucharczyk, 2012; Tadesse & Amare, 2021). GIS was used to evaluate for assessing the risk and the spatio-temporal distribution of plague in India (Rahelinirina & et al., 2010) and other vector and waterbornediseases (Gubbels & et al., 2012) in various nations (Tadesse & Amare, 2021).

Rangeland is essential to the production of livestock. Rangeland is a particular kind of land cover that serves as a grazing area for cattle and other wildlife and is composed of grasslands and shrubby vegetation (Squires, 2010; Tongway & Ludwig 2010; Shah Porun Rana & Moniruzzaman, 2023). Several climatic factors, ecology, watershed, and environment all have an impact on this kind of land. Despite significant improvements in ecological and socioeconomic aspects, rangeland has suffered due to shifting patterns of land use. Rangeland degradation is one of the primary causes of low livestock productivity (Shah Porun Rana & Moniruzzaman, 2023).

Knowing the rangeland's resources is essential to raising livestock productivity. Finding a suitable location is therefore crucial for both livestock production and rangeland management. Analytical hierarchy process (AHP), which is a method for organizing and analyzing complex decisions using math and psychology, is widely used in conjunction with the amalgamation of geographic and information system (GIS) and remote sensing (RS) approaches to find suitable areas for a range of purposes, including suitable locations for cropland (Akram et al., 2018; Mostafiz & et al., 2021; Hossen & et al., 2021; Uddin & et al., 2020); route alignment planning (Singh & Singh, 2017); and defining the groundwater potential zone (Alikhanov & et al., 2021; Rana & et al., 2022; Singh & et al., 2021; Shah Porun Rana & Moniruzzaman, 2023).

GIS-based analyses also find the opportunity to be used in different sectors related to animal husbandry. A very large amount of waste is produced from livestock enterprises, which can be considered a source of non-point pollution. These wastes are released into the environment uncontrollably, polluting natural resources. In order to prevent this situation, it is possible to evaluate animal waste. For this purpose, applications such as biogas and compost are important. In order for these applications to be implemented, detailed analyses and preliminary studies need to be carried out. In this regard, location selection for the construction of these facilities is one of the most serious criteria. Organic waste from agriculture and animals can be shown as the raw materials required for biomass energy. While raw materials are obtained from different locations and transferred to the energy production facility, transportation costs can be minimized with the help of geographic information systems, and the most suitable location for the production facility can be determined. When the studies carried out with the help of GIS-based analyses regarding biogas system facility installations were examined, the geographical distribution of different resource types (agricultural, animal, industrial, etc.) was examined using the network analysis method, and studies were carried out to determine the most suitable site selection (Aydınlı & Uyguçgil, 2023).

Besides, remote sensing and GIS are also popular strategies for assessing the climatic condition of forest areas (Mondal & et al., 2022) and urban areas (Gazi & Mondal, 2018); follow changes in forests (Thakur & et al., 2020; Mondal & et al., 2018); measuring soil erosion (Bag & et al., 2022); and other varied purposes (Shah Porun Rana & Moniruzzaman, 2023).

Furthermore, the use of remote sensing fits in with the larger global sustainable agriculture agenda. These technologies' precision helps minimize environmental degradation, reduce overgrazing, and lessen the ecological footprint of livestock operations. The economic survival of individual farms as well as the resiliency and longevity of the livestock farming industry as a whole in the face of complex challenges depend on this confluence of sustainability and precision.

Different topics regarding the use of GIS in animal husbandry are summarized by Çiçek & Şenkul (2006) as follows (Kurç, 2013):

• Determining the number of animals in a certain region according to their species, creating regional maps, observing animal movements,

• Enterprises engaged in animal production in a certain region; Due to databases created with information obtained from certain sources (provincial organizations affiliated to the Ministry of Agriculture, producer unions, cooperatives, etc.), their numbers and which branch of production (cattle fattening, dairy farming, egg poultry farming, etc.) they operate in are determined and from there, effective production planning based on,

• Ensuring the coordination of producers producing in a certain area and for a certain product, and as a result, increasing their effectiveness in marketing services by creating a harmony between them that can be taken to the point of organization,

• Identification and correct use of pasture areas,

• Identification of suitable lands for forage crop production, which is the most important input of animal husbandry, and ensuring the cultivation of alternative products,

• In the investment decision to be made for a certain animal production, determining the right land in choosing the establishment location of the enterprises and determining its locational suitability and environmental impact levels according to other spatial objects with which the existing enterprises are in relationship.

• In order to prevent animal diseases that threaten human and animal health and occur in a certain area from infecting other living creatures that are nearby or are thought to come into contact with them; Creating risk maps obtained by questioning and analyzing the location, cause and spread of the disease and preparing emergency action plans,

• Determining the factors that limit livestock farming (temperature, drought, land use problems, pollution factors caused by animal waste, etc.) and creating strategies for them.

GIS technology in livestock management calls for a combination of hardware, software, and knowledgeable staff. Farm-specific data collection tools like GPS-enabled devices, drones, and remote sensing technologies gather important spatial information. After processing this data, specialized software programs produce models, maps, and useful insights for farmers.

Additionally, real-time monitoring of livestock health, behavior, and environmental conditions is made possible by the integration of GIS with other technologies, such as Internet of Things (IoT) devices.

Challenges and Future Prospects

Livestock farming is becoming more and more important as the world community struggles with the challenges of food security. Though fundamental, traditional approaches suffer from a number of drawbacks that make it difficult for them to adjust to the changing needs of a growing population and a changing climate. With its many technological advantages, remote sensing is a shining example of innovation that can overcome these constraints.

The livestock industry must become more efficient and adopt sustainable practices in order to meet the challenges of the modern world, which include population growth and rising food consumption. As a result of these demands, remote sensing technologies have become essential instruments for increasing livestock farming's productivity, maximizing resource use, and maintaining environmental sustainability.

Implementing GIS in the livestock industry has potential, but there are obstacles to overcome, including data standardization, accessibility, and cost. Developing standardized procedures for data collection, encouraging farmers to be technologically literate, and lowering the cost and improving the usability of GIS tools are all necessary to address these issues.

Geographic Information System (GIS) is a useful tool for monitoring the implementation of control programs and displaying areas with high disease prevalence. At the regional or national level, the Global Positioning System (GPS) and Geographic Information System (GIS) offer an integrated approach that improves the quality of data analysis and decision making to control the disease and its prevalence. Even though GIS has many applications, there are several limitations that make it difficult to use. Despite some reviews regarding the general application of GIS, organized information regarding its challenges and application in veterinary medicine is still lacking (Tadesse & Amare, 2021).

The power of GIS lies in its capacity to combine geographic data with veterinary medicine data. In the form of globes, maps, charts, and reports, GIS can enable viewing, questioning, understanding, visualizing, and interpreting the data in a variety of ways that will reveal relationships, trends, and patterns (Babalobi & et al., 2005; Tadesse & Amare, 2021). A developing nation's capacity to employ GIS effectively is hampered by numerous factors. Nonetheless, the work done to address these issues results in the development of solutions known as spatial data infrastructures (SDI), which enhance a nation's capacity to make efficient use of geo-information (Bolstad, 2016; Tadesse & Amare, 2021).

Nevertheless, there are obstacles in the way of the livestock industry's smooth adoption and application of GIS. Many farmers still face obstacles due to the cost and accessibility of GIS technology, especially in developing nations with scarce resources. While GIS training and education are essential, farmers frequently lack the abilities and know-how to use these tools efficiently. Additionally, interoperability problems between different GIS platforms and data formats pose compatibility challenges, limiting the seamless exchange of information among stakeholders.

Farmers, government officials and researchers must work together in order to overcome these obstacles and fully utilize GIS in the livestock industry. Farmers must have access to workshops and training programs designed to improve their knowledge and proficiency with GIS. The primary goal of government initiatives should be to encourage farmers, particularly those in underserved areas, to adopt GIS technology by offering subsidies or other incentives. Governments, technology companies, and agricultural organizations can work together to create cooperative partnerships that will help develop GIS solutions that are both affordable and easy to use, and that are specifically tailored to the needs of the livestock industry.

Future developments in GIS technology, such as artificial intelli-gence and machine learning, could improve livestock manage-ment techniques even more. With the help of these advance-ments, farming methods can become more effective and sustai-nable by streamlining data analysis, forecasting disease outbre-aks, and allocating resources optimally.

The potential for GIS in the livestock industry is important, despite ongoing challenges. Addressing issues related to accessibility, affordability, and interoperability can open the door to a more effective, sustainable, and data-driven approach to managing livestock, which will benefit farmers and the agricultural sector at large with coordinated efforts from government agencies, tech companies and farmers.

A new era of data-driven, sophisticated agriculture is being ushered in by the smooth integration of remote sensing applications into livestock farming, which signals a break from traditional methods. The effects of this integration are extensive, influencing the very course of the livestock industry globally and going beyond the boundaries of individual farms.

Conclusion

Geographic Information Systems (GIS) play important role the way farmers manage their operations by opening up a many of possibilities in the livestock industry. But even with all of its benefits, there are still obstacles in the way of its potential appli-cations in this field.

GIS technology enables farmers of livestock industry to make well-informed decisions based on spatial data. Precise mapping of grazing areas, tracking of animal movements, and evaluation of environmental elements impacting livestock health are all ma-de possible by using GIS. By superimposing information about vegetation types, soil quality, and water sources on maps, farmers can optimize resource allocation and grazing patterns by having a thorough understanding of their land. Additionally, by tracking outbreaks and enabling targeted interventions, GIS supports disease monitoring and control, improving animal wel-fare and reducing financial losses.

The integration of Geographic Information Systems (GIS) in the livestock sector presents a numerous of opportunities for enhancing efficiency, sustainability, and overall management practices across dairy-cattle barns, poultries and sheep shelters. Farmers can optimize resource allocation, make data-driven decisions, and mitigate various challenges associated with livestock rearing by utilizing GIS technology. However, to fully realize the potential of GIS in application livestock management, more research, greater adoption, and technological advancements are required.

Standardized protocols must also be established to facilitate data exchange and interoperability across various GIS platforms. When it comes to developing legal frameworks that encourage data sharing while maintaining data security and privacy, governments can play a pivotal role. Investing in research and development to improve GIS technology's affordability and accessibility will be instrumental in ensuring its widespread adoption in the livestock sector.

The potential of GIS in the livestock industry seems bright, even in spite of these obstacles. Technological developments are propelling the creation of GIS applications that are easy to use and specifically designed to meet the requirements of livestock farmers. The capabilities of GIS in monitoring livestock health and behavior are further enhanced by integration with other emerging technologies, such as Internet of Things (IoT) devices and remote sensing. Farmers will can make proactive decisions by using predictive analytics provided by artificial intelligence and machine learning algorithms on GIS data.

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CHAPTER V

Precision Animal Husbandry Technologies And Applications

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Summary

As a result of the developments in information technologies, precision animal husbandry technologies and applications have emerged with the use of hardware, algorithms and software developed to cover computer and electronic-based data collection, transmission, storage and evaluation processes in animal production. The concept of precision animal husbandry refers to a livestock management system that is developed by taking advantage of the latest developments in technology and works in real time, continuously monitoring the reproduction, production, health and

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welfare of animals and their effects on the environment with fully automatic monitoring and control systems, predicts important events such as birth and disease before they occur by using different modeling techniques and ensures that necessary measures are taken. In this study, precision animal husbandry technologies and applications in the field of animal husbandry activities will be emphasized in detail. The concept and structure of animal production, precision animal production, precision livestock technologies and applications are included.

Keywords; Animal production, precision animal husbandry, precision animal production, precision animal production technologies

1. Introduction

Today, rapidly developing and developing technologies provide the opportunity to move to new levels in the field of agriculture as in every field. Developing technologies in the field of information and communication affect agriculture and agricultural technologies, as well as the use of new machinery systems and the need for smarter agriculture. Today, the agricultural system known as precision agricultural technologies is an agricultural system that improves agricultural business and management, while at the same time providing the opportunity to combine information and, of course, technology. Precision agriculture technologies are an agricultural system with a wide range of applicability in many areas of agriculture. Precision livestock farming is an agricultural activity area of this wide range.

The use of advancing technology in animal production is crucial in helping producers to reduce losses and input costs by improving the entire management and production system, while at the same time enabling the implementation of precise and accurate strategies within the animal production cycle. With precision animal husbandry practices, there can be a continuous monitoring of the animals and it offers the opportunity to solve these problems and at the same time to eliminate new problems that may occur. Considering that animal health is very important, sensitive animal husbandry applications are also very important from this point of view. In production enterprises with a large number of animals, it is sometimes very difficult and labor-intensive to take care of all animals one by one. With precision animal husbandry applications, animals can be monitored individually and close attention can be provided. Again, from this point of view, sensitive animal husbandry practices are very important.

2. Objectives of Precision Livestock Practices

Some conditions need to be fulfilled during animal production. Some of these conditions are as follows; breeding with breeds with high meat and milk yield. Ensuring adequate and balanced nutrition of animals and utilizing the individual potential of animals at the highest level that can be utilized. To ensure that preventive health measures are taken against diseases that cause losses, which unfortunately have the largest share in animal production, and to minimize the amount of medication used by ensuring early diagnosis of these diseases and making the nec-essary intervention immediately afterward.

Precision livestock systems aim to provide a real-time monitoring and management system for farmers. With precision animal production applications, it is aimed to make significant contributions to increasing the desired yield and quality in meeting the increasing need for animal food in today's world where the population is increasing day by day and to solve many problems experienced in animal production.

The application of precision animal production practices in animal production, it is aimed to make effective and appropriate decisions by continuously monitoring some individual animal conditions (mobility amount, water consumption, milk conductivity value, milk quantity, etc.), to make the necessary preventive health measures as soon as possible by early diagnosis of changes that will adversely affect animal health, to make the highest level of utilization of the individual potential of animals by making herd management practices correct and timely, and to make sustainable and productive business management. (Özgüven 2017).

At the same time, sensitive dairy cattle farming, which is an area where sensitive animal production practices are being implemented, also has objectives and some of these objectives can be listed as follows; (Bergfeld 2006; Bewley, 2009).

1. Reducing both the physical and psychological burden of the grower or producer

2. To ensure that the success level of the business is increased, to carry out and implement studies to ensure that risks can be minimized

3. To ensure the most efficient use of the existing resources of the enterprise

4. Ensure maximum adaptability and affordability of input factors to the animals' needs

5. Providing human support in herd management tasks and early detection of diseases

6. Minimizing the use of medicines through early detection measures and improvements

7. To ensure that the individual potential of animals is utilized at the highest level.

3. Advantages of Precision Livestock Practices

Electronic IDs, automatic feeding systems, milk yield and quality measurement systems, automatic weighing systems, activity meters, smart drinkers, animal image analysis systems, animal temperature measurement systems, herd management software, milking robots are used in sensitive animal production, allowing producers to make the most of the individual potential of animals by meeting the needs of animals accurately and timely, and reducing the use of drugs by diagnosing diseases earlier and taking preventive health measures (Tarhan et al., 2015).

Precision animal production provides the opportunity to collect data at the individual cow level, such as precise (individual) feeding, regular milk recording (yield and components), pedometers, pressure plates, milk conductivity indicators, automatic heat detection, body weight, temperature, lying behavior, ruminal pH, heart rate, feeding behavior, blood tests, respiration rate, rumination time, movement skill scoring using image analysis. This enables a focus on health and performance, minimizing medication (antibiotics) through preventive health and providing a proactive animal health strategy (Coffey and Bew-ley, 2014). The benefits derived from precision animal production technologies are increased efficiency, reduced costs, improved product quality, minimized negative impacts on the environment, and improved animal health and welfare. These technologies are likely to have a major impact in the areas of health, reproduction and quality control. For huge groups, where individual animal perception might be more troublesome and less inclined to happen, the advantages of summing up information and announcing exemptions are supposed to be higher (Bewley, 2009).

Some of the advantages of precision animal husbandry practices are summarized as follows;

1. Significant increase in milk yield of animals.

2. Improvement, development and increase in animal welfare.

3. Reduction in methane emission in animals.

4. There is a reduction in the time managers have to do their daily work and in this increased time they can take care of a larger number of animals and make more observations, as well as manage herds with a larger number of animals.

5. The formation of a more docile behavior profile in animals is ensured, as well as the ability of animals to move more freely in their environment and to trust themselves.

6. It is possible to produce with a higher number of animals per enterprise.

4. Precision Livestock Technologies

The basic principle underpinning precision livestock technologies (PLF) is that when the needs of animals and crops are met at the highest level, the needs of the supply chain, including farmers and consumers, are monitored. There will be less waste in the system and greater benefits to the economy and environment the more these demands are satisfied. Average farm sizes have grown in agriculture recently as a result of mounting commercial pressure and a consistent drop in the number of producers. Farmers are thus more reliant on technology and have less time to engage in traditional methods. Longer term, off-the-shelf technology adoption has been further reinforced by the emergence of new business models focused on offering a variety of services to the agriculture sector, which benefits all supply chain participants (Andonovic et al. 2018).

4.1. Applying the Internet of Things (IoT) to Precision Animal Husbandry

Many technologies are used in IoT-based precision farming (Figure 4.1). The solutions rely on engineering data for two different purposes; not only to ensure that the resulting product or service is fit for purpose, but also to take into account the impacts in terms of being easily distributed. The data that is at the heart of any solution is referred to as "big data", which consists of data streams, but is quite different from the "big science data" arrays routinely encountered in drug development and oil exploration. The platform has a discernible evolution that allows for the extension of its initial services to offer more important information on various livestock features that are highly significant economically. The infrastructure aligned with animal lameness and solution development methodology can also be applied to offer products addressing other market segments where data collection and analytics monitoring improve operational efficiency (Andonovic et al. 2018).

Figure 4.1. Framework platform for the implementation of precision farming used as an Internet of Things Reference Model (Andonovic et al. 2018; Shivani Panchiwala, Manan ShahManan Shah. 2020).

Disseminated shrewd detecting networks IoT networks are at the core of the sending of a scope of administrations that are pertinent and decidedly influencing numerous global ventures and these innovations incorporate; advanced diagnostics, physical front-end devices, signal processing, networking, and information dissemination. The platform includes all elements of the traditional IoT technology stack and at the same time, the platform is extremely important in focusing on the agricultural sector. An operational decision support platform gains more benefit by effectively integrating multiple sensors than by utilizing individual sensors. For example, each additional sensing method will improve the understanding of applications in the agricultural environment and subsequently make any decision support service more robust in its diagnostic capacity. There is the possibility to extract multiple sensor outputs for variables (both individual and combined) that positively indicate the efficiency of any process (Andonovic et al. 2018). The utilization of robotized estimation strategies to screen animal conduct is turning out to be progressively normal. Software techniques are used to measure, ponder, eat, stand, and lie down with some accuracy in a variety of states. These states can be the reason for recognizing fundamental animal conditions like the beginning of sickness. This approach offers huge application prospects, as in numerous IoT applications upheld by an organization of low-power processors and remote information download networks.

The principle of operation is that an electronic unit is built into a collar around the animals' neck and continuously records individual neck and muscle movements using a three-axis accelerometer. The recorded information is handled utilizing modern programming and downloaded remotely to a PC when a cow enters the getting region of a base station situated in the field or in the draining parlor. Cautions demonstrating the animal's condition are shown on a neighborhood PC or in the cloud. Each collar learns typical personal conduct standards and possibly cautions the rancher when there is an elevated degree of certainty that intercession is required, empowering ranchers to design a restorative activity. (Figure 4.2) The derivation of various cow states is made possible by the substantial variance in the measured raw accelerometer data.For example, for detections such as rumination and eating (Andonovic et al. 2018).

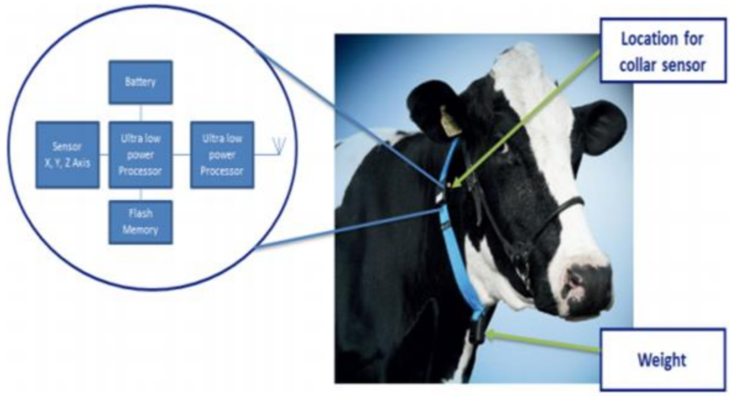

Figure 4.2 Smart collar unit around the neck (Andonovic et al. 2018)

The brilliant collar unit incorporates a 3-hub accelerometer. Two AA batteries, a low-power ZigBee wireless interface, and the processor. A scale empowers the collar to be recorded. The subsequent planning of the animals' energy consumption for the day is the reason for the one of a kind distinguishing proof of a necessary arrangement of individual cow conditions. The amount of data that needs to be downloaded into the application is significantly reduced when advanced software is installed directly on the collar unit; the arrangement creates alarms that are just communicated during basic periods. The net gain with such an approach is scalability; deployment compatibility to serve a variety of farm environments; the operational lifetime of more than 5 years with no battery life required (Andonovic et al. 2018).

4.2. Animal Activity (Movement) Detection and Eating Status

The need to increase dairy herd productivity to its full potential has been the most important factor in adopting precision livestock technologies. Everywhere, there has been a decrease in cows' efficiency, the reasons for which are complicated and incorporate factors, for example, specific rearing practices intended to boost milk yield and other government assistance factors like regenerative illnesses (such as metritis and ovarian cysts). In addition, deficiencies in management practices, poor nutrition and poor estrus detection are among the factors that contribute significantly to low pregnancy rates. Loss of income from milk production is the source of the cost of bovine infertility. Proper rearing of cows is a very serious issue. If the cow is not raised properly, the returns will be very negative. The farmer will suffer great losses. To avoid this, efforts should be made to improve fertility and although overall herd fertility depends on many factors, it is recognized that estrus detection is an area where technology can play a role.

Estrus detection is carried out as follows; The so-called "standing warm-up" to be attached to the cow is considered to be an accurate sign of estrus. If a cow is not in estrus, then she usually exhibits rapid movement when mounted. This rapid behavior is caused by blood estrogen levels that are higher than progesterone levels around ovulation. All things considered, an intensity can endure between 8 hours and 30 hours. If there is a shorter warm-up, it can happen at night and is harder to tell by looking. Other intensity signs are more amiable to mechanical arrangements that can uphold a mechanized intensity recognition arrangement. For instance, cows in heat frequently exhibit more agitation, eat less, and eat for a shorter period. This can be detected through the use of activity monitors. (Figure 4.3). Here, as mentioned before, a triaxial accelerometer is used, providing a rich array of information as inputs to detect not only walking behavior (counting steps), but also the budget for standing or lying down, which can be an indicator of other welfare events (Andonovic et al. 2018).

Monitoring the feed intake of cattle provides a good insight into the overall welfare status, for example sick cows will spend less time eating. Furthermore, rumination chewing, characterized by a constant rhythm, is an important part of the digestive process; a healthy cow chews the cud for 500-600 minutes per day. The chewing activity also helps to maintain the ruminal pH at a level favorable for microbial activity. Here rumination is detected by the movement of the neck muscles. The feeding phase of a cow can be described as follows: the cow plucks the feed (grass, for example) from the ground, partially chews it and then swallows it for reconstruction. As a result, the muscle movements observed in the neck are considerably large and this acceleration can be detected by the spread of accelerometers. This process helps to identify cow behavior at any given time using a simple measurement of acceleration in the neck. The processed output characteristic of ruminant behavior in animals is derived from a sample accelerometer, estimating the variance and frequency content of the accelerometer measurement. However, the jaw movements during eating activity are larger than those during rumination. In addition, head movement patterns are a very important factor in the way animals eat (Andonovic et al. 2018).

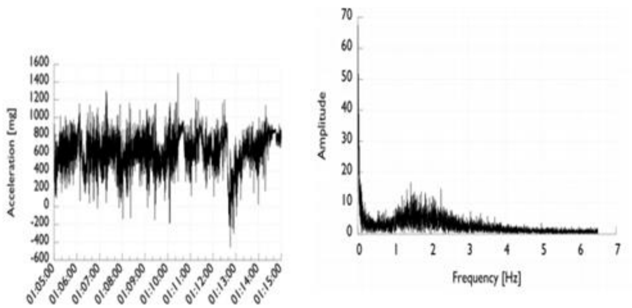

Figure 4.3. Acceleration output represents eating in animals (Andonovic et al. 2018)

In Figure 4.3, the time series representation is shown on the left and the corresponding frequency spectrum is shown on the right. The movement of the jaw is less rhythmic at some times. For example, during eating (Figure 4.3). At the point when the jaw development is less cadenced, the recurrence parts present during rumination can't be noticed. When the figure is looked at, it can be seen that eating has a higher level of variance, with lower frequency movements but no discernible frequency peaks compared to thinking. The most important reason for the variability in the cow's movement is that cows become restless when they move into heat.

The line in red in Figure 4.4 is a measure of how important it is to compare the variability in a cow's movement compared to normal behavior, and can seriously alert a farm business to the possibility that a cow may be ready for insemination. The line in green on the same figure is a measure of the amount of time the cow spends on rumination compared to the average rumination time over the past week. Since it is now realized that this estimation worth ought to diminish when the cow heats up, it gives an extra estimation to reinforce the determination. The line in dark blue represents the time the cow spends eating and an increase is observed. As a result, there is a significant increase in the time of not eating, even though the cow is not eating more. This is due to muscle movements similar to eating. Therefore, the graph shows a significant increase in eating (Andonovic et al. 2018).

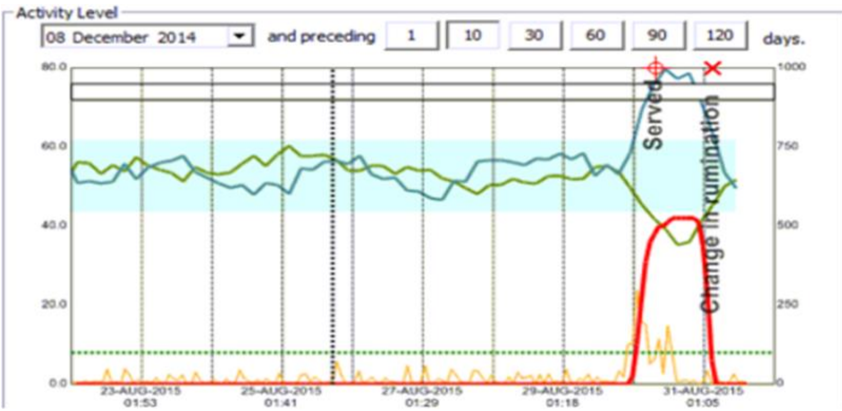

Figure 4.4 An illustration of the degree to which the cow's activity changes over a period of 90 minutes (Andonovic et al. 2018).

4.3.Automation for Animal Identification

Animal identification refers to a process used to identify and track animals. There are various reasons for animal identification and these reasons can be listed as biosecurity control, record keeping, efficient farm management, registration, insurance and verification of ownership of animals. Animal identification is very important in a livestock enterprise. In addition to animal performance, it allows for review the status of animals in production. Therefore, proper identification of animals is essential to understand the need for record keeping. It will also provide a solid basis for improving and developing the management of the herd.

Generally there are two main using area of automatic identification systems for husbandry. The first type of application is a system using a transponder. Its function is to identify the animal for the control system. Systems using transponders usually use a fixed antenna placed inside a stall such as a feeding station or milking stand or along aisles such as the entrance to the milking parlor, automatic weighing system, as shown in Figure 4.5. The second type of application involves recording events related to the health status or reproductive history of the animal. In the case of the second type of application, the automatic identification system has the function of receiving, recording and displaying the animal's identification code. Transponders for portable antennas are used in this application. Portable transponders, when kept close to the animal, allow for reliable identification, thus eliminating the difficulty and risk of error associated with visual recognition of the code (Gökçe et al. 2020).

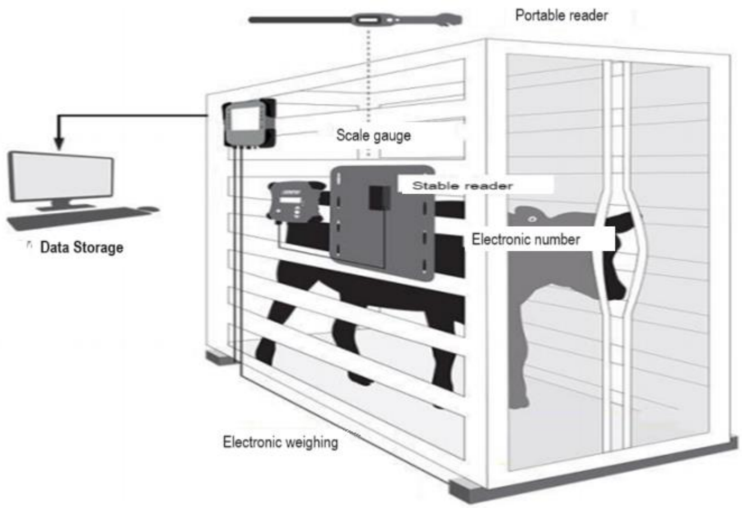

Figure 4.5 Electronic reader (Anonymous, 2019a)

4.3.1. Radio frequency identification system (RFID)

Radio frequency distinguishing proof (RFID) is one of the exceptionally productive ID advances created lately. Radio frequency identification is very effective for fast, secure and automatic data collection by using electronic tags to identify animals. Radio frequency identification, especially in dairy farms, provides fast access to dairy information, is used to improve and develop feeding strategies and manage mental practices, and provides the opportunity to improve automatic data collection by utilizing electronic transmission technology. Information about the animal is recorded in a radio frequency identification ear tag. The information recorded can be the animal's date of birth, vaccinations, reproductive characteristics and more. This makes computerized tracking and reporting of the animal possible.

Electronic tags, called microchips or transponders, are radio frequency identification devices (Anonymous, 2000). The transponder is implanted inside the animal's body. The transponder consists of a silicon chip and antenna elements. Figure 4.6 shows how an RFID system works.

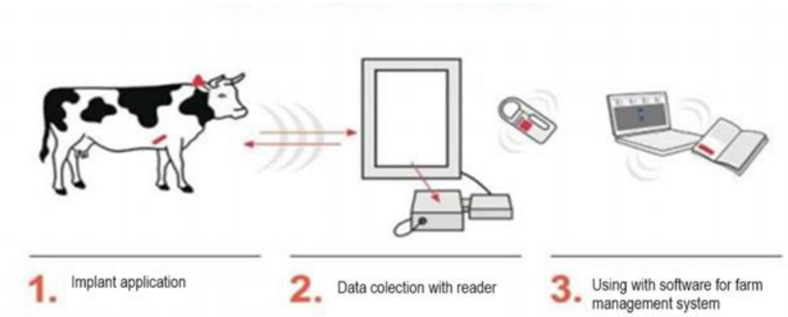

Figure 4.6 Basic Radio frequency identification system in dairy cattle (RFID (https://www.pashudhanpraharee.com/application-of-radio-frequency-identification-rfi-for-dairy-cattle-management/)

RFID technology utilizes electromagnetic energy to send information. RFID has two elements, the reader and the carrier, as shown in Figure 4.7. The reader is connected to a computer. The unique number received by the reader from the passive RFID carrier is transferred to the computer. In the computer, other information about the animal or item identified with RFID can be kept (Erdem and Tuna, 2008).

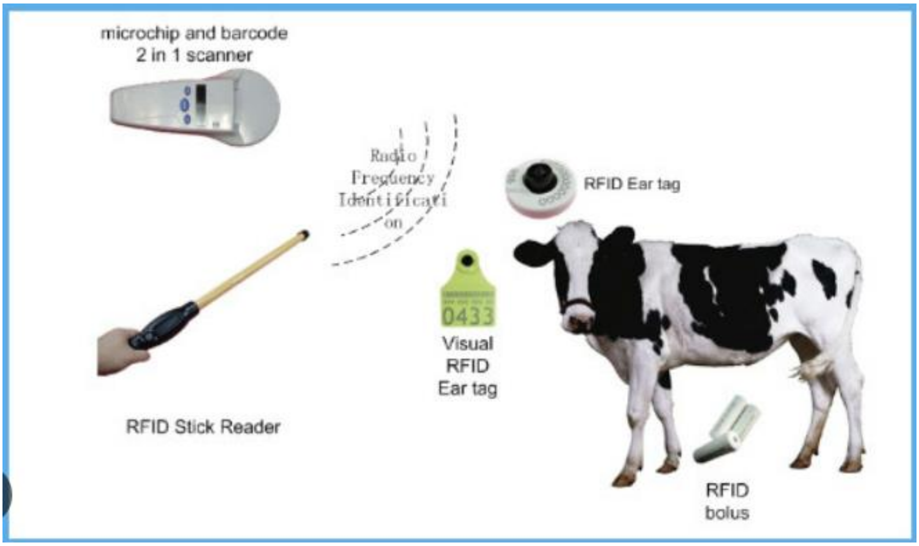

Figure 4.7 Operation of the radio frequency identification system for cattle managemnt

4.4.Animal Feeding Automation

Feeding is an important part of the daily routine dairy farm activities, even in modern farms. The result of feeding is largely dependent on the attention and care of the operator, because the filling of the mixing unit, the delivery and distribution to the barns are done manually. This situation has changed with the use of robots. In the use of robots, labor is needed only in the preparation and cleaning of the feed store called the kitchen. Through the software of the robot system, all the details of feeding can be determined, such as feeding frequency, rations and specific plans for different groups, etc.

One of the robot's features is the feed height sensor. This allows the robot to know the amount of feed in front of the feed wall and to determine when it needs to bring fresh feed. At the same time, the mixing and feeding robot acts as a feed pusher when it is not feeding (Figure 4.8). It ensures that there is always fresh and sufficient feed just in front of the feed wall. Reduces labor requirements and increases milk yield for the investment in feed. Balanced and continuous feeding also reduces maintenance and disease expenses for animals that may occur over time (Kaya and Örs 2015).

Figure 4.8 Mixing and feeding robot

A feed pusher robot is a robot that pushes and evenly distributes feed completely automatically without startling the animals. By providing easy and continuous access to feed, it has the advantage of increasing animal traffic and dry matter intake, especially at night, while reducing waste. Feed pusher robots are harmless to the ecosystem arrangements that utilization exceptionally low measures of energy (Figure 4.9).

Figure 4.9 Feed pusher robot

4.5. Animal Health and Welfare Technology Applications

Historically, dairy farmers have used their experience and intuition to detect problems in their animals. These attributes are of course invaluable and will never be completely replaced by automated technologies. However, there are limitations in human cognition in determining the condition of the animal, and decisions made by experience and intuition are inherently prone to error (Kaya and Örs 2015). Many easily observable clinical symptoms produce physiological responses (e.g. changes in temperature, heart rate, etc.) that are not noticeable to the human eye. The ability to monitor noticeable deviations in the physiological parameters of dairy cows allows the dairy operator to intervene earlier. In the past, many efforts have been made to develop sensors that measure various parameters of each cow. These sensors can be divided into two categories: attached and unattached. Attached sensors are sensors that are worn on the cow or located inside the cow's body. Non-attached sensors are systems that the cows pass by, over or through. The development stages of sensor systems can be defined in 4 levels and these levels are as follows; method of calculation of cow related issues (e.g. activity), translation of changes in the data collected by the sensors (e.g. increased activity) into the production of information about the condition of the cow (e.g. rut-ting), combining sensor data with other data to produce recommendations (e.g. whether the cow should be inseminated or not), decision making automatically by the farmer or the sensor system itself. The sensor itself is the first part of the sensor system, and an algorithm uses the sensor data to give information about the health of individual cows. It is also possible to combine sensor data with non-sensor data during this step. The devices used for the detection of animal health are usually technologies that send the measurement data they collect to receivers in the enterprise wirelessly (Figure 4.10) (Bewley, 2013; Kaya and Örs, 2015).

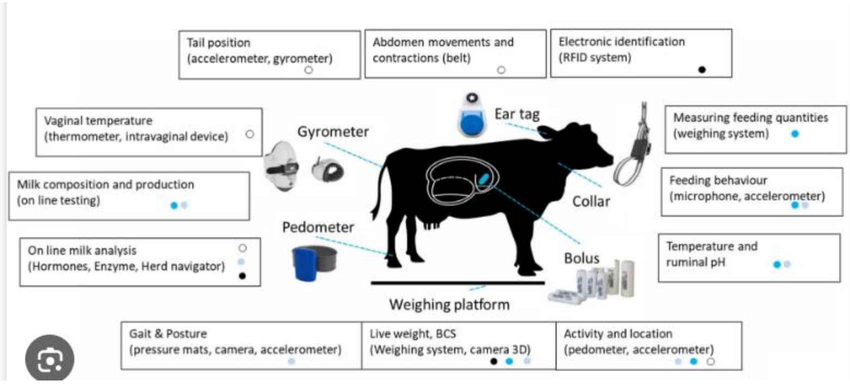

Figure 4.10 Areas monitored in dairy cattle in precision animal production (Kleen L and Guatteo R, 2023)

4.5.1. Mastitis detection devices

Mastitis is a disease that significantly affects the quality and quantity of milk, more intensively in cattle. Milk production is directly affected by mastitis. This disease has serious disadvantages, in most cases, as a result of antibiotic treatment, the milk obtained from other intact udders cannot be used for a certain day, and in advanced cases, udder loss may occur. The most basic method of combating the disease is to detect mastitis at its onset. Somatic cells from mastitis are mixed into the milk. At the very beginning, these somatic cells, which are mixed into the milk, change the electrical conductivity of the milk. By continuously monitoring the electrical conductivity of the milk, mastitis can be detected at the very beginning. The new mastitis devices, which are included in the milking system, directly determine which udder has mastitis by measuring before the first point where the milk is mixed, and the user is warned with the relevant warning lamps on the device. Compared to the old systems that measure according to limit values, the new mastitis devices compare the udders of each animal with each other, thus evaluating the measured values more precisely.

4.5.2. Pedometer

As mentioned before, a pedometer is a battery-operated instrument designed based on the number of steps a cow takes in a specified period. The way the pedometer works is based on determining the relationship between heat and behavioral changes in the cow. The pedometer can be attached to the cow's leg or neck. Whether the pedometer is attached to the leg or the neck does not make a significant difference in terms of the values obtained. This is because the leg activity is equal to or slightly higher than the neck activity. The cow in heat becomes more active and the number of steps increases accordingly. All measurements of the cow's activity are recorded at one minute intervals and then the data are summarized in 15 minute time blocks. At the end of both time blocks, the total recorded information is stored in a memory.

The data obtained from the pedometer is evaluated daily during morning and evening milking. The antenna system or optical reader at the entrance of the milking unit transmits the identity of the cow to which the pedometer is attached and the activity values for the previous 12 hours to the computer. At each milk-ing, these activity values recorded in the computer are automatically compared with the calculated threshold and previous activity values. While an increase in activity is used for heat detection, a decrease in animal activity is an indication that the animal may be sick, and in this case, the animal or animals are taken under surveillance (Figure 4.11) (Kaya and Örs 2015).

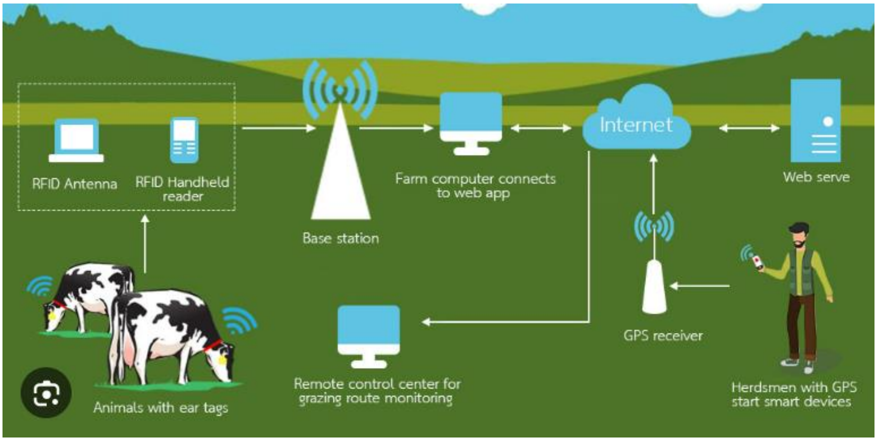

Figure 4.11 Wireless sensor technology (gwrfid.com/rfid-in-livestock)

4.5.3. Determination of body condition score with image analysis systems

Body condition score is an assessment made by scoring between 1 and 5 to determine the level of fatness in cows. Body condition score has effects on health problems that may occur during or immediately after birth and on the ability to progress and milk yield during lactation. Figure 4.12 shows the determination of body condition score with image analysis systems (Özgüven, 2017). Figure

Figure 4.12 Determination of body condition score with image analysis systems (Bewley 2013; Coffey and Bewley, 2014)

4.5.4. Lameness detection with image analysis systems

Lameness, which is one of the common diseases seen in cattle, is classified according to its severity value. To accomplish this, scoring tables have been created based on lameness levels and walking positions. Animals with scores of 3 or higher on the movement scoring scale should be observed, the issue investigated, and solutions sought. (Yaylak, 2008; Çeçen, 2014). Figure 4.13 shows an example of automatic determination of lameness with image analysis systems.

Figure 4.13 Lameness detection with image analysis systems (Poursaberi et al., 2010)

4.5.5. Detection of lameness with mats sensitive to sole pressure

One of the most prevalent and costly clinical conditions affecting dairy cattle is lameness. The floor is of specific significance due to the dissemination of strain and the appropriation of tension on the feet. Lopsided weight bearing on the foot surfaces of dairy cattle raised on hard floors like substantial causes lopsided strain dissemination on the feet. This prompts more prominent strain fixation and weight on the feet. In this way, weight bearing and sole strain dispersion are significant measures. Research on biomechanics began with the utilization of power plates and has advanced further with the improvement of sole tension delicate mats utilized in present day animal lodging research (Figure 4.14) (Nääs et al., 2006).

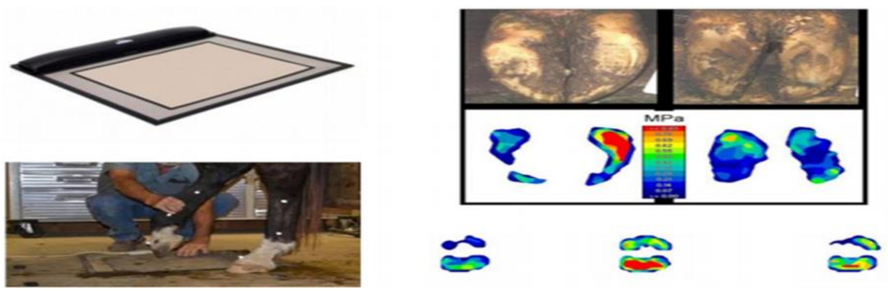

Figure 4.14. Detection of lameness with mats sensitive to sole pressure (Özgüven 2018)

5. Conclusion

Using smart technology in animal production will allow the application of precise and accurate principles throughout the animal production cycle, improving the whole management system and helping farmers for reduce losses. On the other hand, the use of multivariate signal processing methods such as smart metering, electronics, and artificial neural networks can accelerate progress in many areas. Precision dairy farming applications, which can be realized by using advanced technologies in herd management, provide significant benefits to the breeder, the animal and the consumer. Although precision animal husbandry technologies are being adopted at a slow pace, the number of precision dairy farms is increasing day by day in the world. The main reason for the low adoption rate of precision animal husbandry technologies is that they are not sufficiently recognized by farmers. In our country, the application of precision livestock technologies is still very new and few in number. However, the increase in the awareness of the advantages of these technologies such as reducing the need for labor, saving the farmer from routine repetitive work, increasing milk yield, detecting heat, early diagnosis of animal diseases by farmers will increase the application of precision animal husbandry technologies in our country. The widespread application of precision animal husbandry technologies will play an important role in helping dairy farms reach EU standards in terms of milk quality and hygiene and become certified dairy farms.

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CHAPTER VI

Stress Analyzing for Investigating Ethmoid Bone Crack Propagation

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Filiz KARABUDAK [2]

1. Introduction

The ethmoid bone, situated at the junction of the anterior skull base, forms an integral part of the intricate facial skeleton. Its anatomical significance extends beyond structural support, as it accommodates critical components such as the ethmoid sinuses and the olfactory epithelium. Consequently, fractures of the ethmoid bone resulting from facial trauma can precipitate complex clinical challenges, including damage to adjacent structures and sensory dysfunction. Understanding the biomechanical aspects of ethmoid bone fractures is paramount for clinicians and researchers alike, as it

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provides a foundation for devising effective diagnostic and therapeutic strategies (Rhoton, 2002).

Facial trauma, often arising from accidents, sports injuries, or interpersonal incidents, poses a significant risk to the structural integrity of the ethmoid bone due to its central location within the facial skeleton. The unique anatomical features of the ethmoid bone, including its delicate cribriform plate and intricate labyrinthine structure, contribute to its vulnerability in the face of external forces. Moreover, the ethmoid bone's proximity to critical structures, such as the orbits and the anterior cranial fossa, amplifies the potential for severe complications arising from fractures (Peeters, 2016).

Despite the clinical importance of ethmoid bone fractures, a comprehensive understanding of the underlying biomechanics, particularly regarding stress distribution and crack propagation, remains elusive. This study addresses this gap by employing advanced computational modeling techniques to simulate and analyze the mechanical responses of the ethmoid bone under various loading conditions. By unraveling the intricacies of stress distribution patterns, crack initiation, and propagation within the ethmoid bone, we aim to provide a robust foundation for developing targeted interventions that can mitigate the impact of facial trauma on this vital anatomical structure (Kumar, 2022).

As the field of biomechanics continues to advance, the findings from this study hold the promise of informing not only clinical decision-making in cases of ethmoid bone fractures but also contributing to the broader understanding of facial trauma biomechanics. By elucidating the mechanical intricacies of the ethmoid bone, this research endeavors to empower clinicians with enhanced diagnostic tools and guide the development of targeted therapeutic interventions, ultimately improving outcomes for individuals facing the challenges of ethmoid bone fractures (Dobrin, 2009).

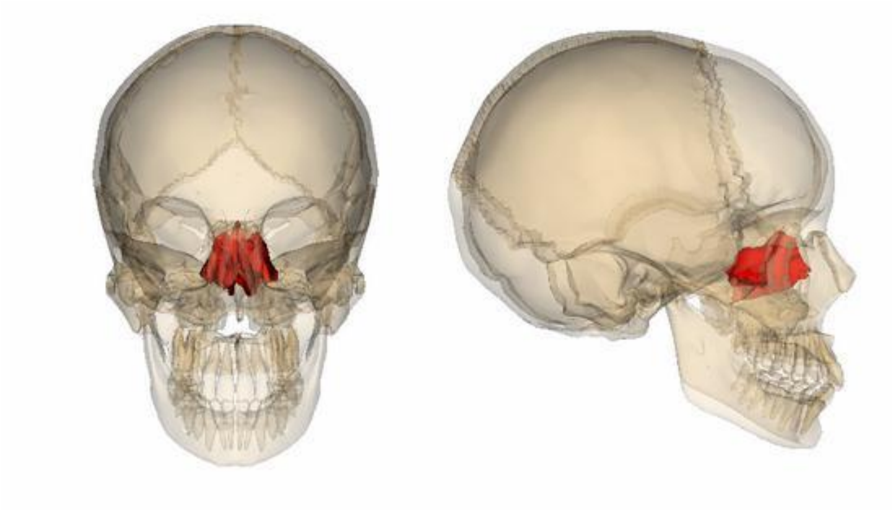

Figure 1. *Ethmoid bone location (red) (Ethmoid Bone Below, 2019, https://talli.ru/en/bones/latticed-bone-from-below-ethmoid-bone/)*

2. Material and Method

2.1. Finite Elements Modeling

Finite Element Analysis (FEA) is a numerical technique widely employed in biomechanics and engineering to simulate and analyze the behavior of complex structures under various loading conditions. In the context of this study, FEA was instrumental in understanding the mechanical response of the ethmoid bone to external forces and predicting the patterns of stress distribution during simulated traumatic events (Harikrishnan, 2023).

The ethmoid bone model, constructed from medical imaging data, was discretized into a finite number of small, geometrically simple elements. Each element represents a discrete section of the ethmoid bone, allowing for the accurate approximation of its structural response to external stimuli. The entire ethmoid bone model was then meshed, creating a finite element mesh that formed the basis for subsequent simulations.

Material properties assigned to the ethmoid bone within the FEA model were crucial in replicating realistic mechanical behavior (table 1). The elastic modulus, representing the bone's stiffness, and Poisson's ratio, characterizing its deformation under stress, were chosen based on existing biomechanical literature and experimental data. These properties were essential for ensuring the accuracy of the simulation results.

Loading scenarios were carefully defined to simulate a range of traumatic incidents that could lead to ethmoid bone fractures. These scenarios included impact simulations mimicking direct trauma, as well as dynamic forces associated with common accident scenarios. The application of these loads allowed for the observation of stress patterns and critical regions where crack initiation and propagation were likely to occur.

FEA software packages, ANSYS, were utilized to solve the system of equations governing the mechanical equilibrium of the ethmoid bone model (Gunasekaran, 2023). The software employed iterative algorithms to calculate the displacement, strain, and stress distribution within the bone structure. Post-processing of the simulation results involved visualizing stress contours and analyzing critical regions where stress concentrations were identified.

The insights gained from the FEA simulations contributed significantly to the study's findings by providing a detailed understanding of how stress is distributed throughout the ethmoid bone under loading conditions. The simulation results aided in identifying regions of high stress concentration, which correlated with anatomical features prone to crack initiation and subsequent propagation.

Three dimensional isoparametric solid elements (SOLID 65) were used to analysis this microstuctural model. Linear elastic material model was chosen for analsyis. Force of 100N was apllied to the model.

Table 1. *Mechaical Properties Ethmoid Bone (Peterson, 2003)*

Density g/cm3	Thickness mm	Modulus of elastisity Gpa	Shear Modulus Gpa	Poisson's Ratio
1.78	2.4	12.5	4.7	3.2

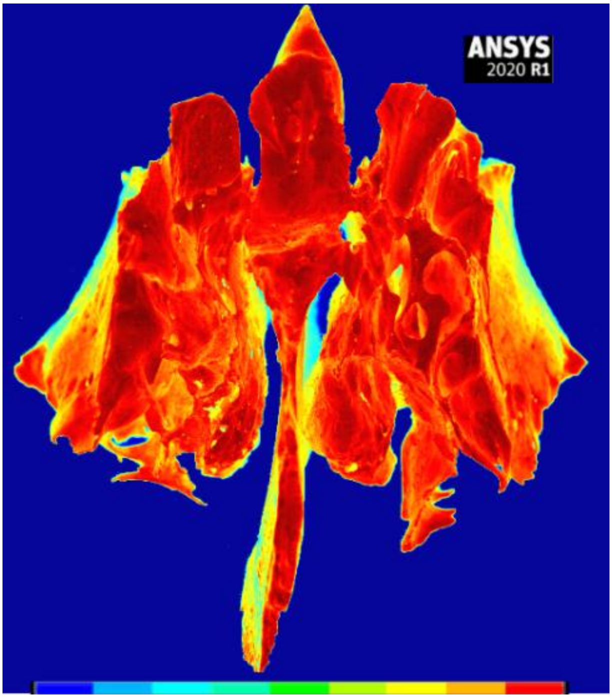

Figure 2. *Ethmoid Bone FEM*

$\mu(t) = \mu_0 \left(1-\sum_{i=1}^{2} ci(1 - e^{-t/ti})\right)$, (Pasquesi, 2018) (1)

The shear modulus is denoted by μ_0, with Ci representing the relaxation moduli, and τi indicating the time constants in the given equation. The specific values for the relaxation moduli and time constants were chosen based on the findings from other prior studies, which focused on investigating high-strain deformation in porcine brain tissue (Raghupathi, 2002).

3. Results and Discussion

The stress analysis revealed critical insights into the patterns and distribution of mechanical stress within the ethmoid bone. Examination of stress concentrations provided a comprehensive understanding of potential areas susceptible to crack initiation and propagation. Figure 1 and 2 shows the stress distribution and Von Misees respectively after applying force of 100 N. A- I show the minimum to maximum values along the Ethmoid bone. Figure 5 shows the crack growth that starts in area A and continues to area B. The correlation between stress levels and crack development emphasizes the importance of considering biomechanical factors in assessing bone integrity.

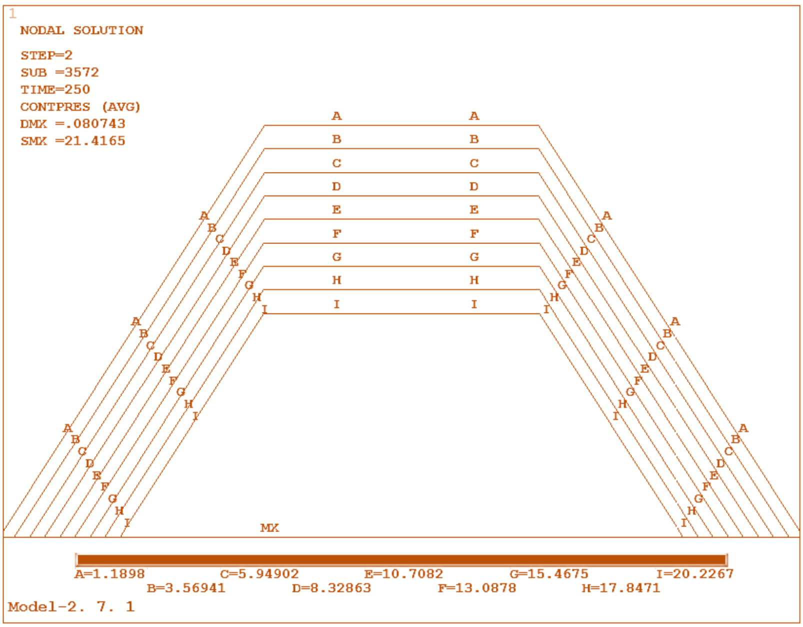

Figure 3. *Stress Distribution*

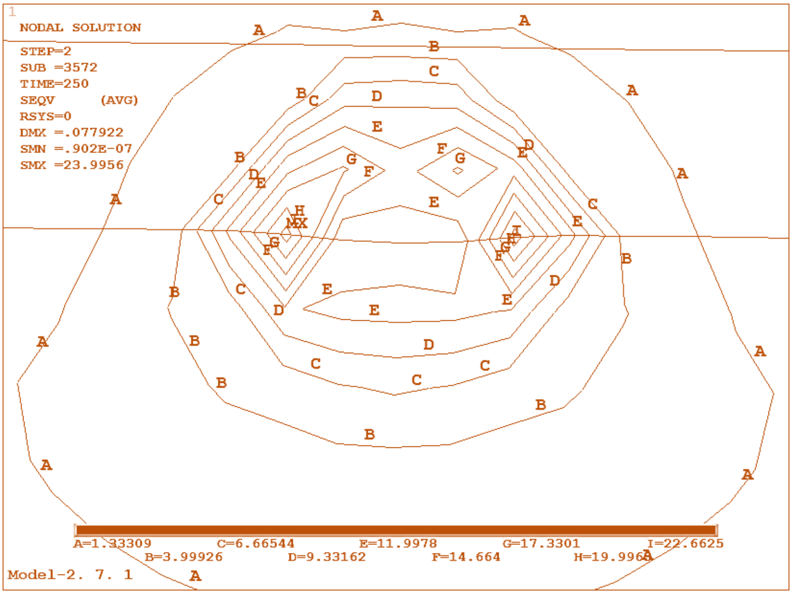

Figure 4. *Von Mises Stress*

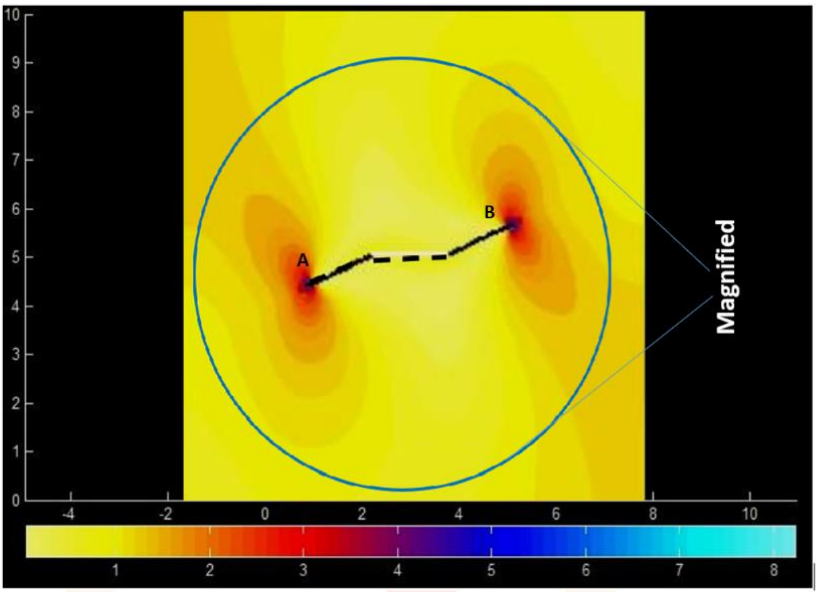

Figure 5. *Magnification of Crack Growth*

Conclusions

The stress analysis conducted on ethmoid bone fracture propagation has yielded valuable insights into the mechanical factors influencing crack initiation and progression. Specific stress concentrations were identified, providing a nuanced understanding of vulnerable regions within the ethmoid bone.

Longitudinal studies are recommended to investigate the dynamic changes in stress patterns over time and their implications for crack propagation. Future investigations could explore the potential role of interventions, such as targeted exercises or protective measures, in reducing stress levels within vulnerable regions of the ethmoid bone.

This study holds practical significance for advancing subsequent steps in surgical procedures related to this specific anatomical region. Additionally, it contributes valuable insights for the development and understanding of patient-specific prostheses, elucidating their functionality and potential applications in the context of the studied body part. The findings may serve as a foundation for optimizing surgical techniques and designing prosthetic solutions tailored to individual patient needs, ultimately enhancing the precision and efficacy of medical interventions in this anatomical area.

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CHAPTER VII

Microalgal Postbiotics: A Sustainable Approach to Modern Health Challenges

Deniz ŞAHİN[1]

Introduction

In the ever-developing field of microbial ecology and its products related to human and animal health, there is a growing interest in obtaining a wide variety of new bioactive substances derived from microorganisms. In this context, it is of great importance to investigate prebiotics, probiotics, parabiotics, synbiotics and especially postbiotics obtained from microorganisms, which are the subject of this review, and to investigate their potential effects to improve human and animal health (Figure 1).

At this stage, it is important to first define the concepts mentioned. The concept of postbiotics has developed particularly in the context of the health benefits attributed to probiotics and their efficacy has been associated with the vitality of organisms.

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However, it is recognised that in addition to living microorganisms, non-living microorganisms, their cellular structure and metabolites produced by the cell may also have a positive effect on health. In the scientific literature, various terminologies such as non-living probiotics, heat-killed probiotics, tyndallized probiotics, cell lysates, paraprobiotics, ghostbiotics and postbiotics have been used by different researchers to describe such products (Vinderola *et al*., 2022; Thorakkattu *et al*., 2022).

In mid-2021, the International Scientific Association for Probiotics and Prebiotics (ISAPP) officially defined the concept of postbiotic (Favero *et al*., 2022). According to the definition made by ISAPP, a postbiotic includes a preparation of non-living microorganisms and/or their components that provide health benefits to the host. The adoption of such a common definition was the result of extensive deliberations by a group of many scientists. This provides a clear and precise framework for the discussion of postbiotics in scientific, industrial and regulatory contexts. The term 'postbiotic' is derived from Greek and is a combination of the words 'post' 'after' and 'bios' 'life' (Camacho *et al*., 2019). The term is in line with the 'biotics' family (probiotics, prebiotics, synbiotics and postbiotics), which centres on microbes or their intracellular and extracellular products. Thus, by definition, postbiotics refer to substances that microorganisms produce when they are no longer alive, i.e. when they are lifeless, dead or inactivated. These products may include whole cells or structural parts such as the cell wall. Microbial metabolites, proteins or peptides can be defined as postbiotics with health effects. By definition, a postbiotic should originate from microorganisms with well-characterised and scientific genomic sequences and be produced by a specific, reproducible biomass production and inactivation process (Vinderola *et al*., 2022; Cuevas-González *et al*., 2020; Thorakkattu *et al*., 2022).

Another widely studied bioactive substance is probiotics. Probiotics are defined as live microorganisms that provide health benefits to the host organism when administered in appropriate amounts. In many studies, probiotic cells have been added to various fermented and non-fermented products in dairy and plant-based categories. However, the viability of probiotic microorganisms added to these products may be affected by the food properties and storage conditions of the product and therefore, low efficiency in the use of probiotics in some foods has been reported (Vinderola *et al*., 2022; Żółkiewicz *et al.*, 2020).

On the other hand, prebiotics, by general definition, are non-digestible food ingredients that support the growth of beneficial bacterial species in the digestive system. Although prebiotics are commonly used synergistically with probiotics, they often outperform probiotics in food processing because they are more stable than probiotics. Examples of prebiotics are various soluble carbohydrates such as fructooligosaccharides, galactooligosaccharides, inulin, mannanoligosaccharides and others (Żółkiewicz *et al.*, 2020; Favero *et al*., 2022).

Another form of biotics which is directly related to probiotics is called parabiotics. Parabiotics are defined as inactive probiotics. Whole or fragmented cells or crude cell extracts can be defined as parabiotics. Dried or lysed yeast cells are among the commonly used parabiotics (Cuevas-González *et al.*, 2020)

Using probiotic organisms together with prebiotics may have positive affect on the intestinal microbiota, increase immunological response, disease resistance and digestibility (del Valle *et al*., 2023). The combination of probiotics and prebiotics is called synbiotics.

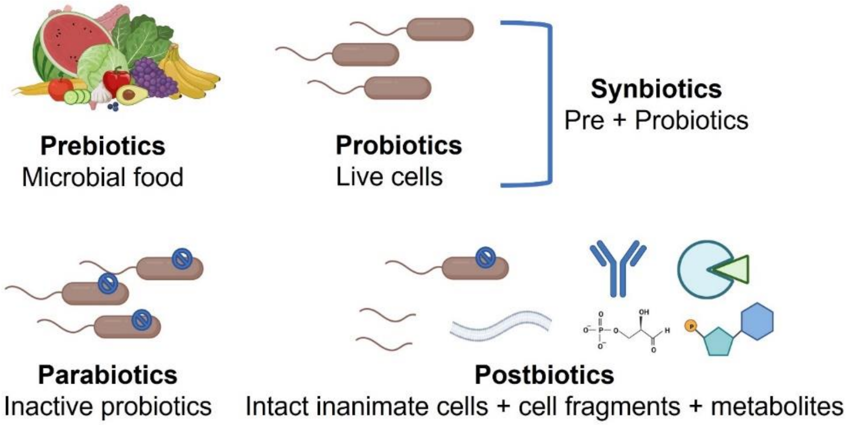

Figure 1: *Biotics family: Prebiotics, probiotics, synbiotics, parabiotics and postbiotics*. Prebiotics are mostly non-digestible fiber containing food for probiotics which are live cells. Synbiotics are combinations of prebiotics and p[i]robiotics. Parabiotics are inactivated intact probiotic cells. Postbiotics are intact inanimate cells, cell parts/fragments or metabolites produced intra or extracellularly.

Microalgal Postbiotics

In this mini-review, especially microalgal postbiotics are examined. Microalgae are organisms used extensively in many industrial applications. They are widely used in the production of many valuable molecules such as fatty acids, carotenoids, proteins, vitamins and polysaccharides for different applications (Figure 2). Microalgae have high potential due to their efficiency and cost-effectiveness in the production phases. The products are highly valuable in several fields including food industry, animal feed industry, cosmetics, pharmaceuticals, biofertilisers, biofuels and wastewater bioremediation (Oleskin & Boyang, 2022; Sompura *et al*., 2021; Ji *et al*., 2015). A wide variety of microalgae species including green, red, brown and diatomaceous algae as well as cyanobacteria play an important role not only in traditional applications but also in postbiotic production.

The ability to produce several bioactive compounds makes microalgae important players in the development of new therapeutic strategies in biomedical technology (Chen *et al*., 2022; Chi *et al*., 2009; Jesus *et al*., 2010). In addition, microalgae, together with sustainable and environmentally friendly production methods, are being extensively used and researched as an alternative to traditional pharmaceuticals and chemical-based therapies. The importance of microalgae in the field of postbiotics lies in their ability to provide compounds that can positively affect human and animal health (Oleskin & Boyang, 2022).

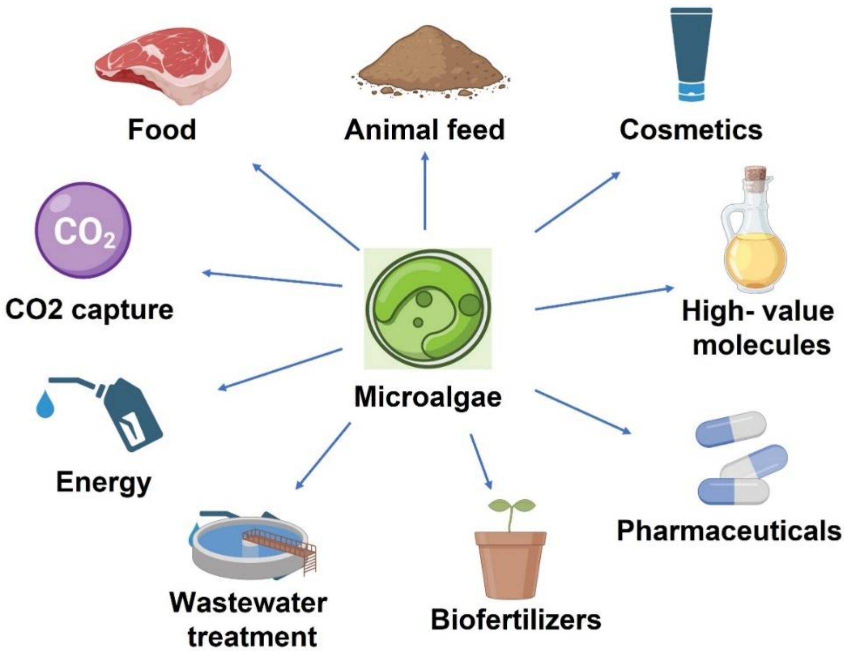

Figure 2: *Applications of microalgae*. Microalgae based products have countless applications from high-value molecule production such as omega-3 fatty acids to CO_2 capturing, wastewater treatment and bioenergy production.

Microalgal postbiotics can be examined under various headings. Firstly, inactivated cells that can be used as probiotics can be used directly. In addition, fragmented cell parts can be used directly. At this point, parts of the cell such as cell membrane, organelles or cell wall can be used. In addition to these, intracellular and extracellular metabolites can also be used as postbiotics. As different microalgae cells continue to be investigated, molecules with very different structures and potential application areas where these molecules can be used continue to be revealed.

The expanding scope of microalgae-derived applications and products now includes the potential of microalgae as probiotics. Microalgae contribute to the normalisation of the microbiota in humans and farm animals. They promote gut health, with microalgal compounds like polysaccharides acting as effective prebiotics, enhancing the growth of beneficial gut bacteria. This is a direct example of health benefits obtained by microalgal postbiotic application.

Many species of microalgae are widely used for the production of various lipids, especially omega-3 fatty acids. The beneficial effects of omega-3 fatty acids on human and animal health have been demonstrated by various studies and many microalgae-based fatty acid products are successfully available in the market (Ji *et al*., 2015). Microalgae such as *Chlorella*, *Schizochytrium* and *Nannochloropsis*, known for their rich omega-3 content which is associated with supporting brain health while contributing to cardiovascular health and cognitive functions (Oleskin & Boyang, 2022). These molecules can be obtained from biomass or directly from extracellular liquid depending on the type of the microalgal cell and production steps.

In addition to lipids, certain proteins produced by microalgae have been linked to advantageous effects on the cardiovascular system and brain activity. Moreover, microalgae-based proteins that can be used as postbiotics are particularly known for their antioxidant and anti-inflammatory effects. For example, proteins such as the phycocyanin pigment-protein complex found in *Spirulina*, a photosynthetic microalgae, are particularly effective in scavenging free radicals, thus protecting against oxidative stress and reducing inflammation in the body (Chen *et al*., 2022; Chi *et al*., 2009; Jesus *et al*., 2010).

Microalgae-based polysaccharides have also gained attention in recent years due to their potential health benefits. Polysaccharides from Spirulina and Chlorella are good examples with various health effects. These positive health effects include antioxidant property, immunomodulatory effect, anti-Inflammatory effects, cholesterol reduction, potential anticancer effect, digestive health and neuroprotection (Costa *et al*., 2021; Kocer *et al*., 2021)

Pigments are also widely produced based on microalgae and used in many applications. Carotenoids are powerful antioxidants that can protect the body from oxidative damage. Astaxanthin, a carotenoid pigment found in microalgae such as *Haematococcus pluvialis, Schizochytrium* species, is known for its strong antioxidant and anti-inflammatory effects making it a valuable ingredient in pharmaceuticals and cosmetics and a potential product for many applications. In addition, phycobiliproteins such as phycocyanin and phycoerythrin in *Spirulina* are widely investigated for their potential anticancer activity and is used as an ingredient in dietary supplements and functional foods (Balasubramaniam *et al*., 2022). Beta-carotene, lutein and zeaxanthin are among the other pigments produced by microalgae cells. In addition to antioxidant effect, microalgae carotenoids have a high nutritional value and used as dietary supplements in functional foods and beverages. Additionally, microalgae carotenoids have applications in food, cosmetic and pharmaceutical applications (Sirohi *et al*., 2022).

Additionally, microlgae based postbiotics have high potential for animals and can be used as feed additives or supplements, particularly in livestock and aquaculture. Microalgal postbiotics from microalgae such as *Spirulina*, *Chlorella*, and *Dunaliella*, among others, can enhance digestibility of animal feed, boost the immune system, stimulate animal growth, promote animal gut health (Saadaoui et al., 2021).

Furthermore, microalgal postbiotics are used in applications in agriculture and aquaculture. Biostimulants derived from microalgae like *Chlorella vulgaris* can be used to enhance plant growth and stress tolerance, leading to improved crop yields. On the other hand, postbiotics from *Spirulina platensis* promote the health and survival of fish and other aquatic animals (Chamorro *et al.*, 2015).

Postbiotics, like those derived from *Chlorella vulgaris*, exhibit bioremediation capabilities, offering a sustainable approach to environmental cleanup. These postbiotics can also be utilized as feedstocks for biofuels, providing a renewable and environmentally friendly alternative to fossil fuels (Kumar et al., 2019).

In conclusion, microalgae-based postbiotics show a wide range of applications for human, animal, agriculture and aquaculture applications, health effects, from antioxidative and anti-inflammatory effects to cardiovascular support, improvement in gut health and potential anticancer and brain development effects. The inclusion of these postbiotics in the diet or their use in pharmaceutical and nutraceutical products represents a natural and sustainable approach to improving health and wellness.

Sustainable production of microalgal postbiotics

During the production of microalgae-based postbiotics, sustainable production can be achieved with approaches such as the use of photobioreactors, especially for photosynthetic microalgae. In these systems, light, temperature and nutrient availability can be regulated to increase biomass and postbiotic production by providing controlled growth. The use of closed systems such as closed photobioreactors will reduce the risk of contamination and increase resource efficiency. A wide range of nutrient sources can be used as media in the cultivation of microalgae. In this way, postbiotic production stages can be integrated with other industrial processes. With approaches such as the use of wastewater as an additive to the medium and the use of microalgae as bioremediation agents, postbiotic production is carried out together with an ecological solution (Balasubramaniam *et al*., 2022; Oleskin & Boyang, 2022; Thorakkattu *et al*., 2022).

For the effective and scalable production of microalgal postbiotics several strategies are employed for extracting and isolating these valuable bioactive metabolites. Optimization of cell disruption techniques such as ultrasonication, bead milling, or enzymatic lysis, followed by centrifugation and filtration to separate postbiotics from cell debris is the key step for the extraction of the valuable molecule. Additional purificational techniques including precipitation, chromatography, and membrane filtration can be applied for the specific postbiotics like exopolysaccharides and pigments. Different fermentation techniques and extraction processes can be applied depending on the specific target metabolite, desired bioactivity, and intended application (Lee et al., 2018).

Again, through genetic modification of commonly used microalgae species and improvements in species selection, productivity and environmental stress factor tolerance can be improved for high postbiotic yields. Cultivation of microalgae on non-arable land minimizes impacts on the ecosystem by reducing competition with food crops. Microalgae such as the photosynthetic *Dunaliella*, *Chlorella*, *Spirulina* and *Nannochloropsis* and especially the heterotrophic *Schizochytrium* species microalgae are particularly suitable for sustainable production given their fast growth rates and high biomass productivity (Balasubramaniam *et al*., 2022; Park *et al*., 2015).

As previously mentioned, microalgal postbiotics provide immunomodulatory, prebiotic, antioxidant and anti-inflammatory benefits. Polysaccharides and phycobiliproteins of some microalgae enhance immune cell activity, while microalgal prebiotic compounds, such as those found in *Chlorella* and *Spirulina*, promote the growth of beneficial gut bacteria. In addition, the astaxanthin compound of *Haematococcus pluvialis* and *Schizochytrium* species microalgae cells has strong antioxidant properties. Omega-3 fatty acids have also been associated with cardiovascular health.

Furthermore, phycocyanin and fucoxanthin offer anti-inflammatory properties. Integrating microalgal postbiotics into diets, functional foods and supplements is a sustainable method to improve overall well-being (Sompura *et al*., 2021).

Conclusion

In conclusion, the investigation of microalgal postbiotics and their potential applications is an extremely important and sustainable field of research due to their numerous benefits for both human, animal and plant healht. A wide range of useful applications can be developed by comprehensively examining prebiotics, probiotics, parabiotics, synbiotics in the biotic family, and postbiotics obtained from organisms, which are the subject of this review.

Microalgae-based postbiotics have been widely studied due to their wide range of application potentials. The antioxidation, immunomodulation, anti-inflammation and potential anticancer properties of microalgae-based postbiotics make them one of the most important parts of microbial biotechnology. Microalgal-based postbiotics have a wide range of applications, from the production of nutritional supplements for humans and animals to the production of biofuels, from wastewater treatment to the production of beneficial molecules.

A wide variety of useful molecules are produced, especially by producing photosynthetic microalgae through the use of photobioreactors. In addition, heterotrophic microalgae species are also used in a wide variety of applications with their fast growth rates. Sustainable production approaches can be followed by growing photosynthetic or heterotrophic microalgae integrated with ecological solutions. In this way, the production of microalgae-based postbiotics can be achieved with sustainable and environmentally friendly approaches. Microalgae cells can be considered as living cells or inactive cells. In addition, cell fragments, macromolecules and intracellular and extracellular metabolites constitute very valuable potential products.

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