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Effect of different agricultural straw on the nutritional parameters of oyster mushroom (*Pleaurotus florida*) in North Gujarat condition

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ABSTRACT

Mushrooms provide numerous benefits to humans. One important attribute is as a food source as they are rich in essential proteins, carbohydrates, amino acids and vitamins. Oyster mushroom species have reported to utilize different agricultural residues for its production. The experiments were conducted to see the effect of growing substrate on nutritional properties of oyster mushroom (*Pleurotus florida*). Different substrates i.e. wheat straw, castor shell, sorghum straw, maize straw, bajara straw, mustard straw and groundnut shell were evaluated during the year 2022-23. Highest crude protein content (24.15 %) and total soluble sugar (44.19 mg/g) were observed in the mustard straw substrate, while, groundnut shell recorded the highest moisture content (92.67 %). Phenol content and antioxidant activity (DPPH) were recorded highest in wheat straw (1.81 mg/g) and (42.94 mg/g), respectively.

Keyword: Mushrooms, *Pleurotus florida*, biochemical properties, agricultural waste

Mushrooms have been favoured as food by mankind since time immemorial. One thousand years ago, the Chinese were the first to do the artificial cultivation of tropical and subtropical mushrooms. As per one estimate, there are 7000 species of mushrooms with different degrees of edibility, 3000 species have been recorded as being edible, 200 species have been grown experimentally, 100 species are economically cultivated, 60 species have been commercially cultivated and only 10 species are cultivated on an industrial scale (Chang and Miles, 2004).

Mushrooms provide numerous benefits to humans. It is a rich food source with rich essential proteins, carbohydrates, amino acids and vitamins (Kakon *et al*., 2012; Toros *et al*., 2022) and fiber (Synytsya *et al*., 2008). They also contain essential micro-elements. Mushroom not just provide nutrition to us but they contain tremendous restorative compounds like â-glucans, lectins, triterpenoids, tocopherol, etc. responsible for curing various types of cancer and tumour (Rathore *et al*., 2017; Maa *et al*., 2018). According to Stanley and Nyenke (2011), oyster mushrooms have a high nutritional value with protein ranging from 25 to 50 per cent, fat from 2-5 per cent, carbohydrates from 17-47 per cent, mycocellulose from 7-38 per cent and minerals ranging from 8-12 per cent (potassium, phosphorus, calcium and salt). Niacin, riboflavin and vitamin D, C, B_1, B_5 and B_6 are also

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abundant in edible mushrooms (Raman *et al*., 2021; Toros *et al*., 2022).

Many of these compounds are needed by human beings for good health and essential for the prevention of diseases (Chang and Miles, 2004). Fungi can be sourced from naturally growing stocks (Boa, 2004) or more readily from cultivation. Few mushrooms that are easy to cultivate including oyster mushrooms (*Pleurotus* spp.) and milky mushrooms (*C. indica*) (Sanchez, 2010; Mahari *et al*., 2020) as compare to other mushrooms species. Many *Pleurotus* species have been proven to comprise a variety of therapeutic qualities, including antihypertensive, antitumor, immunomodulatory, antigenotoxic, neuro-protective, anti-inflammatory, antioxidant, hypocholesterolemic, antiplatelet-aggregating, antihyperglycemic and antimicrobial properties (Ajith and Janardhanan, 2007; Zhou *et al*., 2008; Park *et al*., 2014). Due to the presence of 'ergosterol,' the precursor of Vitamin D responsible to cure many degenerative diseases like osteoporosis, cardiovascular diseases, cancers, diabetes, etc., mushrooms are considered to be the next generation food, especially for vegetarians (Urbain *et al.*, 2011).

Pleurotus species have been cultivated successfully on a variety of substrates, including wheat straw, soybean straw (Elattar *et al.*, 2019) Palm oil waste, shaft, bunch, sawdust, cotton waste (Onyeka *et al.*, 2018; Sardar *et al.*, 2017; Garuba *et al.*, 2017), rice straw, corn cobs (Odunmbaku and Adenipekun, 2018), sugarcane bagasse (Aigbodion *et al.*, 2010), etc.

There are reports that suggests that nutritional composition of the mushroom fruit bodies produced on different substrate differes significantly (Odunmbaku and Adenipekun, 2018; Patil, 2012, Zahid *et al.*, 2010). The present investigations was aimed to determine the nutritional composition of *Pleurotus florida* grown on different substrates, with respect to moisture content, crude protein, total soluble sugars, phenols, and antioxidant activity (DPPH) in Gujrat conditions.

MATERIALS AND METHODS

Cultivation of oyster mushroom

To evaluate the effect of different substrates on nutritional composition of oyster mushroom, seven different locally available substrates in north Gujarat *viz.,* wheat straw, maize straw, bajara straw, sorghum straw, mustard straw, groundnut shell and castor shell were used in present study. Well-dried straw bundles were collected and brought to the laboratory. The straw of each of the above crops was cut down in 4.0-5.0 cm lengths with the help of a hand chaff cutter machine.

The chemical sterilization technique standardized by Directorate of Mushroom Research, Solan (Upadhyay, 2011) was adopted in the present experiment. All the chopped substrates *viz*., wheat straw, castor shell, sorghum straw, maize straw, bajara straw, mustard straw and groundnut shell was soaked in water containing carbendazim (75 ppm) and formaldehyde (500 ppm) for 14-16 hours separately in plastic drum. After that, the substrate was taken out from the solution and kept aside for 2-3 hours to remove excess moisture from substrates.

Before bag filling, the moisture content of the straw was checked by squeezing it between the hands or palms to ensure no water droplets were released. A total of 3.0 kg of sterilized straw (on dry weight basis) was used to fill each bag. Inoculation was carried out using 15 to 20-day-old oyster mushroom spawn (*P. florida*) grown on wheat grains at a rate of 50 g per kg of straw. Transparent white polythene bags (25 x 16 cm, 100 gauge) were used for bag filling, and the mouths of the bags were secured with rubber

bands. The bags were then placed in the incubation room for further growth.

During the complete mycelial run of oyster mushroom (*P. florida*) in the incubation room, the doors were opened only to take observations. A dark period was maintained, as it is required for mycelial growth. At the time of pinhead initiation, light was provided for 8 hours per day at an optimal intensity of 700-800 lux. Ventilation was ensured twice daily during pinhead initiation and the fruiting body development stages. During this period, the temperature was maintained in the range of 15 to 27°C, and relative humidity was regulated by spraying water on the floor and on gunny bags.

Biochemical assay of oyster mushroom (*Pleurotus florida*)

The biochemical properties of oyster mushrooms were analyzed at the Pesticide Residues Laboratory (PRL), Bioscience Research Centre, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. Freshly collected mushrooms from different substrates were analysed for moisture, crude protein, total soluble sugars, phenols, and antioxidant activity (DPPH). The freshly collected mushrooms were shade-dried and then ground into a fine powder using an electric grinder. The powdered samples from each substrate were used for further biochemical analysis.

1. Determination of moisture (%): Moisture content was measured by the method of Gaur *et al.* (2016).

$$\text{Moisture (\%)} = \frac{\text{Wt. of original sample (g)} - \text{Wt. of oven dried sample (g)}}{\text{Wt. of original sample (g)}} \times 100$$

2. Estimation of crude protein: Protein content was measured by Folin-Lowry's method (Lowry *et al.*, 1951).

$$\text{Total Protein (mg/g)} = \frac{\text{Graph Factor} \times \text{Sample reading} \times \text{Total Volume of extract} \times 1 \times 10^{-3}}{\text{Aliquot (ml)} \times \text{Weight of sample (g)}}$$

3. Total soluble sugar: The total soluble sugar was estimated by the Anthrone reagent method (Somogyi, 1952).

$$\text{Moisture (\%)} = \frac{\text{Wt. of original sample (g)} - \text{Wt. of oven dried sample (g)}}{\text{Wt. of original sample (g)}} \times 100$$

4. Estimation of phenols: Total phenol was measured by the phenol-folin method (Snell and Snell, 1953)

$$\text{Total phenol (mg/g)} = \frac{\text{Graph Factor} \times \text{Sample reading} \times \text{Total Volume of extract} \times 1 \times 10^{-3}}{\text{Aliquot (ml)} \times \text{Weight of sample (g)}}$$

5. DPPH (2,2-diphenyl 1-picrylhydrazyl) antioxidant activity: The scavenging activity was determined based on the DPPH scavenging assay described by Lai *et al*. (2001).

Statistical analysis

All the experiments were carried out by employing a Completely Randomized Design (CRD). Critical difference (CD) value was calculated whenever the results were significant at 5 per cent level of significance (Steel and Torrie, 1980).

RESULT AND DISCUSSION

Results on the biochemical properties of the oyster mushroom (*P. florida*) from the various substrates are shown in Table 1with respect to moisture, crude protein, total soluble sugar, phenol and antioxidant activity (DPPH) (2,2-diphenyl 1-picrylhydrazyl). Biochemical properties of oyster mushroom (*P. florida*) grown on different substances showed significant variations. Moisture content varied

from 83.00 to 92.67 per cent. Significantly maximum moisture content recorded in groundnut shell (92.67 %) followed by wheat straw (90.67 %). Crude protein content ranged between 16.46 to 24.15 per cent. Significantly highest crude protein content was observed in the mustard straw (24.15 %) followed by bajara straw (22.36 %). Total soluble sugar varied significantly among different substrate grown oyster mushroom (*P. florida*) which ranges varies from 16.26 to 44.19 mg/g. Mustard straw recorded the highest (44.19 mg/g) total soluble sugar among all followed by bajara straw (41.58 mg/g). Significantly maximum (1.81 mg/g) phenol content was recorded in wheat straw which was followed by sorghum straw (1.70 mg/g). Highest (42.94 mg/g) antioxidant activity (DPPH) of *P. florida* recorded in wheat straw (42.94 mg/g) followed by sorghum substrate (39.86 mg/g).

Biochemical properties of mushroom are varying according to substrates used, environmental conditions and type of species of mushroom grown. In present investigation, nutritional composition of mushroom grown on the locally available straw in north Gujarat conditions showed significant variation. The present results were in accordance with the results obtained by Mandal (2021) who observed that the moisture content (%) of oyster mushroom (*P. florida*) grown on different substrate varied between 84.67 to 90.00 per cent. Similarly, Mandaviya (2018) reported the moisture content (%) of oyster mushrooms (*Pleurotus* spp.) grown on various substrate ranged between 71.40 and 81.00 per cent. Present results are also supported by various previous reports (Ahmed *et al*., 2009; Patil *et al*., 2010; Ashraf *et al*., 2013; Falemara and Joshua 2016, Kinge *et al.*, 2016; Porselvi and Vijayakumar 2019; Raman *et al*., 2021).

Variation in total protein content was also reported by various workers (Odunmbaku and Adenipekun, 2018; Adenipekun *et al*., 2015; Isikhuemhen and Okhyoya, 1996). The high protein content obtained in the mushroom cultivated on different substrates in the study could be due to the richness of carbon and nitrogen in the substrate. The result obtained in this study is very close to the result reported by Odunmbaku and Adenipekun (2018) who cultivated *Pleurotus ostreatus* (Jacq Fr.) Kumm on *Gossypium hirsutum* Roxb (Cotton waste) and *Gmelina arborea* L. sawdust supplemented with rice bran and corn-cobs with protein content ranging from

Table 1: Effect of different substrates on the nutritional composition of oyster mushroom (*P. florida*)

Tr.	Substrates No.	Moisture (%)	Crude protein (%)	Total soluble sugar (mg/g)	Phenol (mg/g)	DPPH (mg/g)
T_1	Wheat straw	90.67[b]	18.60[c]	27.48[c]	1.81[a]	42.94*
T_2	Maize straw	85.07[d]	14.32e	23.00[d]	1.30[d]	37.06
T_3	Bajara straw	90.00[b]	19.44[b]	41.58[b]	1.61[c]	38.67
T_4	Sorghum straw	87.00[c]	15.61[d]	16.26e	1.70[b]	39.86
T_5	Mustard straw	83.00e	21.00[a]	44.19[a]	1.23[d]	35.38
T_6	Groundnut shell	92.67[a]	16.01[a]	23.06[d]	1.06e	26.85
T_7	Castor shell	87.67[c]	15.49[d]	28.44[c]	1.01e	26.30
	S.Em. ±	0.56	0.21	0.35	0.03	0.85
	C.D. @0.05	1.69	0.64	1.05	0.09	0.68
	C.V. %	1.09	2.14	2.05	3.71	2.42

*Mean of three repetitions in all treatments

22.78–24.97 % likewise Patil (2012) documented the protein content of fruiting bodies cultivated on various substrates ranged from 20.33 to 25.33%. The protein content obtained in this study is much higher than 2.11–3.99% reported by Onyeka *et al*. (2018), who reported the influenced of substrate composition on domestically cultivated *Pleurotus ostreatus* growth, yield, and nutritional composition.

The carbohydrate content reported by Odunmbaku and Adenipekun (2018) ranged between 14.24-17.11% when grown on cotton waste and sawdust. The bioconversion of carbohydrates in the colonized wastes into mycelia protein could explain the decrease in carbohydrates seen with the addition of a specific proportion of additives (Iyayi, 2004). The substrate composition is one of the principal factors influencing the nutritional compositions of mushrooms (Odummbaku and Adenipekun, 2018). The grown species have an impact on the nutritional characteristics of mushrooms. The better performance obtained in some substrate may be due high protein, minerals, vitamins, fatty acids, and dietary fibers in the substrate (Prueckler *et al*., 2014; Onipe *et al*., 2015).

CONCLUSION

From the present study, it can be concluded that different substrate material influences the nutritional and biochemical properties of oyster mushroom significantly and different nutritional components are affected by different substrate. Thus, it will be apt use a combination of different available substrate to get high production and nutritional properties in oyster mushroom. Further studies are required on combinations of different substrate to get better quality oyster mushroom.

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REFERENCES

1. Ajith, T. A. and K.K. Janardhanan. 2007. Indian medicinal mushrooms as a source of antioxidant and antitumor agents. *Journal of Clinical Biochemistry and Nutrition* **40(3):** 157-162.

2. Ashraf, J., M.A. Ali, W. Ahmad, C.M. Ayyub and J. Shafi. 2013. Effect of different substrate supplements on oyster mushroom *(Pleurotus* spp.) production. *Food Science and Technology* **1(3):** 44-51. https://doi.org/10.13189/fst.2013.010302.

3. Boa, E. 2004. *Wild Edible Fungi: A global overview of their use and importance to people*. Non-wood forest products series, No. 17, FAO, Rome.

4. Chang, S. T. and P.G. Miles. 2004. *Mushrooms - Cultivation, Nutritional Value, Medicinal Effect, and Environmental Impact*. 2nd ed. pp. 477p. CRC Press, LLC.

5. Falemara, B. C. and V.I. Joshua. 2016. Comparative Yield and Proximate Composition of *Pleurotus ostreatus* (Jacq.) P. Kumm. and *Pleurotus florida* (Mont.) Singer cultivated on different substrates. In Forest Management and the Challenges of Environmental Sustainability. pp 444-450. Proceedings of the 5th Biennial National Conference of the Forest and Forest Products Society. Delta State University, Abraka, Asaba, Delta State, Nigeria. 25th to 28th April, 2016.

6. Gaur, T., P.B. Rao, and K.P.S. Kushwaha. 2016. Nutritional and anti-nutritional components of some selected edible mushroom species. *Indian Journal of Natural Products and Resources.* **7(2):** 155-161.

7. Kakon, A. J., M.B.K. Choudhury and S. Saha. 2012. Mushroom is an ideal food supplement. *Journal of Dhaka National Medical College and Hospital* **18(1):** 58-62.

8. Kinge, T. R., E.M. Adi, A.M. Mih, N.A. Ache and T.M. Nji. 2016. Effect of substrate on the growth, nutritional and bioactive components of *Pleurotus ostreatus* and *Pleurotus florida*. *African Journal of Biotechnology* **15(27):** 1476-1486. https://doi.org/10.5897/AJB2015.15130.

9. Lai, L. S., S.T. Chou, and W.W. Chao. 2001. Studies on the antioxidative activities of Hsian-tsao *(Mesona procumbens* Hemsl) leaf gum. *Journal of Agricultural and Food Chemistry* **49:** 963-968.

10. Lowry, O.H., N.J. Rosebrough, A.L. Farr, and R.J. Randall. 1951. Protein measurement with the folin phenol reagent. *Journal of Biological Chemistry* **193(1):** 265-275.

11. Maa, G., W. Yang, J. Zhaoa, F. Pei, D. Fang, and Q. Hu. 2018. A critical review on the health promoting effects of mushrooms nutraceuticals. *Food Science and Human Wellness* **7(2):** 125-133.

12. Mahari W.A.W, P. Wanxi, L.N. Wai, Y. Han, YL. Xie, K.L. Yik, K.L. Rock, L.M. Nyuk, A. Mohammad, S. Christian, V.L. Quyet, L.S. Pau, C. Wei-Hsin and S.L. Su. 2020. A review on valorization of oyster mushroom and waste generated in the mushroom cultivation industry. *Journal of Hazardous Materials* **400:** 123156. https://doi.org/10.1016/j.jhazmat.2020.123156.

13. Mandal, R.K. 2021. *Efficacy of different substrates on the growth, yield and nutritional composition of oyster mushroom (Pleurotus florida) under sub- tropical conditions*. Ph.D. (Horti.) thesis, Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.).

14. Mandaviya, T.K., A.B. Brahmbhatt and R.I. Chaudhari. 2018.Comparative study on growth and yield performance of pink oyster mushroom on different substrates. *International Journal of Current Microbiology and Applied Sciences* **7(7):** 1981-1985.

15. Park, S.Y., S.J. Jung, K.C. Ha, H.S. Sin, S.H. Jang, H.J. Chae, and S.W. Chae. 2014. Anti-inflammatory effects of *Cordyceps* mycelium *(Paecilomyces hepiali,* CBG-CS-2) in Raw264.7 murine macrophages. *Oriental pharmacy and experimental medicine* **15:** 7-12.

16. Porselvi, A. and R. Vijayakumar. 2019. Evaluation of paddy straw varieties on the cultivation and nutritional value of two oyster mushroom species. *International Journal of Research in Advent Technology* **7(5):** 556-563.

17. Raman, J., K.Y. Jang, Y.L. Oh, M. Oh, J. Im, H. Lakshamanan, and V. Sabaratnam. 2021. Cultivation and Nutritional Value of Prominent *Pleurotus* spp.: An Overview. *Mycobiology* **49(1):** 1-14. https://doi.org/10.1080/12298093.2020.1835142.

18. Rathore, H., S. Prasad, and S. Sharma. 2017. Mushroom nutraceuticals for improved nutrition and better human health: A review. *Pharma Nutrition* **5(2):** 35-46.

19. Sanchez, C. 2010. Cultivation of *Pleurotus ostreatus* and other edible mushrooms. *Applied Microbiology and Biotechnology* **85:** 1321-1337.

20. Snell, F. D. and C.T. Snell. 1953. *Colorimetric methods of analysis including some turbidimetric and nephelometric methods*. Volume III. 606 p. David van Nostrand incorporated company Princeton, New Jersey, Toronto, New York, London.

21. Somogyi, M. 1952. Notes on sugar determination. *Journal of Biological Chemistry* **195:** 19-23.

22. Stanley, H.O. and C.U. Nyenke. 2011. Cultural studies on mycelial of *Pleurotus pulmonarius* (oyster mushroom) in selected culture media. *International Journal of Science and Nature* **2:** 183-185.

23. Steel, R.G.D. and J. H. Torrie. 1980. *Principles and procedures of statistic a biomatereal approach*. 2nd edition. McGrow-Hill. New York, USA.

24. Synytsya, A., K. Mickova, I. Jablonsky, M. Slukova, and J. Copikova. 2008. Mushrooms of genus *Pleurotus* as a source of dietary fibres and glucans for food supplements. *Czech Journal of Food Sciences* **26(6):** 441-446.

25. Toros, G. H., H. El-Ramady, and J. Prokisch. 2022. Edible mushroom of *Pleurotus* spp.: a case study of oyster mushroom *(Pleurotus ostreatus* L.). *Environment, Biodiversity and Soil Security* **6:** 51-59.

26. Urbain, P., F. Singler, G. Ihorst, H.K. Biesalski, and H. Bertz. 2011. Bioavailability of vitamin D2 from UV-B-irradiated button mushrooms in healthy adults deficient in serum 25-hydroxyvitamin D: A randomized controlled trial. *European Journal of Clinical Nutrition* **65:** 965-971.

27. Zhou, X., L. Luo, W. Dressel, G. Shadier, D. Krumbiegel, P. Schmidtke, F. Zepp, and C.U. Meyer. 2008. Cordycepin is an immune regulatory active ingredient of Cordyceps sinensis. *The American Journal of Chinese Medicine* **36(5):** 967-980.

28. Elattar, A.M., S. Hassan and S.F. Awd-Allah. 2019. Evaluation of oyster mushroom (Pleurotus ostreatus) cultivation using different organic substrates. *Alexandria Sci Exch J* **40:** 427-440.

29. Onyeka, E.U., E. Udeogu, C. Umelo and M.A. Okehie. 2018. Effect of substrate media on growth, yield and nutritional composition of domestically grown oyster mushroom (*Pleurotus ostreatus*). *Afr J Plant Sci* **12(7):** 141-147.

30. Sardar, H., M.A. Ali, M.A. Anjum, F. Nawaz, S. Hussain, S. Naz and S.M. Karimi. 2017. Agro-industrial residues influence mineral elements accumulation and nutritional composition of king oyster mushroom (*Pleurotus eryngii*). *Sci Hortic* **225:** 327-334.

31. Garuba, T., K.A. Abdukkareem, I.A. Ibrahim, O.I. Oyebamiji, O.A. Shoyooye, and T.D. Ajibade. 2017. Influence of substrates on the nutritional quality of *Pleurotus pulmonarius* and *Pleurotus ostreatus*. *Ceylon Journal of Science* **46(1):** 67-74.

32. Odunmbaku, O.K. and C.O. Adenipekun. 2018. Cultivation of *Pleurotus ostreatus* (Jacq Fr.) Kumm on *Gossypium hirsutum* Roxb.(cotton waste) and *Gmelina arborea* L. sawdust. *Int Food Res J* **25(3):** 1140–1145.

33. Aigbodion, V.S., S.B. Hassan, T. Ause, and G.B. Nyior. 2010. Potential utilization of solid waste (bagasse ash). *J Miner Mater Char Eng* **9 (1):** 67–77.

34. Patil, S.S., 2012. Cultivation of *Pleurotus sajor-caju* on different agro wastes. *Sci Res Report* **2(3):** 225–228.

35. Zahid, M., S. Barua, and S.M. Huq. 2010. Proximate composition and mineral content of selected edible mushroom varieties of Bangladesh. *Bangladesh J Nutr* **61–68:** 22-23.

36. Upadhyay, R.C. 2011. Oyster Mushroom Cultivation. In Mushroom Cultivation, Marketing and Consumption, Singh *et al.* (eds). pp 129-138. ICAR-Directorate of Mushroom Research, Solan.

37. Ahmed, S.A., J.A. Kadam, V.P. Mane, S.S. Patil and M.M.V. Baig. 2009. Biological efficiency and nutritional contents of *Pleurotus florida* (Mont.) Singer cultivated on different agro-wastes. *Nat Sci* **7(1):** 44–48.

38. Adenipekun, C.O., R. Lawal, and O.S. Isikhuemhen. 2015. Effect of growth supporting additives on the performance of *Auricularia auricula* on *Mansonia altissima* A. chev sawdust. *Int Food Res J* **22(5):** 2167-2173.

39. Isikhuemhen, O.S. and J.A. Okhyoya. 1996. Cultivation of *Pleurotus tuber-regium* (Fr.) Singer for production of edible sclerotia on agricultural wastes. In Mushroom Biology and Mushroom Products: Proceedings of the 2nd International Conference. University Park, Pennsylvania. University Park, PA, Pennsylvania State University, World Society for Mushroom Biology and Mushroom Products. June 9-12, 1996.

40. Prueckler, M., S. Siebenhandl-Ehn, S. Apprich, S. Hoeltinger, C. Haas, E. Schmid, and W. Kneifel. 2014. Wheat bran-based biorefinery 1: composition of wheat bran and strategies of functionalization. *LWT–Food Sci Technol* **56(2):** 211–221.

41. Onipe, O.O., A.I. Jideani, and D. Beswa. 2015. Composition and functionality of wheat bran and its application in some cereal food products. *Int J Food Sci Technol* **50(12):** 2509–2518.