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Original Paper

The valorization of the functional potential of tomato processed waste

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***Abstract*—This investigation aimed to undertake an effective waste management strategy by valorizing the functional potential of thermally processed tomato processed waste fragments collected from three different zones of different states of India viz. Shillong (Sample A, Meghalaya), Falakata (Sample B, West Bengal), and Jalpaiguri (Sample C, West Bengal). Thermal processing of fragmented waste samples prior to the extraction process was carried out with three different drying techniques viz. solar drying, hot air oven drying, and combined drying. The experimental investigation with a comparative design revealed that the total phenolic content (TPC), lycopene content, and β-carotene content of solar dried waste fragments derived from samples A & B are significantly higher than those in sample C. Moreover, the sun-dried pomace fraction of tomato waste contains the maximum amount of bioactive components viz. lycopene (303.452mg/kg in sample A, 297.96 mg/kg in sample B, and 203.583 mg/kg in sample C), β-carotene content (299.6mg/kg in sample B, 299.1mg/kg in sample A, and 223.004 mg/kg in sample C) and total phenolic content (6.8698mg/kg in sample B, 5.9541mg/kg in sample A, and 5.7915mg/kg in sample C) followed by skin lycopene (282.297mg/kg in sample A, 276.8 mg/kg in sample B, and 182.603 mg/kg in sample C); β-carotene (280.41mg/kg in sample A, 278.002mg/kg in sample B, and 188.258 mg/kg in sample C) and total phenolics (6.4413mg/kg in sample B, 5.2633mg/kg in sample A, and 5.0223mg/kg in sample C) and seed lycopene (276.8mg/kg in sample B, 86.746 mg/kg in sample A, and 62.163mg/kg in sample C); β- carotene (85.23mg/kg in sample B, 84.01mg/kg in sample A, and 66.23mg/kg in sample C) and total phenolics (5.9228mg/kg in sample B followed by 4.6602mg/kg in sample A and 4.641mg/kg) respectively. The solar drying technique is considered to be a novel pretreatment process compared to other treatments e.g., oven drying, and combined drying, in the efficacy of extraction of bioactive components from tomato processed waste fractions due to its lower impact on heat-sensitive biomaterials.**

Keywords*— *Tomato processed wastes, Extraction, functional constituents, nutritional constituents, Total phenolic content.

I. Introduction

Tomato (*Lycopersicone sculentum Mill*.) is considered to be a broadly produced vegetable. As per statistics, it was produced worldwide with a range of 170 MT in 2014 [1]. According to World Processing Tomato Council (WBTC), worldwide processing of tomatoes reached 40 MT for the production of various tomato-derived products, e.g., tomato extract, paste, purée, thickened tomato sauce, and thermally processed tomatoes. [2].

Both raw and processed tomato products contain a high nutritional potential, due to a substantial amount of vitamin-like microelements, naturally occurring fat-soluble carotenoids, and polyphenolics as antioxidative constituents, sharing a range of more than 80% of the total carotenoids [3,4]. However, other carotenoids, such as alpha, beta, gamma, delta carotene, phytoene, phytofluene, and lutein, are also available.

According to [5], these days, lycopene has been acknowledged to be an important candidate to provide significant health improvement properties and possesses of two times more antioxidative properties than that of β-carotene as a vitamin A precursor. During tomato processing in the industry, large quantities of waste are produced comprising of skins, seeds, fiber-rich fraction, and pomace that comprise around 7.0–7.5% on the basis of total raw materials. The waste management issue in tomato waste processing causes a huge problem around the world environmentally and economically. The problem can be efficiently managed by recirculating these useful wastes which can also significantly reduce processing costs [28].

Tomato seeds as an important tomato waste fragment bear high nutritional quality and contain ample valuable components, including high nutritional quality along with natural colorants, carotenoids nutrients, proteins, minerals, phytochemicals, polyphenols, and phytosterols [6].

Seeds extracted from the tomato canning industry can be a good supplement to chick ratios of around 15%, and no such deleterious effects on growth characteristics was observed. According to [7], tomato pomace could be considered a potential resource of tocopherol in the diet of broiler chicken to minimize oxidative rancidity of lipid during heat treatment and prolonged freezing preservation of meat and to extend shelf stability.

Several investigations were carried out to exploit tomato waste as a useful by-product for the isolation of lycopene [8]. The added value of pectin could be extracted from tomato waste by the novel ultrasound-assisted extraction [9].

Moreover, this waste was also utilized for the production of novel polymeric carbohydrates through anticytotoxic and antioxidative activity along with biological film formation ability [10]. Technological advancement in eco-friendly manner could be an efficient way to utilize tomato processed waste for the synthesis of value-added products. According to [11], tomato processed waste has the potential to encourage the synthesis of cellular mass of microbes influenced by heat tolerant and salt tolerant thermophiles and halophiles respectively, and to synthesize biocatalysts and biologically derived polymers. According to [12], protein derived from tomato waste can be utilized to produce antioxidant and antibacterial hydrolysates through fermentation. Pretreatment of tomato peel waste fragments by the application of enzymatic breakdown will produce oleoresin [13]. The oleoresin mixed with tomato seed oil will be treated as a functional food due to the availability of a significant amount of lycopene. Some investigators reported that tomato processed waste in powder form can be added to food products for effective utilization [29].

According to [14], dried tomato peel can be added directly into hamburgers both in raw and cooked form. Lycopene-enriched dry fermented sausages can be produced from fermented sausage by adding dried tomato peel [15]. According to [16], the enhanced prevention of oxidative rancidity followed by lipid oxidation can be carried out in pressure-processed minced chicken meat by adding tomato processed waste.[17] reported that tomato peel can be incorporated directly to prepare carotenoids enriched edible oil. Dry tomato processed waste significantly affects various qualitative properties of wheat bread viz. physicochemical and sensory properties [18]. Moreover, snack food can be produced from extruded barley flour in combination with tomato pomace [19]. This study aimed to evaluate and explore the functional potential of tomato processed waste in terms of various bioactive components viz. polyphenols, lycopene, beta carotene, and anti-oxidative potential. The outcome of this work will focus on the recycling of tomato processed waste for the development of value-added products.

II. Materials and Methods

A. The collection of raw materials

Tomato cultivation has yet to gain traction in India. Mostly, tomatoes reached the local market from adjacent states viz. Meghalaya and West Bengal due to huge cultivation. Therefore, tomato as raw material for this study was obtained from Shillong (Meghalaya; sample A) and West Bengal viz. Falakata (sample B), and Jalpaiguri (sample C). After tomato processing, the pulp was discarded and the waste fragments comprising of skin/peel, seed, and pomace were sorted for future extraction. Finally, the evaluation of functional potential will be carried out for all these waste fragments extracted from sample A, sample B and sample C.

B. The drying of tomata processing waste

Tomato waste, i.e., seed, skin, and pomace were dried separately by means of solar drying, drying by a hot air oven followed by 5 hours at 40°C and the combination of sun and oven drying techniques in this study.

C. The extraction of tomato processinng waste

Different fragments of tomato processed wastes viz. skin, seed, and pomace were extracted through the following flow diagram (figure 1).

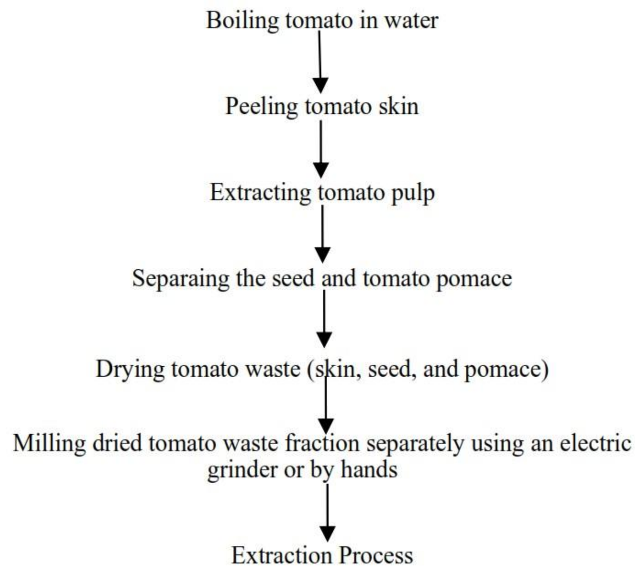

Fig. 1. General steps in tomato wastes extraction

D. Estimation of lycopene content of thermally treated tomato processed waste

Lycopene is determined according to the method of [20]. In this method, 1 g tomato processed waste powder was well mixed by agitation with a 16-ml mixture of acetone and hexane in 2:3 ratio in a test tube for 15 minutes. The value of absorbed light (A) of the hydrocarbon layer at 453, 505, and 663 nm wavelengths were calibrated using a spectrophotometer. The mathematical formula used for determining the lycopene content in milligrams per 100 gm of the sample was as follow:

$$\text{Lycopene (mg/100gm)} = -0.0458A_{663} + 0.372A_{505} - 0.0806A_{453}$$

A663, A505, and A453 are the respective absorbances at 663, 505, and 453nm in wavelength. The experimental values were determined in mg per kg.

E. The estimation of β-carotene content of thermally treated tomato processed waste

β-carotene is estimated by following the technique of [20]. In this method, 1 g tomato processed waste powder was well mixed with 16 ml ofacetone and hexane in a 4:6 ratio in a test tube for 15 minutes. The value of absorbed light (A) of the hexane layer at 453, 505,663, and 645 nm in wavelengths were recorded using a spectrophotometer. The mathematical formula for determining the β-carotene content in milligrams per 100 gm of the sample was as follows:

$$\beta\text{-carotene (mg/100gm)} = 0.216A_{663} - 0.304A_{505} + 0.452A_{453}$$

A663, A645, A505, and A453 are the absorbance at 663, 645, 505, and 453 m, respectively. The results were measured in mg per kg.

F. The estimation of total phenolic content (TPC) of thermally treated tomato processed waste

The TPC was estimated by using the Folin –Ciocalteau phenol technique,based on the demonstration by [21]. At this stage, 0.50 ml of liquid tomato waste fragments were separated from the waste powder. The liquid was then mixed with 0.25 ml of Folin-Ciocalteau reagent. Afterward, a mixture of 0.75 ml of saturated sodium carbonate solution and 0.95 ml of d.w. was added. The mixture was then incubated for 30 minutes at 37°C, and absorbance was recorded at 735 nm using a UV-spectrophotometer (LAMDA-35 Elmer Perkin, USA). The estimation was compared to a calibration curve with standard Gallic acid (GA) solution. The TPC was estimated as GA equivalents (GAE) in mg per kg. Equations are used for the estimation of TPC.

$$Y \text{ (mg/100kg)} = 11.924 X - 0.0307$$

where
Y = Absorbance value
X = Concentration from the calibration curve

$$\text{Total phenolic content (TPC)} = C V / M$$

where
C= Concentration from the calibration curveV= Volume of the Solution
M= Weight of the sample

III. Results & Discussion

A. Lycopene content in thermally treated tomato processed waste fragments (seed, skin, and pomace)

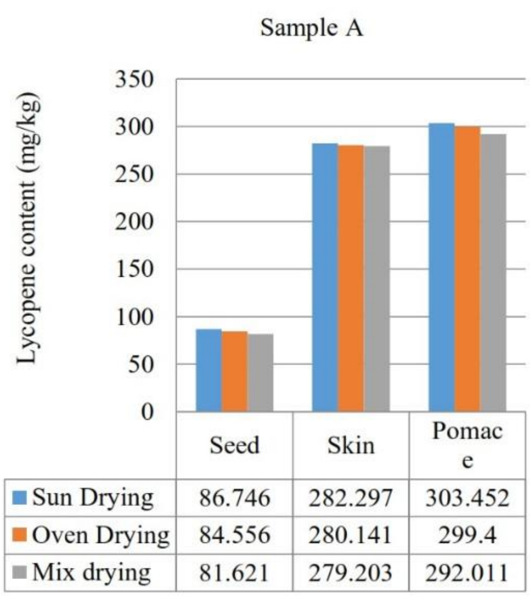

Fig. 2. Lycopene content in sample A

The lycopene content of Sample A (Shillong, Meghalaya) seed, skin, and pomace produced by solar drying, hot air oven drying, and mix drying is shown in Figure 2. The lycopene contents of seed on sun drying, oven drying, and mix drying were 86.746 mg/kg, 84.556 mg/kg, and 81.621 mg/kg, respectively. In the skin portion, the lycopene contents resulting from sun drying, oven drying, and mix drying were 282.297 mg/kg, 280.141 mg/kg, 279.203 mg/kg respectively, while the pomace contents were 303.452 mg/kg, 299.4 mg/kg, and 292.011 mg/kg, respectively. Solar drying yielded better results compared to others because of less influence on the decrement of the value of lycopene. The pomace fraction was found to be the highest value compared to skin and seed fragments due to its greater availability in fleshy parts. The dehydrated tomato processed waste contains about 510.6 mg/kg of lycopene [22]. This value is higher than the obtained value in our study. This might be due to the fact of different solvent-assisted extraction processes as well as various chemical compositions of tomato processed waste fractions.

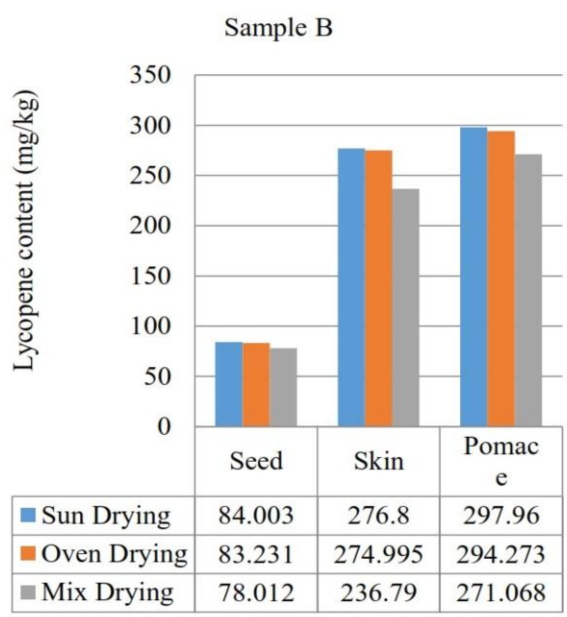

Fig. 3. Lycopene content in sample B

The lycopene content of sample B (Falakata, West Bengal) seed, skin, and pomace using different drying methods viz., solar drying, hot air oven drying, and mix drying are shown in Figure 3. The lycopene contents of seed resulting from sun drying, oven drying, and mix drying were 84.003 mg/kg, 276.8 mg/kg, and 78.012 mg/kg, respectively. In the skin portion, the lycopene contents resulting from sun drying, oven drying, and mix drying were 276.8 mg/kg, 274.995 mg/kg, and 236.79 mg/kg respectively, while in the case of pomace the contents were found at 297.96 mg/kg, 294.273 mg/kg, and 271.068 mg/kg. Similar results were identified in the thermally treated pomace fraction of sample B.

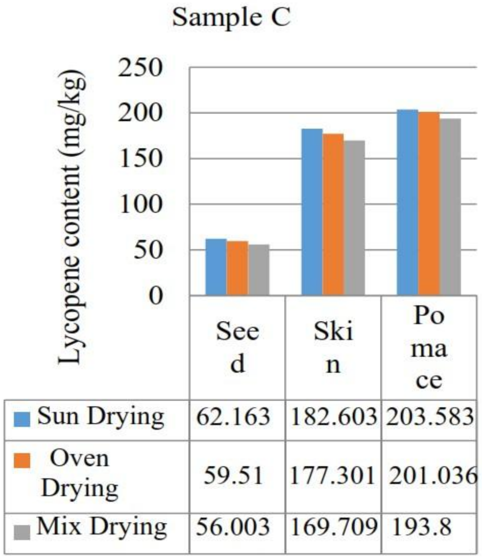

Fig. 4. Lycopene content in sample C

The lycopene contents of sample C (Jalpaiguri, West Bengal) from seed, skin and, pomace processed using solar drying, hot air oven drying, and mix drying are shown in Figure 4. The lycopene contents of seed processed using sun drying, oven drying, and mix drying were 62.163 mg/kg, 59.51 mg/kg and 56.003 mg/kg. In the skin portion, the lycopene contents identified from sun drying, oven drying, and mix drying were 182.603 mg/kg, 177.301 mg/kg, 169.709 mg/kg respectively, while the contents of pomace were 203.583 mg/kg, 201.036 mg/kg, and 193.8 mg/kg, respectively. The thermally treated tomato pomace as waste fragment also demonstrates similar results generally found in sample C.

B. *β-carotene* content in thermally treated tomato processed waste fragments (seed, skin, and pomace)

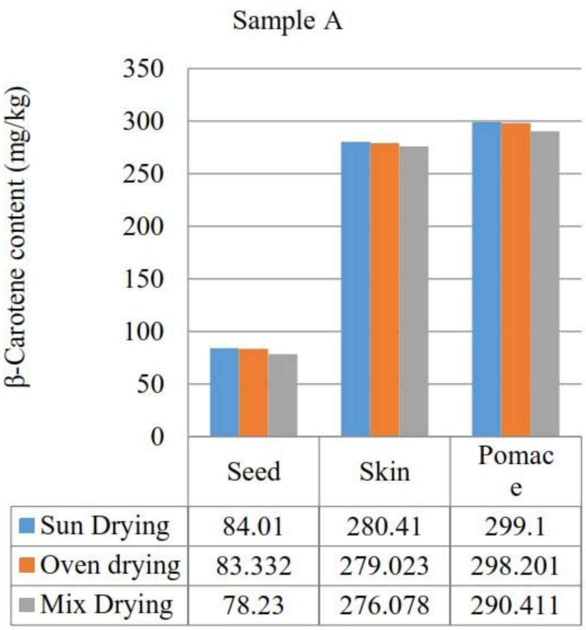

Fig. 5. β-carotene content in sample A

The beta-carotene contents of sample A (Shillong, Meghalaya) obtained from seed, skin, and pomace processed using solar drying, hot air oven drying, and mix drying are shown in Figure 5. The β-carotene contents of seed obtained from sun drying, oven drying, and mix drying were 84.01 mg/kg, 83.332 mg/kg, and 78.23 mg/kg. In the skin portion, the β-carotene contents derived from sun drying, oven drying, and mix drying were 280.41 mg/kg, 279.023 mg/kg, 276.078 mg/kg, while in case of pomace the contents from the same methods were found at 299.1 mg/kg, 298.201 mg/kg, and 290.411 mg/kg, respectively. Solar drying in tomato pomace shows the highest value as compared to skin and seed fragments due to the greater availability in the fleshy part in sample A.

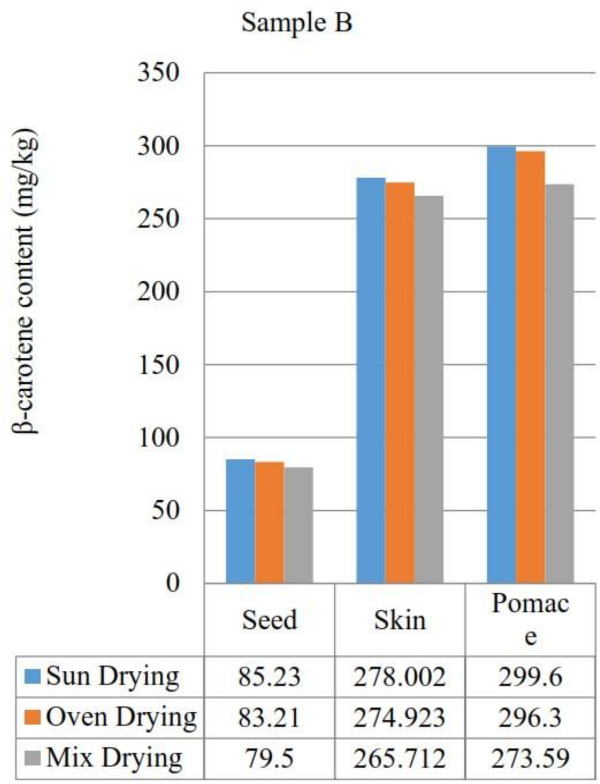

Fig. 6. β-carotene content in sample B

The β-carotene contents of sample B (Falakata, West Bengal) obtained from seed, skin, and pomace processed using different drying methods viz., solar drying, hot air oven drying, and mix drying are shown in Figure 6. The β-carotene contents of seed resulting from sun drying, oven drying, and mix drying were 85.23 mg/kg, 83.21 mg/kg and 79.5 mg/kg. In the skin portion, the β-carotene contents associated with sun drying, oven drying, and mix drying were 278.002 mg/kg, 274.923 mg/kg, and 265.712 mg/kg, while in the case of pomace the contents were 299.6 mg/kg, 296.3 mg/kg, and 273.59 mg/kg. Similar results in the pomace fraction were identified. β-carotene content of tomato processed waste was 95.6 mg/kg [22]. That result is comparable with our obtained result.

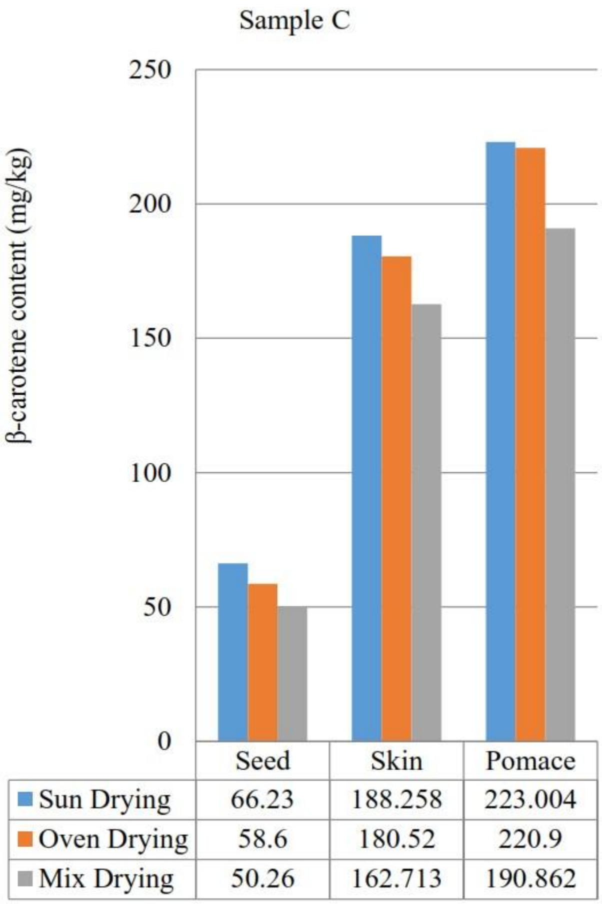

Fig. 7. β-carotene content in sample C

The β-carotene contents of sample C (Jalpaiguri, West Bengal) derived from seed, skin, and pomace processed through different drying methods viz., solar drying, hot air oven drying, and mix drying are shown in Figure 7. The β-carotene contents of seed processed through sun drying, oven drying, and mix drying were 66.23 mg/kg, 58.6 mg/kg, and 50.26 mg/kg. In the skin portion, the β-carotene contents from the same three methods were 188.258 mg/kg, 180.52 mg/kg, and 162.713 mg/kg, while in the case of pomace the β-carotene contents were 223.004 mg/kg, 220.9 mg/kg, and 190.862 mg/kg. Sun-dried fleshy pomace fragment of sample C yields significantly more satisfactory results compared to other fractions. The result is in comparison with the finding of [23], who reported that total carotenoid contents of dried tomato pomaces range from 30.54 to 50.54 mg/100g (d.w.). The difference may result from different extraction rates of carotenoids by various solvent mixtures, the application of different total carotenoid determination methods, expression of results in terms of different standard compounds, and chemical compositions of tomato pomaces influenced by seed/peel ratio, and their chemical properties [24].

C. Total phenolic content in thermally processed tomato waste fragments (seed, skin, and pomace)

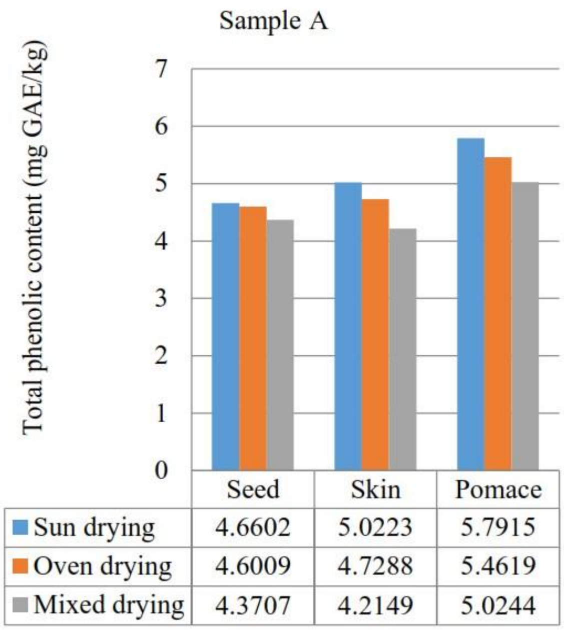

Fig. 8. Total phenolic content in sample A

TPC of sample A (Shillong, Meghalaya) involving the seed, skin and, pomace treated using different drying methods viz., solar drying, hot air oven drying, and mix drying are shown in Figure 8. The phenolic content of seed on sun drying, oven drying, and mix drying was found to be 4.6602 mg/kg, 4.6009 mg/kg and 4.3707 mg/kg. In skin portion, the phenolic contents resulting from sun drying, oven drying, and mix drying were 5.2633 mg/kg, 4.7288 mg/kg and 4.2149 mg/kg, while in case of pomace phenolic contents were identified at 5.9541 mg/kg, 5.4619 mg/kg, and 5.0244 mg/kg. Total phenolic content (TPC) of solar dried pomace in sample A reflects similar trend. The result of our study is in accordance with the result of [22] who reported that the TPC of dried tomato waste was 4.2295 mg GAE/1000g.

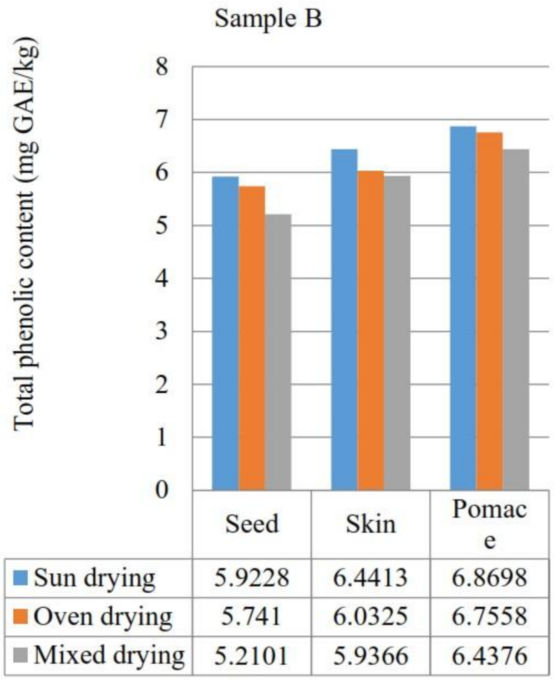

Fig. 9. Total phenolic content in sample B

TPC of sample B (Falakata, West Bengal) seed, skin, and pomace treated using different drying methods viz., solar drying, hot air oven drying, and mix drying are shown in Figure 9. Total phenolic content of seed on sun drying, oven drying, and mix drying was 5.9228 mg/kg, 5.741 mg/kg, and 5.2101 mg/kg. In the skin portion, the phenolic contents resulting from sun drying, oven drying, and mix drying were 6.4413 mg/kg, 6.0325 mg/kg, and 5.9366 mg/kg, while in the case of pomace Total phenolic contents were 6.8698 mg/kg, 6.7558 mg/kg, and 6.4376 mg/kg. Therefore, the TPC content of tomato pomace in sample B treated by sun drying was superior to two other methods. A very recent study shows that freeze-dried tomato pomace yields higher phenolic content (8.530 mg GAE/100g) than cabinet–dried tomato pomace (6.530 mg GAE/1000g) [25]. It is comparable with our obtained experimental results.

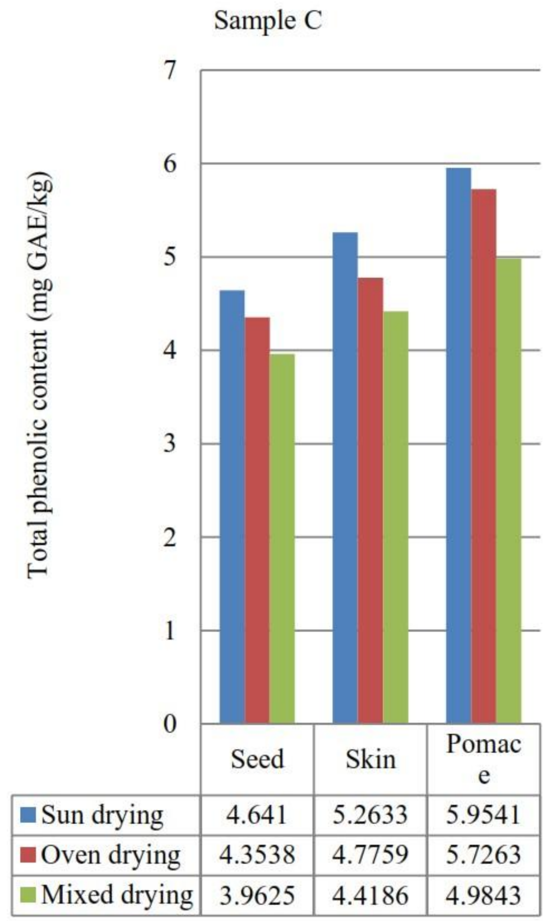

Fig. 10. Total phenolic content in sample C

Total phenolic content of sample C (Jalpaiguri, West Bengal) derived from seed, skin, and pomace treated using different drying methods viz., solar drying, hot air oven drying, and mix drying are shown in Figure 10. Total phenolic contents of seed processed using sun drying, oven drying, and mix drying were 4.641 mg/kg, 4.3538 mg/kg, and 3.9625 mg/kg. In the skin portion, the phenolic contents generated from the same three methods were 5.0223 mg/kg, 4.7759 mg/kg, and 4.4186 mg/kg, while the total phenolic contents in pomace were 5.7915 mg/kg, 5.7263 mg/kg, and 4.9843 mg/kg and maintain the conventional pattern. The result of our study is in coherence with a previous study reporting similar results in dried tomato waste (4.53 mg /1000g) [26]. According to [27], TPC in dried tomato pomace was found in the range 2.2–4.1.54 mg /1000g. This has significantly validated our experimental results.

IV CONCLUSION

The results of this study demonstrate that thermally treated tomato waste fragments viz. skins, seeds & pomace, possess a significant potential and therefore can be deemed very important in the development of waste management strategy. Sun drying is found as a significant method of pretreatment prior to extraction for obtaining valuable bioactive components from the skin, seed, and pomace as compared to oven drying and mixed or combined drying techniques due to the negligible effects of these components on the application of moderate temperature. Pomace fraction shows better results in terms of the extraction of functional constituents than the other two fractions viz. skin and seed. Sun-dried pomace fraction of sample A contains 303.452mg/kg of lycopene, which is significantly higher than 297.96 mg/kg in sample B and 203.583 mg/kg in sample C. Similarly, the highest amount of β-carotene is found at 299.6mg/kg in sample B, which is slightly higher than those in sample A and sample C, i.e., 299.1mg/kg and 223.004mg/kg. The highest amount of total phenolic content is 6.8698mg/kg identified in sample B, followed by 5.9541mg/kg in sample A and 5.7915mg/kg in sample C.

REFERENCES

[1] FAOSTAT. (2014). Food and Agriculture Organization Statistics Data base. Retrieved fromhttp://www.fao.org/faostat/en/#data.

[2] WPTC (The World Processing Tomato Council). (2015). World production estimate as of 15 October2 015. Retrieved January10, 2017, fromwww.wptc.to/

[3] Toor, R.K., & Savage, G.P. (2005). Antioxidant activity in different fractions of tomatoes. Food Research International, 38(5), 487-494. https://doi.org/10.1016/j. foodres.2004.10.016..

[4] Dorais, M., Ehret, D.L., & Papadopoulos, A.P. (2008). Tomato (Solanum lycopersicum) health components: from the seed to the consumer. Phytochemical Review 7(2): 231-250. https://doi.org/ 10.1007/s11101-007- 9085-x.

[5] Kong, K.-W., Khoo, H.-E., Prasad, K. N., Ismail, A., Tan, C.-P., & Rajab, N. F. (2010). Revealing the power of the natural red pigment lycopene. Molecules, 15, 959987.doi:10.3390/ molecules15020959

[6] Persia, M. E., Parsons, C. M., Schang, M., & Azcona, J. (2003). Nutritional evaluation of dried tomato seeds. Poultry Science, 82, 141–146.doi:10.1093/ps/82.1.141

[7] King, A. J., & Zeidler, G. (2004). Tomato pomace may be a good source of vitamin E in broiler diets. California Agriculture, 58, 59–62.doi:10.3733/ca.v058n01p59

[8] Nobre, B. P., Palavra, A. F., Pessoa, F. L. P., & Mendes, R. L. (2009). Supercritical CO2 extraction of trans-lycopene from Portuguese tomato industrial waste. FoodChemistry,116,680685.doi:10.1016/j.foodchem.2009.03.011

[9] Grassino, A. N., Brnčić, M., Vikić-Topić, D., Roca, S., Dent, M., & Brnčić, S. R. (2016). Ultrasound assisted extraction and characterization of pectin from tomato waste. Food Chemistry, 198, 93–100. doi:10.1016/j. food chem 2015.11.095

[10] Tommonaro, G., Poli, A., De Rosa, S., & Nicolaus, B. (2008). Tomato derived polysaccharides for biotechnological applications: Chemical and biological approaches. Molecules,13,1384–1398. doi:10.3390/ molecules 13061384

[11] Di Donato, P., Fiorentino, G., Anzelmo, G., Tommonaro, G., Nicolaus, B., & Poli, A. (2011). Re-use of vegetable wastes as cheap substrates for extremophile biomass production. Waste & Biomass Valorization, 2(2), 103111.doi:10.1007/s12649-011-9062-x

[12] Moayedi, A., Hashemi, M., & Safari, M. (2016). Valorization of tomato waste proteins through production of antioxidant and antibacterial hydrolysates by proteolytic Bacillus subtilis: Optimization of fermentation conditions. Journal of Food Science and Technology-Mysore,53(1),391–400.doi:10.1007/s13197-015-1965-2

[13] Zuorro, A., Lavecchia, R., Medici, F., & Piga, L. (2014). Use of cell wall degrading enzymes for the production of high-quality functional products from tomato processed waste. Chemical Engineering Transactions, 38355360.doi:10.3303/CET1438060

[14] García, M. L., Calvo, M. M., & Selgas, M. D. (2009). Beef hamburgers enriched in lycopene using dry tomato peel as an ingredient. Meat Science, 83, 45–49. doi:10.1016/j.meatsci.2009.03.009

[15] Calvo, M. M., García, M. L., & Selgas, M. D. (2008). Dry fermented sausages enriched with lycopene from tomatopeelmeatScience,80,167172.doi:10.1016/j.meatsci.2007.11.016

[16] Alves, A. B., Bragagnolo, N., Da Silva, M. G., Skibsted, L. H., & Orlien, V.(2012).Antioxidant protection of high-pressure processed minced chicken meat by industrial tomato products. Food and Bio-products processing,90,499505. doi:10.1016 /j.fbp.2011.10.004

[17] Benakmoum, A., Abbeddou, S., Ammouche, A., Kefalas, P., & Gerasopoulos, D. (2008). Valorisation of low quality edible oil with tomato peel waste. Food Chemistry,110, 684690.doi: 10.1016/j.foodchem.2008.02.063

[18] Nour, V., Ionica, M. E., & Trandafir, I. (2015). Bread enriched in lycopene and other bioactive compounds by addition of dry tomato waste.18.Journal of Food Science and Technology Mysore,52,8260–8267.doi:10.1007/s13197-015-1934-9

[19] Altan, A., McCarthy, K. L., & Maskan, M. (2008). Evaluation of snack foods from barley-tomato pomace blends by extrusion processing. Journal of FoodEngineering,84,231242.doi:10.1016/j.jfoodeng.2007.05.014.

[20] Nagata,M., and Yamashita,I., (1992). Simple method for simultaneous determination of chlorophyll and carotenoids in tomato fruit. *Nippon ShakuhinKogio Gakkaish,**39**,925-928*

[21] V. L. Singleton, Joseph A. Rossi, Colorimetry of Total Phenolics with Phosphomolybdic - Phosphotungstic Acid Reagents, American Journal of Enology and Viticulture. January 1965 16: 144-158; published ahead of print January 01, 1965.

[22] Nour, V., Panaite, T. D., Ropota, M., Turcu, R., Trandafir, I., & Corbu, A. R. (2018). Nutritional and Bioactive Compounds in Dried Tomato processed waste. CyTA Journal of Food, 16, 222–229. doi: 10. 1080/19476337.2017.1383514.

[23] Luengo, E., Condón-Abanto, S., Condón, S, Álvarez, I., & Raso J. (2014). Improving the extraction of carotenoids from tomato waste by application of ultrasound under pressure. Separation Purification Technology, 136,130- 136. https:// doi.org / 10.1016/ j.seppur.2014. 09.008.

[24] Aksoylu Özbek, Z., Çelik, K., Günç Ergönül, P., & Hepçimen, A., Z. (2020). A Promising Food Waste for Food Fortification: Characterization of Dried Tomato Pomace and Its Cold Pressed Oil. Journal of Food Chemistry and Nanotechnology, 6(1), 9-17. https://doi.org/10.17756/jfcn.2020-078.

[25] Bhat, M.A., & Ahsan, H. (2018). Quality characteristics of freeze and cabinet dried tomato pomace. International Journal of Pure and Applied Biosciences, 6(2),891-897. https://doi. org/10.18782/2320-7051.4044.

[26] Liadakis, G.N., Tzia, C., Oreopoulou, V., & Thomopoulos, C.D. (1995). Protein Isolation from tomato seed meal extraction optimization. Journal of Food Science, 60(3), 477-482. https://doi.org/10.1111/j.1365-2621.1995.tb09807.x.

[27] Fărcaş, A.C., Socaci, S.A., Michiu, D., Biriş, S., & Tofană, M. (2019). Tomato waste as a source of biologically active compounds. Bulletin UASVM Food Science and Technology, 73(2), 55-60.

[28] Ida Bagus Suryaningrat, Elida Novita, Uswatun Kasanah. 2020. Cleaner Production Practices in Agroindustry: A Case of Small Scale Cheese Factory in Indonesia. International Journal of Food, Agriculture, and Natural Resources. Vol 1 (1):19-23. https://doi.org/10.46676/ij-fanres.v1i1.5

[29] P. Kumaran, S. Natarajan, R. Shanmuga Raj, S. Dhanaraj, V. Rubesh Kumar. 2021. Performance and emissions on VCR diesel engine with turbocharger setup running using tomato seed oil. Materials Today: Proceedings. Vol 45. https://doi.org/10.1016/j.matpr.2020.10.080.