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Research paper

Comparative study of the nutritional characteristics and fatty acid profiles of the seeds and seed oils of sweet, bell and bird varieties of pepper (capsicum species)

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Abstract

The proximate compositions of the seeds and fatty acid contents of the seed oils of the three varieties of Capsicum (pepper) species fruits – sweet, bell and bird pepper – have been determined using standard AOAC methods. Their proximate compositions gave moisture contents as 82.54%, 83.32% and 84.74% for bird, sweet and bell peppers respectively. Other proximate values in the various pepper samples ranged as follows: crude fat 1.52%–2.21%, crude protein 2.64%–3.51%, crude fibre 2.72%–4.71%, ash contents 1.62%–3.03% and carbohydrate contents 4.52–6.96%. The order of abundance of the fatty acids were linoleic > oleic > stearic > palmitic in each sample. All the other fatty acids, except myristic acid in bell pepper seed oil, had values lower than 1.00% in all samples. The total unsaturated fatty acids predominated the total saturated ones with values ranging from 79.23% in bird pepper to 82.33% in bell pepper. The total polyunsaturated fatty acids ranged from 57.80% in sweet pepper to 66.50% in bell pepper while the total essential fatty acids ranged from 57.78% in sweet pepper to 66.00% in bell pepper. The total unsaturated/saturated (P/S) ratio was highest in bell pepper, making it the most nutritionally useful of them all.

Keywords: *Pepper Seeds; Pepper Seed Oils; Proximate Compositions; Fatty Acid Contents; Total Unsaturated/ Total Saturated (P/S Index)*

1. Introduction

Pepper belongs to the Capsicum species of plants. It is a genius of flowering plants in the nightshade family Solanaceae. The genus contains over 20 species of annual and perennial herbs or shrubs that are native to Central and South America (Waslsh & Hoot, 2001). Pepper (Capsicum species) is cultivated worldwide anyway, but it is extensively cultivated in America, Asia, Africa, the Mediterranean basin and China (Zou Yu et al., 2015; Chouaibi et al., 2019). Capsicum annuum can diversely be used in food preparations as flavouring and for nutritional purposes, making it one of the most important vegetables. Pepper seeds are separated from the fruit and, thereafter, the flesh is processed. Worldwide, millions of tons of pepper seeds are generated as a by-product of the processing of the fruit. Some of them are used as animal feed but most of them are discarded as waste without treatment leading to environmental pollution (Jarret et al., 2013). The seeds can be obtained from the discarded waste in the production of pepper powder and constitute about 4.14% fresh weight of pepper (Jeong et al., 2011).

In recent years, numerous studies have been conducted to highlight the medicinal benefits of red pepper seeds. It has been shown that the seeds are rich in bioactive phytochemicals (Silva et al., 2013). They have also been recognized for their antimicrobial, antiproliferative, antiobesity, anticancer and antioxidant activities (Jeon et al., 2010; Jeong et al., 2011). Previous chemical studies have also indicated that pepper seeds contain sterols, saponins, anti-adipogenic and phenolic compounds responsible for the biological activities (Sung and Lee, 2016). Red pepper seed oils are rich in polyunsaturated fatty acids and the amount of linoleic acid could be as high as 71%, a percentage that is higher than those of oleaginous seed oils (Yilmaz et al., 2015; Chouaibi et al., 2019). Moreover, some other important bioactive compounds such as polyphenols, tocopherols, phytosterols, and aromatic compounds have also been found in pepper seed oils (Yilmaz et al., 2015). On other hand, it has been revealed that red pepper seed oil is useful as antibacterial, antioxidant and anti-corrosion agents (Ozyıldız et al., 2012; Kurniawan and Madurani, 2015; Yilmaz et al., 2015).

Despite the fact that pepper, the Capsicum species of plants, have been in cultivation and consumption since the ages in Nigeria and Africa, and despite the lots of bioactive phytochemicals contained in the seeds and the high degree of unsaturation of the seed oils, there has been a paucity of data on the production of pepper for its seed oil. The aim of this study is, therefore, to evaluate the composition and fatty acid profile of the seeds of some common pepper species available in Nigeria so as to elucidate its dietary importance and its usefulness to the daily needs of man.

2. Materials and method

2.1. Sample collection and preparation

Fresh samples of the various ripe pepper fruits were purchased from Owode market, Gbongan road, Osogbo, Nigeria. Each sample variety of fruits was washed clean, and the seeds separated from the pulps and kept in a polythene bag in a refridgerator, ready for analysis.

2.2. Sample treatment

2.2.1. Proximate analysis

Moisture, ash, crude fat and crude fibre were determined in accordance with the official methods of the Association of Official Analytical Chemists (AOAC, 2012). Moisture content of each sample was determined by oven drying of 200g of each seed sample to a constant weight at 105°C. Crude protein content was determined by Kjeldahl method using 6.25 as the conversion constant after the determination of its nitrogen. Crude fat content was determined by Soxhlet method using n-hexane as solvent. Ash content was determined gravimetrically after ignition at 550°C. Carbohydrate content was calculated by difference. All analyses were carried out in triplicates.

2.2.2. Fatty acid analysis

The fatty acids of the each oil sample was converted to their methyl esters and the esters analysed using a PYE Unicam 304 gas chromatograph fitted with a flame ionization detector and PYE Unicam computing integrator. Helium was used as the carrier gas. The column initial temperature was 150°C rising at 5°C min-1 to a final temperature of 220°C. The injection port and detector temperatures were maintained at 220°C and 250°C respectively. The peaks were identified by comparing with peaks of standard fatty acid methyl esters under the same operating conditions. (Adeyeye et al., 2018).

3. Results and discussion

3.1. Proximate composition

The proximate compositions of the seeds of the three pepper varieties (sweet pepper, bell pepper and bird pepper) are shown in Table 1. The moisture contents ranged between 82.54% in bird pepper through 83.32% in sweet pepper to 84.74% in bell pepper. The high moisture contents are close but lower than 89.27 and 92.50% recorded for Solanium aethiopicum L and 92.50% for Solanium macrocarpon L by Leung et al., 1968. The high moisture contents of the fruit is indicative of its freshness, making it to aid digestion better and thereby contributing to good and healthy living. But it also facilitates bacterial action on the fruit, giving it a very short shelf life and easy perishability [Adepoju & Oyewole, 2008; Adeyeye et al., 2020]. Water is clearly the most important nutrient and the most abundant substance in the human body. It comprises about three quarters of the human mass and is a major component in every cell. In addition water is needed to separate (by hydrolysis) a phosphate group from adenosine triphosphate (ATP) or guanosine triphosphate (GTP) to get energy [Robinson, 1990]. It is also the containing medium or the solvent for electrolytes and all other ions throughout the human body.

Table 1: Proximate Compositions of the Seeds of Three Pepper Varieties - Fresh Weight (%)

Component	Sweet pepper	Bell pepper	Bird pepper
Moisture	83.32	84.74	82.54
Ash content	3.05	1.62	2.12
Crude fat	1.52	1.92	2.21
Crude protein	2.65	2.64	3.51
Crude fibre	3.83	4.71	2.72
Carbohydrate	5.73	4.52	6.96

The crude protein content ranged between 2.64% in bell pepper and 3.51% in bird pepper. Protein is important as a source of amino acids. It plays a part in the organoleptic properties of food, and it is also required for the formation of enzymes and hormones. In addition, it aids in the formation of antibodies that enable the body to fight infection (Brosman, 2003). It is an essential food component needed in our bodies to repair, regulate and protect itself. On the other hand, protein deficiency causes growth retardation, muscle wasting, oedema, abnormal swelling of the belly etc [Murray et al., 2000). The low protein contents in the fruit seed samples show that it may not be able to provide enough of the needed protein for the body system.

The ash contents ranged between 1.62% in bell pepper through 2.12% in bird pepper to 3.03% in sweet pepper. These values are higher than 1.52% reported for garden egg (Adeyeye et al., 2020a), but lower than 3.55% for Andrographis paniculata (Adeyeye et al, 2018). The reasonable levels of ash contents in the samples are a reflection of reasonable levels of mineral elements in the samples.

The seeds had low fat contents of 1.52% in sweet pepper, 1.92% in bell pepper and 2.21% in bird pepper. These low fat contents are not in favour of their use as sources of edible oils commercially.

The fruit had a crude fibre content of 2.29%. This is slightly lower than 2.96% obtained for S. aethiopicum but higher than 1.11% for S. macrocarpon [Chinedu et al., 2011]. The reasonable fibre and low carbohydrate contents in the pepper seeds encourage their consumption for weight loss. Fibre fills up the tummy quickly and subsequently reduces the consumption of other high calorie options. Dietary fibre helps to lower cholesterol levels in the human body, protecting the heart in the process. It also helps to lower the risk of coronary heart diseases, hypertension, diabetes, colon and breast cancer, piles and appendicitis [Omale & Ugwu, 2011]. It is useful for maintaining bulk motility and increasing intestinal peristalsis by surface extension of the food in the intestinal tract. It is also necessary for a healthy condition, curing of nutritional disorders and for food digestion [Pereira et al., 2004].

The fruits had low carbohydrate contents of 4.52% in bell pepper, 5.73% in sweet pepper and 6.96% in bird pepper. The low carbohydrate contents means that they may not be good sources of energy in feed formulations. But since these products are from the waste, other areas of adaptation are to be looked into for their use.

3.2. Fatty acid composition

Table 2: Fatty Acid Compositions of Sweet, Bell and Bird Pepper Seed Oils

Fatty acid	% Composition Sweet pepper	Bell pepper	Bird pepper
Caprylic (C8:0)	0.05	0.00	0.00
Capric (C10:0)	0.06	0.05	0.06
Lauric (C12:0)	0.15	0.85	0.62
Myristic (C14:0)	0.20	1.20	0.80
Palmitic (C16:0)	9.08	3.50	8.75
Palmitoleic (C16:1)	0.86	1.50	1.32
Stearic (C18;0)	10.05	12.14	10.65
Oleic (C18:1)	21.80	14.33	15.45
Linoleic (C18:2)	56.14	64.25	60.25
Linolenic (C18:3)	1.64	1.75	1.36
Arachidonic (C20:4)	0.02	0.50	0.85
Total saturated fatty acids	19.59	17.67	20.77
Total unsaturated fatty acids	80.46	82.33	79.23
Total mono-unsaturated fatty acids	22.66	16.77	15.83
Total poly-unsaturated fatty acids	57.80	66.50	62.46
Total essential fatty acids	57.78	66.00	61.61
Oleic/Linoleic ratio	0.388	0.223	0.256
Linoleic/Linolenic (LA/ALA) ratio	34.23	44.30	3.814
[P/S index]	36.71	4.659	3.01
PUFA/SFA ratio	4.107	2.95	3.76

P/S index = Total unsaturated/Total saturated ratio.

The fatty acid compositions of the pepper fruit oils are as shown in Table 2. The three pepper seed oils had similar contents of fatty acids, (saturated and unsaturated), from capric, through lauric, myristic, palmitic, palmitoleic, stearic, oleic, linoleic, linolenic to arachidonic, except sweet pepper that had some caprylic acid which the others did not have. However, the percentage concentrations are different from one pepper seed oil to another. Four fatty acids were predominant in each seed sample, including linoleic, the most abundant with values of 56.14% in sweet pepper, 60.25% in bird pepper and 64.25% in bell pepper, followed by oleic acid (14.33%, 15.45% and 21.80% in bell, bird and sweet peppers respectively), stearic acid (10.05%, 10.65% and 12.14% in sweet, bird and bell pepper seeds respectively) and palmitic acid (3.50%, 8.75% and 9.08% in bell, bird and sweet pepper seeds respectively). Linoleic acid being most abundant fatty acid in these pepper seed oils showed a similarity to its content in Caesalpinia bonducella seed oil as well as that in garden egg fruit oil (Adeyeye et al., 2020a; Adeyeye et al., 2020b). Linolenic acid was the next most abundant in each case, ranging from 1.75% in bell pepper through 1.64% in sweet pepper to 1.36% in bird pepper. This was followed by palmitoleic acid with the highest value of 1.50% in bell pepper, 1.32% in bird pepper and 0.86% in sweet pepper. Other fatty acids had percentage values lower than 1.00% in all cases except myristic acid in bell pepper seed with a value of 1.20%.

As fatty acids are vital to the normal operation of all body systems, these dominant fatty acids each has some important roles to play in the human body. The circulatory system, respiratory system, immune system, brain, and other organs require one fatty acid or the other to function properly. Oleic acid is most commonly used for preventing heart diseases and reducing cholesterol. Conjugated linoleic acid is useful against cancer, hardening of the arteries, atherosclerosis, obesity, weight loss caused by chronic disease, body building, and limiting food allergy reactions. Linolenic acid is used for conditions that affect the skin, including systemic sclerosis, psoriasis, and eczema. It is also used for rheumatoid arthritis, polyps in the mouth, high cholesterol and other blood fats, heart disease, metabolic syndrome (Syndrome-X), diabetic nerve pain, attention deficit-hyperactivity disorder, depression, depression after childbirth, chronic fatigue syndrome, and hay fever (allergic rhinitis). Some people use it to prevent cancer and to help breast cancer patients respond faster to treatment with the drug tamoxifen. Deficiency leads to poor growth, skin lesions, reproductive failure and other symptoms (Jarret et al., 2013).

The total essential fatty acids ranged from 57.78% in sweet pepper through 61.61% in bird pepper to 66.00% in bell pepper. These results showed that these pepper seed oils are valuable sources of essential fatty acids which are highly needed in the body, but must be supplied from food sources since they cannot be produced in the body. They play a natural preventive role in cardiovascular diseases and promote the reduction of both total and high density lipoprotein cholesterol. Inappropriate balance of essential fatty acids contributes to various kinds of malfunctioning while a proper balance maintains and even improves health (James et al. 2006; Adeyeye et al. 2018). For example, the deficiency of alpha-linolenic acid alters the course of brain development and perturbs the composition and physicochemical properties of brain cell membranes, neurones, oligodendrocytes, and astrocytes. This leads to physicochemical modifications, induces biochemical and physiological perturbations, and results in neurosensory and behavioural upset (Bourre 2004). Its deficiency also induces more marked abnormalities in certain cerebral structures than in others, and the frontal cortex and pituitary gland are more severely affected. These selective lesions are accompanied by behavioural disorders more particularly affecting certain tests like habituation and adaptation to new situations (Bourre 2004). It also decreases the perception of pleasure, by slightly altering the efficacy of sensory organs and by affecting certain cerebral structures. Linolenic acid in the seed oil is also important as it is used in the biosynthesis of arachidonic acid and thus some prostaglandins (Nelson & Cox 2005). Palmitoleic acid plays an important role in increasing insulin sensitivity by suppressing inflammation, as well as inhibiting the destruction of insulin-secreting pancreatic beta cells, which makes it useful for a diabetic patient (especially for type 2 diabetes mellitus).

The total unsaturated fatty acid contents ranged from 79.23 % in bird pepper, through 80.46 in sweet pepper to 82.33% in bell pepper and total saturated from 17.67 % in bell pepper to 20.77% in bird pepper respectively. This range is in general agreement with the range of values of 75.2 – 87.3% reported by Jarret et al. (2013) for a number of Capsicum species and others in literature. The high content of linoleic acid makes red pepper seed oil specifically prone to oxidation. On the other hand, as an essential fatty acid, it makes it highly desirable for human consumption. Furthermore, the high degrees of unsaturation of the seed oils reduce their probability of aiding heart diseases (Ajewole & Adeyeye, 1991).

The polyunsaturated/saturated (PUFA/SFA) ratios for all the peppers were moderately high. This is an advantage as foods with high PUFA/SFA ratios are considered beneficial for human health, as they contribute to the reduction of body fat and total cholesterol (Simopoulos, 2002). Furthermore, PUFA, especially omega-3, when incorporated into the cells can act by modulating several metabolic and signaling pathways and by exerting protective effects against inflammatory and tumoral events (Alexander, 1998; Rose & Connolly, 1999; D'Arrigo et al., 2004; Gladine et al., 2012).

The presence of the following saturated fatty acids in the seed oil makes the fruit applicable to one or other important uses. Stearic acid is a natural fatty acid. It is a common additive in soaps, cleaners, lotions and hair care products, as well as house cleaners, candles and plastics. Caprylic and capric acids are useful in the production of esters used in perfumes. Caprylic acid is good in the treatment of some bacterial infections, because with its short chain length it has no difficulty in penetrating fatty cell wall membranes (Nair et al., 2005). Capric acid is used in the manufacture of lubricants, greases, rubber, dyes, plastics, food additives and pharmaceuticals (David et al., 2006). Lauric acid is believed to have antimicrobial properties (Muhammad & Ajiboye, 2010). By making it to undergo β-oxidation it can be used to produce energy. It can also be stored in adipose tissues (Nelson & Cox, 2005). Myristic acid is a raw material in cosmetics production. Palmitic acid is the first fatty acid produced during fatty acid synthesis. From it, longer chain fatty acids can be synthesized (Murray, et al., 2000; Muhammad & Ajiboye, 2010).

4. Conclusion

The proximate compositions and fatty acid contents of the seeds and seed oils of sweet, bell and bird varieties of pepper have been reported in this study. The seed oils gave high percentages of unsaturated fatty acids compared to saturated fatty acids, and high levels of essential fatty acids, values greater than 55% of the total fatty acid content of each seed oil, making the seed oils nutritionally rich food complements and good nutritional potentials. Their low fat and carbohydrate contents with reasonable fibre contents make the fruits to be good for consumption, especially by the obese and the diabetic. Being cheap and easily accessible, the fruits are readily affordable by the poor and low income group of the society. The high levels of unsaturated fatty acids in the pepper fruit oils make them advantageous for the consumers, thereby adding greater value to the fruits

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