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FOOD SCIENCE & TECHNOLOGY | REVIEW ARTICLE

Ethnomedicinal use and pharmacological potential of Japanese quail (*Coturnix coturnix japonica*) birds` meat and eggs, and its potential implications on wild quail conservation in Zimbabwe: A review

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Abstract: A logical review of literature was conducted on Japanese quail (*Coturnix coturnix japonica*) farming, consumption and potential of quail egg constituents for pharmacological use. While there is potential to tap on nutritional and therapeutic benefits from Japanese quail meat and eggs to foster food security and pharmacological improvements, there is no consensus among Zimbabwean communities concerning authenticity of the purported benefits. The role of quail eggs and meat as wealthy nutrient sources and functional foods is undermined. This work examined: nutritional composition and ethnomedicinal benefits of quail meat and eggs, drivers of Japanese quail farming in Zimbabwe, and implications of Japanese quail farming on wild quail conservation. Reviewed literature stated that quail eggs and meat contain nutrient compounds with therapeutic properties useful in prevention and treatment of various diseases including cardiovascular diseases. Japanese quail is regarded as an important agricultural bird for meat and egg production motivated by nutritional and medicinal benefits in many parts of the world. Japanese

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PUBLIC INTEREST STATEMENT

The identification of functional food sources is pivotal in food security strategies and prevention of malnutrition, particularly in developing countries. Japanese quail birds are popular game birds farmed for food production globally. Japanese quail particularly gained popularity due to their delicacy and functional properties of their nutrient constituents. Japanese quail eggs and meat contain essential nutrients, which aid in the prevention and curing of various ailments affecting human societies. Therapeutic properties of Japanese quail eggs and meat imply potential for pharmacological use of their derivatives. However, the exploitation of wild quails and Japanese quail farming practices may negatively affect the conservation of wild quail species. This review paper examines ethnomedicinal benefits of Japanese quail eggs and meat and also assess potential implications of increased demand for quail eggs and meat to the conservation of wild quail species. The review is important in the demystification of controversies and myths that has surrounded the adoption of Japanese quail farming in Zimbabwe.

quail farming is also described as a cost effective poultry enterprise due to lower production cost requirements. However, some quail farming and harvesting practices may be incompatible with ecosystem integrity and threaten wild quail conservation. Conclusively, Japanese quail consumption may benefit human health and present a practical solution to protein shortages in developing countries. Information generated by this work is important in demystifying controversies surrounding Japanese quail farming in Zimbabwe. Characterization of bioactive compounds in Japanese quail eggs and meat to describe their physiological mechanism for disease curing is recommended.

Subjects: Agriculture & Environmental Sciences; Natural History – Evolution and general biology; Food Chemistry

Keywords: conservation; ethnomedicinal; food security; functional food; nutritional value; therapeutic

1. Introduction

The Japanese quail bird (*Coturnix coturnix japonica*, Linnaeus 1758) has become a popular delicacy in Zimbabwe over the past few years mainly because of purported nutritional value and therapeutic properties of nutrient components contained in their eggs and meat (Mushava, 2016). The bird was introduced in Zimbabwe as a farmed game bird species for egg and meat production in 2011 by local poultry farmers (Mushava, 2016). Information about nutritional and therapeutic benefits of quail egg and meat consumption as well as profitability of the quail farming practice was spread through intensive farmer education and training workshops across the country, which resulted in a hype and influx of people venturing into the practice across the country. However, Japanese quail farming was briefly banned in Zimbabwe by government in 2016 citing the lack of substantial locally driven scientific evidence supporting the proclaimed benefits. Derogatory media frames have also discouraged quail farmers and negatively influenced consumer perceptions, negatively affecting the once promising quail farming agricultural enterprise. Consequently, there has been a notable decline in number of Japanese quail farmers as well as quail product retail outlets in the country. Japanese quail farming and consumption remains a novel practice among African countries, but retains potential to thrive as awareness about benefits associated with quails increases (Bakoji et al., 2013).

The Japanese quail (*C.c.japonica*) is a small hardy bird with males being smaller bodied than females (Chang et al., 2005). Sexual dimorphism is much pronounced in the farmed Japanese quail (*C.c.japonica*) than the wild common quail (*Coturnix coturnix coturnix*) species (Rodríguez-Teijeiro, Puigcerver, Gallego, Cordero, & Parkin, 2003). Farmed Japanese quail exist in various breeds, which are selected for different productivity objectives (Douglas, 2013). Common farmed Japanese quail breeds in Zimbabwe include the Jumbo Pharaoh, Golden Manchurian, English white, A&M giant and Goliath breeds (Jeke, Phiri, Chitindingu, & Taru, 2018). The common quail is the nominate form of the wild quail species with the widest distribution in the world (Perennou, 2009). The wild quail is a Palearctic migratory bird species, which breeds in North Africa and Europe (Sardà-Palomera, Puigcerver, Brotons, & Rodríguez-Teijeiro, 2012). Habitat preferences for the wild quail species includes cereal crop fields such as barley, wheat, hay and clover as well as bush veld with cereal grass species where they forage on grain and the species tend to match its biological cycle with that of cereal crops (Puigcerver, Sardà-Palomera, & Rodríguez-Teijeiro, 2012).

Looking at the sub Saharan Africa situation where undernourishment and malnutrition is persistent, quail farming and consumption presents a viable and practical solution to the problem of animal protein shortage if included in poultry programs aimed at assisting developing countries (Geldenhuys, Hoffman, & Muller, 2013; Jeke et al., 2018; Wahab, 2002). Most countries in the sub

Saharan Africa failed to meet the millennium development goal (MDG) 1.C target; which is to halve the proportion of the population living in hunger by 2015 (Rosen, Meade, Fuglie, & Rada, 2016). There is still a large population in African countries that is deprived of food especially as climate change impacts continue to affect food production (Chitindingu, Benhura, & Muchuweti, 2014). For example, around 790 million people in the developing world are reportedly still undernourished and have limited dietary intake, lacking essential nutrients especially proteins. There is therefore need for strategies among the developing countries to improve food security and nourishment especially through identification of food alternatives with high nutritional benefit such as functional foods (Chitindingu, Benhura, et al., 2014; Genchev & Mihaylov, 2008; Tunsaringkarn, Tungjaroenchai, & Siriwong, 2013). The expansion and diversifying of agricultural production is fundamental in the face of perturbations for improving food security and community livelihoods for sustainability (Chitindingu, George, et al., 2014; Frison, Cherfas, & Hodgkin, 2011). Japanese quail farming may positively affect poultry egg production in Africa, which had reportedly declined over past years (Biswas, Jairath, Mandal, & Khanna, 2015; Tukur, 2011). Besides quail farming providing direct benefits for local people nourishment, it also presents an alternative strategy for climate change adaptation communities enhancing global efforts to improve food security.

Despite Japanese quail farming and consumption being widespread in many parts of the world, the practice remains novel among African countries including Zimbabwe (Atere, Ajurojo, & Atere, 2015; Bakoji et al., 2013; Jeke et al., 2018). There is a gap in knowledge that exists regarding quail farming and consumption among the general populace of Zimbabwe. A paucity of information on nutritional composition and therapeutic benefits of quail eggs and meat exist and so precipitating consumer anxiety (Mushava, 2016). Criticisms and negative media frames have also sketched the quail farming practice in African countries particularly in Zimbabwe dismissing it as a money-swindling gimmick whose purported benefits are unsubstantiated. The potential of Japanese quail farming and consumption to contribute significantly towards food security and improve human diets in sub Saharan countries is underrated and unappreciated. This review of literature intends to demystify and unravel myths and controversies surrounding Japanese quail farming and consumption in Zimbabwe through highlighting on global Japanese quail farming practices, benefits of quail consumption, and their potential for pharmacological use and discuss the conservation implications of Japanese quail farming in the Zimbabwean context.

2. Methods

Both holistic and historical research approaches were employed in this study, in order to uncover the mystery behind the quail bird, which has become a topical issue across many sectors in Zimbabwe including, nutrition, health, business and conservation sectors. The holistic approach enabled us to understand the relationships and linkages between human societies and quail farming, human nutrition and conservation of the species. Meanwhile, the historical approach helped us to understand the evolution of quail farming and its significance in the human society and policy frameworks that shape global game bird utilization and conservation in relation to the quail bird. An in-depth analysis of peer reviewed journal articles, books, book chapters, reports and academic theses on Google Scholar covering issues on quail bird utilization and significance in human societies, nutritional and medicinal benefits as well as quail farming and conservation was conducted. Key word and key phrase searches were the main criteria used for the selection of articles used for the reviewing of literature (Muposhi, Gandiwa, Bartels, & Makuza, 2016). The key phrases which guided this review include quail egg and meat nutrient composition, medicinal properties in quail meat and eggs, conservation threats for quails and quail genetics. Research journal databases related to the key words and topics were synthesized to draw conclusions based on a thorough assessment and evaluation of the content. A collaborative assessment approach was adopted. Under this approach findings from literature were shared and discussed through electronic mails and also brief meetings by the researchers to synthesize the ideas and come up with a refined output.

3. Results and discussion

The Japanese quail has gained much economic value as an agricultural species for egg and meat production in many parts of the world (Chang et al., 2005; Genchev, 2012). Studies conducted suggest that the consumption of the farmed Japanese quail exceeds wild quail consumption (Chepkemoi et al., 2015; Perennou, 2009). For example, while about 1.3 million wild quails are hunted annually in Spain, there are some companies in France which process about 20 million farmed Japanese quails for meat annually (Perennou, 2009). The consumption of farmed Japanese eggs is also much popular than wild quail egg consumption (Chepkemoi et al., 2015; Genchev, 2012). The variation in quail egg consumption thresholds is based on the differences in egg yields and accessibility between the farmed species and the wild species where the later have a relatively lower egg yield of about 36 eggs which are often laid concealed in tall grass annually as compared to farmed Japanese quails which lay up to 300 eggs annually (Puigcerver et al., 2012; Rodríguez-Teijeiro et al., 2003). This difference in egg yield and accessibility makes farmed Japanese quail the chief producer of quail eggs available for human consumption as they are able to supply large quantities of eggs which is feasible for economic production and also meet the demand for human consumption.

3.1. Drivers of quail farming in Zimbabwe

The farming of Japanese quails for human consumption is largely a result of their productivity and cost effectiveness as compared to other poultry species (Chang et al., 2009; Crawford, 1990; Douglas, 2013). Although initial domestication was due to the bird's singing, there was increased agricultural use of the bird mainly for meat and egg production (Chang et al., 2009). Cost benefit analysis of quail farming business has affirmed it as a cost effective poultry business option with greater potential for profitability (Bakoji et al., 2013; Douglas, 2013). Quail farming requires relatively lower production costs in terms of space, food and antimicrobial requirements than traditional poultry farming such as chicken production (Douglas, 2013; Kar, Barman, Sen, & Nath, 2017). Japanese quail requires less floor area than the traditionally farmed chicken. In addition, Japanese quail has a lower daily feed requirement which is 20–25 g per day as compared to chicken feed requirement of 120–130 g per day (Bakoji et al., 2013; Douglas, 2013). Due to their resistance to popular poultry diseases such as new castle, fowl pox, ulcerative enteritis among others, fewer costs are incurred in terms of buying antimicrobials and vaccines when rearing quail birds (Bakoji et al., 2013; Chang et al., 2005; Douglas, 2013).

The perceived profitability of the Japanese quail farming business in an economically challenged environment associated with high unemployment levels, has prompted many people to venture into quail farming business in Zimbabwe triggering a hype for quails in the inception stages of the practice. Myths and metaphors occurring in media frames influence public perceptions of issues and also influence policy makers (Gandiwa et al., 2014). Similarly people's response to the quail farming business has been shown to be influenced by media frames as high influx of people engaging in quail farming in the country were observed as media frequently reported on the benefits of the enterprise, and subsequently pulling out as a result of negative publicity and a withdrawal of the topic from media. There has been undermining of quail farmers' commitments to promote consumption of functional foods as a means to reduce the prevalence of non-communicable diseases in the country through the introduction of Japanese quail. Biswas et al. (2015) suggests the incorporation of small poultry as a means to supplement limited food supply as demand continue to increase. Contrary, Japanese quail farming practice was branded as a financial scam based on unfounded claims and lacked critical institutional and government support to establish successfully. It is therefore important to generate sufficient scientific information to authenticate purported benefits of Japanese quail and raise public awareness about quail farming and consumption for communities to make informed decisions regarding the utilization of the bird species in Zimbabwe.

3.2. Japanese quail as important game bird for food provision

The use of quail as important food resource is recorded in the Bible where quail meat was consumed by the journeying Israelites. The quail bird was domesticated first for their singing, and later for meat and egg production in the 14th century (Chang et al., 2005). Archaeological evidence suggests traditional quail consumption in the ancient societies as depicted by the presence of quails on the paintings in the Egyptian pyramids (Douglas, 2013). The linkages between quails and earliest societies may be suggestive of the significance of the game bird as an important food resource. Although large mammals are most preferred as source of food because of their body size and return for energy invested in hunting, consumption of game birds is notable in semi-arid regions of Brazil. In addition, animal species whose consumption is influenced by perceived nutritional and medicinal benefits may form important part of local people's diet regardless of relative quantities being consumed (Alves, 2012). Trapping of wild quail is popular in countries such as Turkey, Portugal and Spain where around 9 million wild quails are harvested annually for human consumption. The largest market for Japanese quail meat is in France where approximately 20 million tons of quail meat is processed annually for human consumption while the largest quail egg consumer is Japan (Perennou, 2009).

Consumers are now particular about the nutrient composition of food they consume (Swanepoel, Leslie, Rijst, & Hoffman, 2016). According to AG Genchev, Ribarski, Afanasjev, and Blohin (2006) Japanese quail meat and eggs are packed with essential nutrients which are limiting in human diet. Japanese quail meat has a high carcass yield. Despite their small size, eggs from Japanese quail contain nutrients, which are four to four times the value of chicken eggs (Genchev, 2012). Japanese quail eggs contain higher content of crude protein, crude fat and mineral ash per unit egg weight than the traditionally consumed chicken egg and other popular poultry species used for food such as guinea fowl and pheasant (Chepkemoui et al., 2015; Song, Choi, & Oh, 2000) (Table 1). Jeke et al. (2018) reported that Japanese quail eggs contain relatively high crude protein ($13.09 \text{ g } 100 \text{ g}^{-1}$) which is limiting in human diets. Characterization of protein quality in quail birds eggs have shown the presence of sufficient amounts of essential amino acids such as lysine ($\text{C}_6\text{H}_{14}\text{N}_2\text{O}_2$) ($790 \text{ mg } 100\text{g}^{-1}$), valine ($\text{C}_5\text{H}_{11}\text{NO}_2$) ($869.5 \text{ mg } 100\text{g}^{-1}$) and leucine (Flodin, 1997; Layman & Walker, 2006). Important non-essential amino acids contained in quail eggs include aspartic acid ($\text{C}_4\text{H}_7\text{NO}_4$) ($1488 \text{ mg } 100\text{g}^{-1}$) and alanine ($\text{C}_3\text{H}_7\text{NO}_2$) ($739.0 \text{ mg } 100\text{g}^{-1}$) (Genchev, 2012). Japanese quail eggs also contain functional proteins such as ovomucoid, ovotransferrin and lysozyme.

In addition, the profiling of nutrients contained in quail eggs shows that there are sufficient amounts of polyunsaturated fat acids which are important in the prevention of cardiovascular diseases (Dvorska, Surai, Speake, & Sparks, 2001; Mennicken et al., 2005; Sinanoglou, Strati, & Miniadis-Meimaroglou, 2011). Presence of clinically important nutrients in quail eggs reduces the need for nutrient supplements in human diet. In addition, the presence of sufficient essential nutrients also reduces the prevalence of nutrient deficiency caused diseases such as kwashiorkor,

Table 1. Nutrient content per unit weight of eggs from different poultry species; adapted from (Chepkemoui et al., 2015; A Genchev, 2012; Jeke et al., 2018)

Poultry species	Egg weight (g)	Crude protein (%/g)	Crude fat (%/g)	Cholesterol (mg/g yolk)	Ash (%/g)
Japanese quail	12.06	1.00	1.00	14.3	0.09
Guinea fowl	46.65	0.27	0.23	14.6	0.02
Pheasant	25.79	0.50	0.42	14.1	0.04
Chicken	60.31	0.30	0.05	14.0	0.02
Wild quail	11.75	2.00	0.23	14.2	0.09

marasmus and osteoporosis among others and contributes significantly to healthy communities (da Silva et al., 2009). Japanese quail consumption thus may provide the much needed food supplement for developing countries, preventing people from changing food consumption patterns, which compromise nutrition.

Comparison of Japanese quail eggs and other poultry species such as chicken (*Gallus gallus*), turkey (*Meleagris gallopavo*), guinea fowl (*Numida meleagris domestica*) and pigeon (*Columbia livia domestica*) showed that Japanese quail eggs contain the highest levels of essential trace elements [Manganese (Mn), Iron (Fe), Cobalt (Co) and Copper (Cu)] (Abduljaleel, Shuhaimi-Othman, & Babji, 2011). Japanese quail eggs were also proven to contain lower levels of non-essential metal Arsenic which is harmful to human health (Abduljaleel et al., 2011; Crosby, 1977). Low Arsenic (As) level in the quail eggs make their consumption comparatively safer and healthier than other poultry species including chicken eggs which are widely consumed by humans since they contain less toxic elements. Quail eggs and meat have greater nutritional composition comparative advantage over other poultry types and can play a crucial role in resolving world food challenges especially protein shortages in the developing nations (Genchev, 2012; Genchev et al., 2006; Tunsaringkarn et al., 2013). Japanese quail eggs thus are a better source of nutrients for human diet among poultry species. Japanese quail may constitute an important source of nutrients helping communities fight malnutrition and contribute significantly in improving local people's livelihoods and so promoting sustainable development (Biswas et al., 2015). Incorporation of Japanese quail farming in the mainstream poultry production particularly for developing countries may yield positive results towards improved food security and nourishment (Bakoji et al., 2013; Wahab, 2002). Also, the increasing demand for animal protein and increasing global human population may promote the use of game birds including quails as food resources.

3.3. Variation in nutrient composition in quail birds

Nutrient composition also varies between the wild quail species and the farmed Japanese quails (Chepkemoi et al., 2015). There is also reported variation in the nutritional composition among different breeds of the farmed Japanese quails (Genchev et al., 2006; Jeke et al., 2018; Nasr, El-Tarabany, & Toscano, 2016) (Table 2). Major factors influencing the quality and nutritional composition of quail eggs are layer's age, trait, feed composition, as well as storage conditions and time (Genchev, 2012). Variation in egg characteristics and nutrient content in quail birds may also be caused by differences in feed composition, particularly protein content. In trait based egg nutritional composition comparisons, (A Genchev, 2012) reported higher crude protein content in eggs of the Pharaoh quail breed (14.08%) than Golden Manchurian (13.91%). In addition the Pharaoh breed also exhibited higher crude fat content (11.15%) than Golden Manchurian breed (10.65%). In another breed comparison study, the English white quail breed was approved by (Genchev & Mihaylov, 2008) as a better quail breed for egg and meat production than the Pharaoh breed as the breed exhibited lower levels of crude fat content coupled with a better water retention capacity. Although figures were slightly different, Jeke et al. (2018) also reported

Table 2. Variation in nutrient composition of eggs from different Japanese quail breeds; adapted from (Genchev, 2012; Jeke et al., 2018)

Parameter	Jumbo Pharaoh	Manchurian Golden	A&M Giant
Weight (g)	12.81	12.54	12.96
Crude protein (g100g ⁻¹)	14.08	13.91	13.01
Crude fat (g100g ⁻¹)	11.15	10.65	11.33
Cholesterol (mg/g yolk)	14.16	14.12	14.02
Ash (g100g ⁻¹)	0.98	0.89	0.96

a higher crude protein content in Jumbo pharaoh breed ($13.7 \pm 0.18 \text{ g } 100 \text{ g}^{-1}$) as compared to golden Manchurian (13.07 ± 0.15) and Texas A&M giant (13.01 ± 0.75) breeds. The trait-based variation in nutritional content implies that when selecting Japanese quail types for farming, farmers should pay attention to selection of productive breeds as this has influence on the nutritional benefits associated with the species. Understanding the variations in nutrient composition among quail birds is important for designing feeding regimes as well as for breeding purposes in order to produce desirable traits for increased productivity (Mahmoud, Khadiga, & El-Full, 2016).

3.4. Ethno-medicinal use and pharmacological potential of Japanese quail birds

The use of animal derivatives in medication has been a common practice among various cultures such as the Brazilian, and African societies from time immemorial (Alves, 2012). Indigenous knowledge systems (IKS) promote the identification of useful plants and animals in disease prevention and treatment. The utilization of genetic material for medicinal purposes is embodied in culture, religion and societal perceptions based on the utilitarian value of biodiversity components. Disease prevention and healing capabilities of plant and animal derivatives is well documented and appreciated in many societies, particularly in Africa where it has been the mainstream healthcare system before the introduction of western health system. Besides the provision of basic nutritional requirements for consumers, foods should also contribute towards the improvement of physical and mental wellbeing of consumers (Miranda et al., 2015). Confirmation of ethnomedicinal use of quail eggs and meat in societies through indigenous knowledge sharing may promote consumption of Japanese quail and the hunting of wild quail for the same benefit in Zimbabwe.

Recent developments in food and health include the modification of poultry diets to achieve designer eggs which qualify as functional foods in the United States of America (Kovacs-Nolan, Phillips, & Mine, 2005). The increase in drug resistance in some microorganisms and emergence of new diseases calls for the identification of new sources of medicines to improve disease treatment (Chitindingu et al., 2014; Eloff, 2001). There is reported antimicrobial activity in Japanese quail eggs including antibacterial, antifungal, antiviral, anti-inflammatory and anticancer activity (Kovacs-Nolan et al., 2005). Nutrition plays a very important role in the treatment of non-communicable diseases including diabetes, heart disease, stroke and cancer (Hankinson, Manson, & Colditz, 2002). Quail eggs and meat are regarded as functional foods due to their possession of sufficient amounts of quality nutrients which are capable of healing certain ailments (Hankinson et al., 2002; Kovacs-Nolan et al., 2005). The eggs contain important bioactive compounds which may provide leads to discovery of more antimicrobials promoting pharmacological improvements for treatment of various diseases (da Silva et al., 2009; Kovacs-Nolan et al., 2005).

The nutrient profile of Japanese quail eggs provides mechanisms for disease prevention and treatment. Fatty acid analysis done by da Silva et al. (2009) suggests that both farmed Japanese quail and wild quail species contain higher amounts of beneficial polyunsaturated fatty acids (PUFA) than saturated fatty acids (SFA). The presence of sufficient amounts of α 3-polyunsaturated fatty acids (PUFA) and bioavailable functional nutrients such as docosahexaenoic acid (DHA) ($\text{C}_{22}\text{H}_{32}\text{O}_2$), linoleic acid ($\text{C}_{18}\text{H}_{32}\text{O}_2$) and oleic acid ($\text{C}_{18}\text{H}_{34}\text{O}_2$) in Japanese quail eggs is beneficial for human diet in the prevention and treatment of coronary heart diseases (Lavie, Milani, Mehra, & Ventura, 2009; Sinanoglou et al., 2011). The ability of quail eggs components to function in the prevention and treatment of cardiovascular diseases is important in increasing life expectancy as these diseases are the leading cause of mortality and morbidity globally (Miranda et al., 2015). Japanese quail eggs thus provides alternative egg choice which help in reducing consumption of saturated fats which is an important dietary strategy helping consumers to reduce serum cholesterol levels. In addition (Connor, 2000) confirms that DHA is important in inhibiting progression to Alzheimer's disease in ageing people as well as adult onset diabetes mellitus. Furthermore, DHA also has positive inhibitory effects on disease conditions such as arthritis, hypertension, atherosclerosis and some cancers (Kelley et al., 1999). In addition quail egg yolk also contain the lowest cholesterol making them more appropriate for a healthy diet. Japanese quail eggs thus provides

alternative egg choice which help in reducing consumption of saturated fats, forming an important dietary strategy helping consumers to reduce serum cholesterol levels.

Japanese quail eggs also contain several functional protein families which are beneficial for human health including protease inhibitors such as lysozyme, cystatin, ovomucoid, ovom inhibitor and ovomacroglobulin (Mine & D'Silva, 2008). Reviewed literature showed that the most abundant type of essential amino acid in Japanese quail eggs is leucine ($C_6H_{13}NO_2$) ($1139 \text{ mg } 100 \text{ g}^{-1}$) which is important in modulating the use of glucose by skeletal muscles and also facilitating muscle recovery. Leucine plays an important role in facilitating protein sparing and minimizing loss of lean tissue in treatment of obesity and metabolic syndrome (Layman & Walker, 2006). There are also high proportions of valine ($C_5H_{11}NO_2$) ($869.5 \text{ mg } 100 \text{ g}^{-1}$) and lysine ($C_6H_{14}N_2O_2$) ($790 \text{ mg } 100 \text{ g}^{-1}$) in quail eggs. Lysine is crucial in human health as it is essential amino acid needed for production of antibodies, hormones, enzymes and collagen formation which plays a crucial defense role in disease prevention and treatment. Clinically lysine is important in preventing and speeding healing of herpetic outbreaks and osteoporosis. Lysine is able to counteract reproduction of the two types of herpes simplex virus in humans (Flodin, 1997). Lysine is the most deficient amino acid in food supply especially in countries living in poverty, making Japanese quail egg consumption beneficial. Quail eggs also contain the highest levels of non-essential amino acid alanine ($C_3H_7NO_2$) ($739.0 \text{ mg } 100 \text{ g}^{-1}$) which is important for its role in elimination of toxins from the liver (Tunsaringkarn et al., 2013). Further inquiry into the effectiveness of eggs from Japanese quail birds in disease prevention and treatment may be carried out by comparing minimum inhibition concentrations of quail eggs and conventional antimicrobials. Such comparisons are important in the assessment of Japanese quail eggs' potential for incorporation in the pharmacological processes.

Japanese quail egg can also be used in the preparation of formulations for cosmetic treatments for skin conditioning (nee Kricsfalussy, nee Szabo, Rakoczi, & Halmos, 1987). Japanese quail eggs have been proven to have superior cosmetic effect than chicken egg due to their high yolk, dry matter, fat content as well as protein and vitamin A ($C_{20}H_{30}O$) content. Vitamin A plays a fundamental role in skin therapy by preventing dry skin. Quail eggs also exhibit excellent stability characteristics producing cosmetic formulations which resist decomposition and has longer shelf life (nee Kricsfalussy et al., 1987). In addition, high amino acid content in quail eggs especially tyrosine ($C_9H_{11}NO_3$) plays an important role in metabolism and favours pigment formation promoting healthy skin colour. The use of quail eggs in the cosmetic industry adds to the socio-economic value of the quail birds in human societies making it a multipurpose bird species.

3.5. Potential health threats from quail consumption

Although providing many benefits, egg consumption has associated adverse effects on human health and nutrition. As a result there may be need for moderation in egg consumption especially due to cholesterol content (Miranda et al., 2015). Despite the high nutritional value of quail eggs, there is also concern over the possibility of human intoxication and the spread of diseases from the eggs (Abduljaleel et al., 2011; Tunsaringkarn et al., 2013). For instance, eggs have been useful indicators of environmental pollution as a result of heavy metal accumulation in the egg due to feed composition (Abduljaleel et al., 2011; Abduljaleel, 2014). There have been reports of consumption of raw eggs among some consumers as they seek to maximize the nutrient intake from the quail eggs and this might also aid in the spread of egg borne diseases due to contamination (Atere et al., 2015). Egg shells might contain loads of bacteria such as *Escherichia coli*, *Salmonella enteritidis* and *Salmonella typhimurium* which may contaminate eggs when opening the egg and would infect humans if the eggs are consumed raw (Atere et al., 2015; Zubair, Al-Berfani, & Issa, 2017). For example, eggs and egg products were responsible for 52% of food borne diseases reported in Spain between 1993 and 2002 (Miranda et al., 2015). EFSA Panel on Biological Hazards (2014) also highlighted on possible infections from the consumption of particularly raw eggs whose storage time is exceedingly prolonged. In this regard, it is therefore important to consider hygienic conditions of egg production and handling, including storage time and temperature in order to minimize infection risks.

The consumption of migratory wild quail may spread avian borne disease known as coturnism which is caused by human poisoning after consumption of infected birds (Korkmaz, Güven, Eren, & Dogan, 2011). The wild quails seasonally transmit the disease to people after eating seeds from hemlock (*Conium maculatum*) or hedge nettle *Slachys annua* as well as aristolochic acid in insects (Chang et al., 2009). Coturnism may cause acute rhabdomyolysis that can be lethal due to renal failure and shock (Korkmaz et al., 2011). Coturnism incidences occur seasonally and it is important to understand the timing of the disease as depicted by the birds` direction of migration. It is important to note that coturnism cannot be contracted from the consumption of farmed Japanese quail which are not exposed to hemlock consumption. The transmission of several epidemics including Severe Acute Respiratory Syndrome (SARS) and monkey pox have been linked to interactions in wildlife markets (Alves, 2012). Similarly, various avian borne diseases such as avian influenza H5N1 may be transmitted from quail birds to humans, and chances of spreading may be increased by the high quail populations being reared per unit area especially in the backyard housing system. It is therefore important that the interdependence between quail farming and humans should be considered in the development of environmental safety and public health practices in quail farming. Japanese quail egg consumption may also cause egg allergy problems, a condition which is more prevalent in children. Quail eggs contain some of the allergens identified in poultry eggs such as Lysozyme, Ovotransferrin and Ovalbumin (Miranda et al., 2015). Allergic reactions vary in severity from mild urticaria to systemic anaphylaxis, and may prompt avoidance of egg consumption thus affecting health and quality of life in affected groups (Burks et al., 2012).

3.6. Implications of quail consumption on wild quail conservation

The wild quail is categorized as least concern (LC) conservation status by the IUCN (Perennou, 2009). However, there has been observed decline in the wild quail population over past years (Puigcerver et al., 2012). In Zimbabwe, the population status and distribution of wild quail is undocumented and so unknown. Harvest pressure is one of the major threats to wild quail conservation (Perennou, 2009; Puigcerver et al., 2012). Harvesting and consumption of quails for their nutritional wealth and ethno-medicinal benefits may put pressure on wild quail population as the wild type is known to have superior nutrient quality than the farmed species. In Zimbabwe, the wild quail species has been hunted for family subsistence among other game birds which have been utilized for protein supply such as guinea fowl, francolins, doves and geese (Geldenhuys et al., 2013). Demand for game bird meat is associated with use of sophisticated trapping methods, posing serious threats to population growth (Griffiths, 1998; Rolland, Hostetler, Hines, Percival, & Oli, 2010). While it is easy to monitor and observe harvest trends for big game, the impacts of trapping on game birds may be devastating and only become noticeable when impacts are severe (Campbell, Martin, Ferkovich, & Harris, 1973; Perennou, 2009) Mechanisms to manage harvest quotas should be designed to promote sustainable off takes. There is need for population assessment and monitoring to ensure sustainable bag limits which are based on scientific data.

Another conservation challenge that is associated with Japanese quail farming in Zimbabwe is the potential for hybridization between wild quails and the farmed species. Hybridization may result from escapes of farmed quails from housing units or deliberate releases of unproductive stock such as off layer birds and also restocking practices (Chang et al., 2009; Randi, 2008). Hybridization is identified as a threat to wild quail conservation in countries where farmed Japanese quail was used for restocking purposes (Chazara et al., 2010; Perennou, 2009; Simberloff, 1996). Hybridization may threaten the gene pool of wild quail populations and also cause the breakup of gene complexes co-adapted to local environments (Simberloff, 1996). In addition, hybridization may cause introgression which affect phenotypic expression of wild quail functional traits such as body size, plumage, sexual calls and migratory behaviour (Barilani et al., 2005; Chazara et al., 2010). Genetic profiling of the farmed Japanese quail in Zimbabwe is therefore important to establish relationships with the native wild quail and also assess the potential for successful breeding between the two species and associated impacts thereof. There should also be legislative measures preventing the release of farmed Japanese quail into the wild.

4. Conclusions and recommendations

There is convincing evidence in literature supporting the consumption of quail eggs and meat as beneficial for human health due to functional properties of their nutrient constituents. It was concluded that quail eggs and meat consumption may be potentially healthier than the traditionally consumed poultry alternatives as they contain a more favourable proportion of nutrients promoting healthier diet in human societies. Japanese quail farming should therefore be incorporated in agricultural practices as a diversification strategy to improve food security in developing countries.

The assessment of local people ethnoecological knowledge about quails may be crucial in providing linkages between Japanese quail farming and indigenous people's cultural practices in regards to quail use. There is need for genetic profiling of farmed Japanese quail and the wild quail species in Zimbabwe to investigate possibilities of hybridization between the species. Strategies promoting efficient quail farming and conservation should be crafted and supported through policy development inclusive of all important institutions of the country.

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