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A Review on Exploring the Anti-aging Sources: Thai Food, Fermented Food and Bioactive Compounds

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Abstract

Background: Everything on earth is mortal, and so is our body and skin. From a minute cell to the intestine, every part has a natural tendency to slow down its growing process as we age. Aging is an unstoppable process, but it can be maintained and delayed with the right choices. Various internal and external factors regulate it. Diet is one of the easiest ways to delay the accelerated process of aging. Thai cuisine, fermented food and bioactive compounds contain all the nutrients required for slowing down the aging process. **Aim:** This review mainly focuses on anti-aging potential of Thai cuisine, bioactive compounds and fermented food, and their relation with the cellular and molecular mechanisms of aging. **Methodology:** This thematic review was studied and evaluated using Scopus, PubMed and Google Scholar articles. Studies identified anti-inflammatory, anti-oxidant, anti-cancerous, probiotic and metabolic activity, and cellular protection activities of Thai cuisine, fermented food and constituting bioactive compounds were methodically scrutinised. **Results:** It was detected that Thai and fermented foods are vital sources of flavonoids, bioactive peptides, probiotics, organic acids and polyphenols. They have the potential to attenuate oxidative stress, curtail inflammatory pathways, augment mitochondrial function, boost microbiota of the gut and delay the cellular aging process. **Conclusion:** Thai and fermented food are rich in bioactive compounds and can be combined with other cuisines to serve their really promising nutritional property; despite the current studied are convincing, a solid scientific proof is still needed like clinically controlled trails before introducing it in real world application.

Major Findings: Variety of Thai cuisine, fermented foods and contributing bioactive compounds possess anti-inflammatory, antioxidant and probiotic activity in glowing, healthy skin, thus extending the durability of life.

Keywords: Anti-aging Food, Bioactive Compounds, Fermented Food, Seafood, Thai Food

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1. Introduction

Aging is a complex biological process characterised by a gradual deterioration in physiological processes and a heightened susceptibility to illness. All tissues and organs are impacted, with the skin acting as one of the most obvious signs of aging. Genetics and cellular metabolism are examples of intrinsic variables that affect skin aging, while environmental exposures and lifestyle decisions are examples of extrinsic factors. Developing strategies that promote healthy aging and lessen the detrimental effects on skin function and appearance requires an understanding of these systems[1].

Therefore, aging is a complicated biological phenomenon. It is characterised by a gradual decline in physiological processes over time, decreased resilience and heightened susceptibility to age-related illnesses, which ultimately result in death, but throughout history, research has continuously focused

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on anti-aging treatments (cosmetic surgery, drugs and natural remedies)[2]. In addition to these prevalent cosmetic procedures, the commercial anti-aging market has expanded vividly. The considerable and growing demand for anti-aging products and therapies is reflected in the global anti-aging market, which is estimated to be worth over $60 billion. Historically, middle-aged and older persons have been the main customers of anti-aging goods, but current trends show that younger groups looking for preventative measures are becoming more interested[3]. A wider acceptance of anti-aging treatments is also reflected in shifts in public perception, with many customers concentrating on holistic approaches that incorporate skincare, lifestyle modifications, and cutting-edge therapeutic technology.

In this manuscript, our focus is on natural anti-aging foods such as Herbal plants, Fruits, Thai and Fermented foods. All these natural recipes contain antioxidants, flavonoids and other bioactive compounds (phytochemicals or polyphenolics), which contribute to anti-aging. By focusing on these foods, this study aims to elucidate their potential and discuss them in a stepwise manner.

Firstly, Thai foods such as rice, appetisers, spicy dips, curries, soups and desserts, as well as seafood like salmon, fatty fish and tuna, contain health-beneficial spices. Local vegetables can also be consumed as natural antioxidants and anti-inflammatories. Proper consumption of such a diet can also contribute to an anti-aging marvel. Another natural way is to combat aging using microorganisms to produce various fermented foods like fermented milk, red wine and natto. These foods contain micro-communities that act as mediator in the decline of the aging process due to their anti-carcinogenic, anti-allergic and anti-diabetic properties. Fermented foods, due to their higher quantity of bioactive compounds, are particularly promising in this regard. Moreover, bioactive compounds found in these foods can protect the skin against UV radiation, making them potential nutricosmetic or cosmeceutical products[4-6]. Aging is the ultimate fate of our body cells and depends on the health of the body cells (on the diet). Numerous factors contribute to aging, like poor eating habits, lack of sleep, poor lifestyle, less movement or no exercise and excessive screen time or binge-watching[7]. Another trending contributor behind aging is AGEs (Advanced Glycation End- Products), which target our blood vessels and damage them, causing problems in the eyes, skin and nerves[8]. In cosmetology, the main focus is on the signs of aging, like the colour of skin, glow, formation of patches, wrinkles, and sagginess (less elasticity)[9,10].

Fermented food is the best kind of food for anti-aging skin. It includes several Lactic Acid Bacteria (LAB), acetic acid bacteria, yeast and moulds. These are beneficial for human beings due to the presence of various nutrients that keep our gut health safe

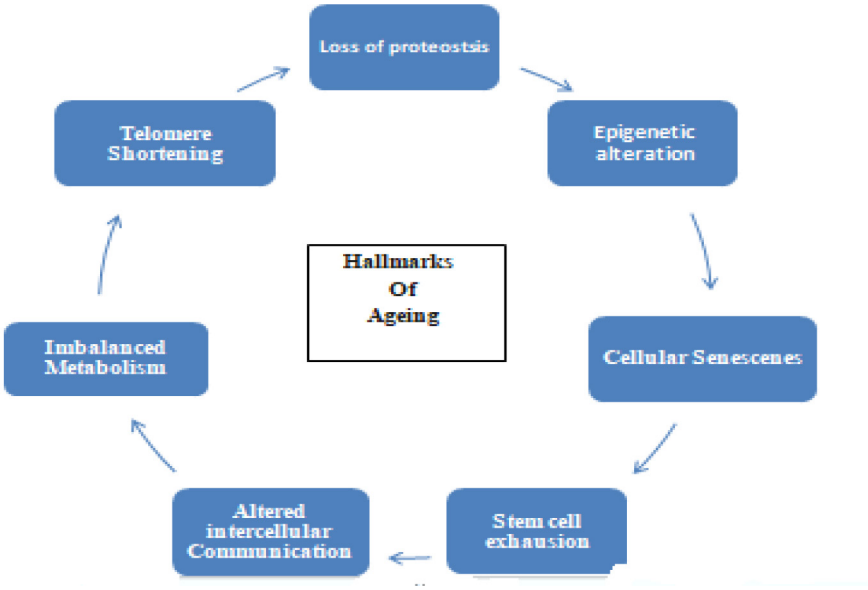


Figure 1. Hallmarks contributing to aging[12].

and secured[11]. In the future, these natural foods and microbial processes can be used as anti-aging solutions. The hallmark of aging is shown in Figure 1[12]. All these foods and natural remedies are explained below in detail.

2. Thai Food

Thailand is indeed renowned for its unique culture and delicious anti-aging and anti-inflammatory crops like black rice[13]. Thai cuisine has gained worldwide recognition for its strong flavours, incorporating salty, sweet, sour, and spicy elements. They are naturally injected with antioxidants as well as nutrient-dense properties. The healthy fat ingredients contribute to supporting the muscles of the jaw and face line. Thai food is not only about attractive aroma and delicious spices, but the medicinal treasure it carries that wars with accelerated signs of aging, infection and cell damage instead boosts metabolism, enhancing the immune system's activity. No fights are easy, especially one like combating diseases like Cancer and Thai dishes are a great source of anti-cancerous properties like lemongrass, turmeric and kaffir lime.

Fresh veggies from Thailand, like carrot, bok choy (Pak choy in India), bell pepper, in combination with some herbs like mint and cilantro, contributes in fighting aging as they are full of Vitamin A, C and E, ultimately enhancing the elasticity of skin and production of collagen.

One of the causes for an early aging of skin is the lack of hydration and dry pores that, if left unhydrated for a long-time results in permanent dryness. Fats keep the skin brighter and tighter by providing it with the necessary hydration needed to combat dryness. It may include a balanced diet with natural fat fillers like Coconut milk, fishlike mackerel or salmon that are rich in Omega-3 fatty acids. To keep skin radiant, youthful and glowing, there is a soup named Tom yum that is not only flavoured with spices but also hydrating. Spicing up your diet with spices like turmeric, pepper, and ginger reduces the age-related wrinkles on the face and hands, as well as pain or discomfort in joints. The main reason behind this can be chronic inflammation, and these spices act as a bag full of anti-inflammatory properties and longevity. Overall, anti-aging foods depend on natural ingredients, whether it's herbs, chemicals, veggies or natural sugar like coconut sugar for moderation of food and not the processed diet of chemical sweetener agents and refined sugar[14,15].

2.1 Rice

Rice plays a significant role in Thai cuisine, offering a range of flavours and being paired with various ingredients and dishes. Some of the varieties of rice are jasmine and red rice that aren't just staples but also promotes the health. The vitality of life depends on Vitamins B and E, as well as fibre and magnesium that are the main proportions of this rice. The red and black coloured rice consists of antioxidant properties that fight free radicals and neutralise them, thus protecting skin cells from damage as well as fighting oxidative stress. It is typically prepared as non-glutinous rice or steamed rice.

A well-known dish, kanomjeen, features rice noodles served with a coconut milk-based broth. As a staple carbohydrate, rice is essential to the Thai diet. The detoxification process of internal organs is a very important process, and the rice prepared in Thailand is prepared accordingly with a combination of small portion oil mixed with herbs like ginger, lemongrass, turmeric and galangal as they do have inflammatory property.

The elasticity is affected by the presence of elastin and anti-wrinkle because collagen is affected by a process called glycation that directly accelerates sugar spike, and the aging process can be prevented by having a diet rich in complex carbohydrates that provide energy steadily. Black rice, in particular, is rich in bioactive compounds such as cyanidin-3-glucoside, catechin, and peonidin-3-glucoside, which provide strong antioxidant properties[16,17].

2.2 Appetizers

Indulge in a delightful array of appetisers featuring a variety of flavours such as tamarind, cucumber, chilli pepper, tomatoes, lime juice, and garlic. There's something for everyone, from the refreshing papaya salad or 'som tam' to the abundance of green vegetables and digestive lime juices[18,19].

The appetisers are not just tasty but full of antioxidant and anti-inflammatory properties, like fresh spring rolls, herb-infused soups, and papaya salad, which are rich in vitamins. To slow down the aging process,

one must ingest a diet that fights oxidative stress and infections, aids digestion, increases metabolism, and improves blood circulation. For this purpose, Thai Appetizers are the best source supporting collagen production. They must be prepared using green papaya, which is rich in enzymes and vitamin C, in combination with spices like chilli, pepper, lime, and garlic. One of the healthiest varieties of spring rolls is prepared in Thailand and is filled with herbs, vegetables, and spices wrapped with rice paper. Sometimes, tofu and shrimp can be added, not only to enhance flavour but boosts energy and metabolism. A balanced diet keeps the body fine, a nutrient-rich, low-fat diet and herbs like basil, coriander and mint are a good choice. Don't miss out on the exquisite wild betel leaf wraps known as 'Miang Kham, ' which tantalise the palate with a blend of ginger, coconut flakes, palm paste, shrimp paste and more[20,21].

2.3 Spicy Dip

It consists of spicy, sour, sweet, and salty flavours. Its ingredients include fish sauce, chilli pepper, shallot, and garlic cloves. The famous "*Nam Phrik ka pi*," a spicy shrimp paste dip, is also a signature dish of Thai cuisine. This helps in our bodies defencing system to fight both inside and out. Capsaicin, a compound found naturally in chilli peppers, has anti-inflammatory and antioxidant properties. It improves the skin renewal process and digestion by removing toxins, thus enhancing blood circulation and Basal Metabolic Rate (BMR). Gut health is one of the major factors in detoxifying and boosting immune function. Dip made using shallot and garlic has a sulphur compound that has anti-microbial properties and makes skin glow and youthful. A great source of vitamin C is lime juice, essential to produce collagen that acts as a barrier to protect skin cells from damage through free radicals. The addition of veggies with herbs makes Thai food a balanced one as well as a weight-\controlling, low-calorie diet with a mini-pack of anti-aging compounds and vitamins.

2.4 Coconut Milk-based Curry

In coconut milk-based curry, the main components are coconut milk and curry paste. The curry paste contains garlic, coriander root, coriander seed, shallot, lemongrass, pepper, and cumin seed. Coconut oil acts as a natural solvent by separating polar and non-polar compounds. Additionally, the curry paste exhibits high anti-microbial activity[22, 23].

The curries have a different variety, like red, green, and massaman curry, which are prepared when coconut is mixed with spices and herbs, giving it a creamy texture and mouth-watering aroma. Coconut oil contains a chain of medium triglycerides (MCTs), a great source of growth and energy, a good fat that always provides hydration, glow, and smoothness and maintains elasticity while we age. Another important star contributor is lauric acid, with natural antiviral and anti-bacterial properties. Hence reduces premature aging by improving circulation and immune functions. A balanced diet consists of fruits, veggies, nutrients, minerals like selenium and zinc, and vitamins like A, C, and E that nourish and beautify smooth skin and strong hair.

2.5 Dessert

Mostly consists of plant-based natural ingredients. Indulge in a delightful vegetarian dessert option featuring the luscious sweetness of ripe mango paired with sweet sticky rice, also known as '*Khao Niao Mamuang*'. This delectable treat is crafted with a blend of palm sugar, rice, and coconut milk, complemented by the richness of muhallebi[24]. Mangoes are renowned for their uniquely sweet taste and captivating aroma. Within the mesocarp of mangoes, you'll find a treasure trove of antioxidants such as ellagic acid, mangiferin, beta carotene, and Vitamin C, offering a delightful and nourishing experience[25].

The purpose of adding palm sugar is that it has a low glycemic index, so it will cause a slow rise in sugar and protect the skin from being damaged due to the process of glycation. Ingredients rich in fiber like banana in sticky rice and taro in coconut milk, improve digestion, boost metabolism, and provide glowing skin.

3. Fermented Food

Fermented foods rely on beneficial microorganisms to support growth and metabolic processes. These microorganisms offer various advantages, such as long-term preservation, improved microbial stability, enhanced safety, extended shelf life, and better mineral bioavailability. One of the most notable fermented foods is *kimchi*, which has demonstrated potential antidiabetic, anti-obesity, and anti-aging effects[26].

The anti-aging properties of fermented foods are particularly noteworthy, as they are believed to promote healthy and radiant skin. These foods include a wide range of plant-based, meat, and dairy products[27].

3.1 Fermented Soy Products

The presence of protein in soybeans or *sauerkraut* (fermented soya) of plant origin is the highest in amount. Miso is a semi-solid dish prepared from salt, soybeans, and koji, a type of mould. It contains many probiotics, especially *lactobacillus* species, and is rich in isoflavones that enhance skin and bone health and mimic estrogen. Miso is rich in elements like manganese and zinc that are sources for cell regeneration activities and collagen synthesis.

Fermentation of soyabean into a soyabean firm cake is called Tempeh, used in sandwiches, as an alternative for meat and in fries, rich in Vitamin B-12, which is rare in plant food, as well as supporting tissue and muscle health repair. Tempeh is a bag full of digestive enzymes and probiotics.

One such product is soy sauce, i.e. a naturally brewed and liquid spice made using water, wheat and salt. It contains a small proportion of antioxidants and requires less added salt. It also contains the flavonoid class that consists of two main compounds: Daidzein, which enhances mitochondrial activity, and genistein, which helps in insulin resistance activity[28-30].

3.1.1 Natto

The ancient and traditional food of Japan is prepared by fermenting soybeans with *Bacillus natto.* It is best recommended for the prevention of heart attacks, osteoporosis, strokes, cancer, and obesity, which may contribute directly or indirectly to aging. It is made mostly over rise and soya sauce, and mustard. There is an enzyme named nattokinase, known best for supporting cardiovascular health. It is packed with a high amount of Vitamin K2 that helps in regulating calcium and strengthening bone health. It also aids in healthy aging by circulating the proper flow of blood in our body and by reducing stiffness in the arteries. So basically, it's best when used as an anti-aging source[31,32].

3.2 Fermented Dairy Items

Fermentation is a key source for more utilisation and enrichment of dairy products using lactic acid-producing bacteria worldwide. Lactose, a milk sugar, converts into lactic acid directly after fermentation[33,34]. Therefore, it improves milk's shelf life, adds flavour, and thickens the texture. It has antioxidant properties and is rich in bioactive compounds like probiotics, peptides and short-chain fatty acids.

3.2.1 Dadih

Also known as dadihh or dadiah. It is an Indonesian dairy product, prepared from raw buffalo milk in bamboo tubes by lactic acid fermentation, wrapped in banana leaves, traditionally made by the Minangkabau people from West Sumatra. It is sour, tastes like yoghurt, and has a creamy texture. It is beneficial because of the colonisation and survival of bacterial strains in the intestinal guts[35].

3.2.2 Kimchi

Kimchi, a type of fermented food originating from Korea, is packed with incredible health benefits. Made from a combination of yellow and green vegetables and fermented with species like *Weissella, Leuconostoc,* and *Lactobacillus.* The paste is prepared from fish sauce, chilli flakes, salt, ginger, garlic, and sugar. It is stored at cool temperatures in earthen pots, onggi and jars. *Kimchi* is fermented because of the continuously multiplying lactic acid bacteria naturally. *Kimchi* has been shown to strengthen the immune system, exhibit anti-cancer as well as anti-obesity properties, and contribute to anti-aging effects. This superfood is not only delicious but also a powerhouse of wellness[36,37]. It is overloaded with probiotics (*Lactobacillus plantarum*) that enhance and improve gut flora and digestion, ultimately supporting the immune system and aiding in biological aging. Also rich in antioxidants like ginger or garlic that prevent damage to DNA and neutralise free radicals that maintain smooth and youthful skin. It also improves brain health and cures the loss of memory, mood and cognitive function that lessens with aging. The beta-carotene and Vitamin C in *kimchi* are involved in collagen production and act as a barrier from UV radiation.

3.2.3 Yogurt

Yoghurt is produced through the fermentation of milk. Camel milk has been found to have antimicrobial activity[38]. The fermentation process involves

Streptococcus thermophilus, Lactobacillus bulgaricus and *Lactobacillus delbrueckii*. It is packed with Vitamin D and calcium for strong bones. It also helps in maintaining blood pressure and cholesterol. Yoghurt aids in the digestion of lactose, improves digestion and metabolic activities. In elders, it reduces the risk of common cold and enhances the activity of natural killer cells more effectively than normal milk, thus boosting the immune system and contributing to anti-aging[39].

4. Bioactive Compounds

The important complexes found in foods are bioactive compounds that are efficient in regulating different metabolic activities. Fruits contain a large content of bioactive compounds, especially tannins, flavonoids and phenolic acids. Maximum amounts of polyphenols like catechin, epicatechin, proanthocyanidinB2, rutin and chlorogenic acid are present in fruits. Fruits like apple, *Citrus sinensis*, and *Ribes nigrum* have highly anti-oxidant properties[40,41]. The macronutrient content *viz* carbohydrates, fats, proteins and dietary fibres of different fruits shown in Table 1.

5. Herbal Involvement

Medicinal plants have been cherished for their healing properties for thousands of years. These natural wonders, comprised of leaves, roots, seeds, and flowers, offer a holistic approach to treating various ailments and nourishing the skin. Their ability to soothe, rejuvenate and protect the skin without any harmful side effects is truly remarkable[48].

Some of the most beneficial and valuable herbals are:

1. Turmeric, or *curcuma longa* herb, has antioxidant and anti-inflammatory activity supports by slowing down the aging process or diseases.
2. Ginseng (the root of immortality) reduces fatigue, enhances cell regeneration and boosts immunity.
3. Cinnamon or *Cinnamomum verum* has an active compound, cinnamaldehyde, which controls blood sugar levels and enhances blood circulation.
4. Neem or *Azadirachta indica* have an antimicrobial activity that promotes clear skin and fights oxidative damage.
5. Holy Basil/Tulsi or *Ocimum sanctum*-it detoxifies the body, boosts immunity, fights infectious pathogens and maintains blood sugar levels.

These not only shield the skin from harmful radiation and ward off skin cancers, but also exhibit antimicrobial properties, keeping our skin and surroundings clean and healthy[49]. The anti-cancerous properties of medicinal plants have been well-documented, making them an indispensable part of skincare and overall well-being[50].

For instance, *Borago officinalis L.* boasts anti-inflammatory properties and can be easily incorporated into salads for a healthful boost. Meanwhile, *Moringa oleifera* is renowned for its ability to safeguard against radiation, thanks to its rich content of flavonoids such as quercetin, luteolin and rutin. These compelling benefits underscore the undeniable power of medicinal plants in promoting skin health and overall vitality[51].

6. Risk-benefits and Limitations

The current evidence supports the potential of Thai fermented foods and their bioactive compounds as a good anti-aging food. However, it still lacks certain parameters that validate its potential. It states about the *in-vitro* based experiments or on animal models, but for real-world practice, it must undergo a well-designed human clinical trials and proper Bioactive profiling. One of the other challenges is the lack of uniformity

Table 1. Fruits and their macronutrient content in grams

Fruits	Macronutrients (In Gram)				References
	Carbohydrates	Fats	Proteins	Dietary Fibers	
Citrus sinensis	11.75	0.12	0.94	2.4	[42]
Fragaria x. Ananassa	7.68	0.30	0.67	2	[43]
Malus pumila	13.81	0.17	0.26	2.4	[44]
Ribes nigrum	13.8	0.2	1.4	4.3	[45]
Prunus avium	16.01	0.2	1.06	2.1	[46, 47]

in the composition of food and in the process of fermentation. Fluctuations in preparation and the raw material used also affect the growth, concentration and availability of microbial strains, which also makes the analysis difficult.

Thai cuisines are currently being promoted as an "anti-aging" diet. The presence of metabolites like GABA and redox-active compounds can be enhanced by fermentation, but is claimed to be preclinical rather than documented in humans[52]. It is mandatory to note that certain Thai cuisines of fish like pla-ra, tai-pla or miang contain LAB and polyphenols; despite this, the response and specificity of strain results vary, thus hindering it from wider relevance[53].

There are various conflicts regarding accountability for the direct effects of polyphenols on antioxidant activity. This is an indirect process that first effects of gut microbiome and depends on the absorption of polyphenols with an unpredictable amount of concentration[54].

Thai fermented sea foods (fish) contain a high amount of sodium, and if they are stored poorly it may develop certain toxins, leading to cardiovascular issues[55].

7. Conclusion

Aging is a natural process that cannot be skipped or escaped from but can be delayed by proper diet and lifestyle. Foods like Thai and fermented foods are a natural way with anti-inflammatory and anti-aging properties. Many of the fruits have antioxidant properties and bioactive compounds that slow down the aging process. Medicinal plants have stood the test of time as powerful healers, utilising various plant parts to treat ailments and rejuvenate the skin. Their ability to nourish, protect, and fortify the skin against radiation and cancer is unparalleled. These plants are beneficial and essential for maintaining healthy, radiant skin. For example, *Borago officinalis L.* is a potent anti-inflammatory agent and a perfect addition to salads for its health-boosting properties. *Moringa oleifera,* on the other hand, is a formidable shield against radiation, owing to its high concentrations of flavonoids like quercetin, luteolin, and rutin. The evidence is clear: Medicinal plants are indispensable for promoting skin health and well-being.

8. Future Perspectives

A revolutionary future propelled by rising interest in sustainability and wellness around the world. The production of bioactive substances, including probiotics, peptides, and other active compounds, can be maximised by combining contemporary biotechnology, omics technologies, and precision fermentation. Beyond conventional food applications, genetic engineering and sophisticated synthetic biology methods will improve strain creation for a variety of uses, such as medicines, cosmetics, and nutraceuticals. Through the upcycling of agricultural outputs and waste reduction, fermentation is playing an increasingly important role in sustainable food systems, addressing both food security and climate change. Similarly, Thai foods, fruits and other natural ingredients exhibits encouraging anti-aging potential due to their antioxidant qualities, suppression of enzymes linked to aging, and modification of pathways linked to longevity. It is a worthwhile candidate for additional study and development as a dietary supplement because of its many health advantages. Preclinical animal studies should be the first step in future research to assess safety, effectiveness, and ideal dosage. Human clinical trials should be conducted to evaluate long-term safety and efficacy after positive results.

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Author Contribution

Conceptualization - A.J. and M.K; resources - A.J., O.S., D.S. and M.K; writing-original draft preparation - A.J. and M.K; writing-review and editing - A.J., O.S., D.S. and M.K; supervision - D.S. and M.K. All authors contributed to the final reviews of the manuscript. All authors have read and agreed to the published version of the manuscript.