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Mini Review

Prospects of Medicinal and Commercial Utilization of Potato Peel Waste

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ABSTRACT:
Potato (Solanum tuberosum) is an annual herbaceous, self-pollinated species, belongs to family solanaceae and the genus Solanum. Potato peels are a contributor to organic waste in households, hotels, restaurants and food processing industries. Unless proper waste management is performed, this potato peel waste can cause environmental pollution due to decomposition. Potato peel has essential organic matter and nutritionally beneficial compounds, which can be utilized in many ways. Apart from being able to serve as a natural antioxidant for foods, phenolic compounds that are present in potato peel can be particularly beneficial in the treatment of chronic diseases, and also in the prevention of cancer. The potato and its peel contain important nutrients like fibre, potassium, vitamin C and vitamin B-6 and almost no cholesterol which contribute towards good cardiovascular health. Varying amounts of essential nutrients like; iron, potassium, riboflavin, folate, and other vitamins are found primarily in the periderm of the potato skin in higher amounts when compared with the flesh of the tuber. Potato peel waste, by various procedures such as extraction, fermentation, and other processes, can be utilized to produce bio-fuels, dietary fibre, biofertilizer, biogas and food additives. So, this review introduces the application of potato peel utilization and the potential use of potato peel.
Keyword: Potato peel waste, potato peel, bio-fuels, dietary fibre, biofertilizer, *Solanum tuberosum*.

1. INTRODUCTION

Potato (*Solanum tuberosum*), fourth most significant crop in the world, after wheat, rice and maize [1]. Potato belongs to family Solanaceae and genus Solanum, is among the oldest crop plants cultivated for the food purpose. Thebotanical name, *Solanum tuberosum* was coined by Linnaeus in his book "Species Plantarum" [2]. The history of potato started from Andes Mountains of South America about 8000 and 5000 BC near Lake Titicaca which is located at12,500 feet above sea level in the border provinces between Bolivia and Peru. Wild potatoes have been known to be a food in South America from as early as 13,000 years ago. Many wild potato species show resistance to insects and diseases as they contain compounds like glycoalkaloids (solanine and chaconine), but they impart bitter taste and are toxic to humans at high enough levels, so choosing of non-bitter potatoes for cultivation was first step in domestication. A technique called freeze-drying as found in the Andes to remove bitterness from potato tubers but gradually selection and propagation of non-bitter tubers as made to eliminate bitter tubers [3].

Western South America is the primary centre of the origin of the potato and its wild relatives. Where it grows wild in nature and presents the widest diversity of forms like tuber shape, size, colour, taste etc. Probable ancestor of all cultivated potatoes is *Solanum stenotomum*. From South America potato tardily started its travel across the continent, but it acquired great importance in 1530s when Spanish conquistadors searched for gold in Peru. They brought potato to Europe between the years of 1570 and 1593. The potato was familiarized in India by the Europeans in early 17^{th}century, which was previously introduced in Europe by the Portuguese. In the 20^{th}century, potato became one of the most beloved and produced food sources in the world. United States of America was the last major country who adopted potato. Now potato is cultivated throughout the world more than 100 countries including Europe, North America and countries of the former Soviet Union, Asia, Africa and Latin America [4].

The potato is a dicot plant belonging to family Solanaceae and the genus *Solanum*. This is a largest genus of angiosperms and comprises nearly 2,000 species. Genus *Solanum* has been divided into two sub genuses namely *Pachystemonum* and *Leptostemonum* as per the latest classification. *Pachystemonum* has been further divided in to five sections of which section Petota, contains most of the tuber bearing species. Section Petota has been divided under

two subsections, namely Estolonifera and Potatoe. All cultivated species grouped under the series *Tuberosa* of subsection/subgenrepotatoe [5]. About 72 % of the species are diploid (2n=24) and nearly 12% tetraploid (2n=48). The rest are triploid (2n=36), pentaploid (2n=60) and hexaploid (2n=72). The widely cultivated potato belongs to tetraploid species *Solanum tuberosum L*.

As per a survey of the Food and Agriculture Organization of the United Nations, over 370 million metric tons of potato tuber were produced worldwide in 2019 only. This was a significant increase over the 325 million ton production of the year 2012. There is an increase in growth production of potato per year so these are a huge wastage of the potato peel per year. The problem of management of potato peel waste cause considerable concern to the potato industries in worldwide.[6]

As a consequence of the processing of potato products in the industries, a lot of potato by-products are generated. One of them includes the potato peels which are a major organic waste product of industries processing the potato as their primary raw material. The peel of potato is considered a major waste disposal issue for the commercial industry as it contains a significant amount of the elements C, H, O and N (**Table 1**).

Table 1: Elemental content of potato peel shows that it contains (in % dry basis) [12].

Sl. no.	Elements	% dry basis
1	Carbon	43.78 ± 0.15
2	Hydrogen	5.96 ± 0.12
3	Nitrogen	4.06 ± 0.01
4	Oxygen	46.21 ± 0.28

Up-grading of this by-product to value added products is therefore of interest to the potato industry. The peeling is accomplished by abrasive peeling, steam peeling or lye peeling, depending on the types of products to be processed. Abrasive peeling is used for chips, whereas steam peeling is used for frozen and dehydrated products. The use of lye peeling requires a neutralization step, after peeling. Potato skin is composed of suberized phellem cells, the outer component of the tuber periderm. The periderm tissue is made up of two different cell types; viz., the phellogen (cork cambium); which is a meristematic (single celled) layer; and thephelloderm (a parenchyma-like layer). The phellogen produces the phellem cells and phelloderm that is derived from inward cell divisions of the phellogen. Another layer is the periderm which is a tissue of secondary origin that replaces the epidermis it gets damaged [7].

Potato peel contains various polyphenols and phenolic acids which are responsible for its antioxidant activities (**Table 2**), whereas fatty acids and lipids showed antibacterial activities [8]. Potato peel also contains; starch (25%), non-starch polysaccharide (30%), protein (18%), acid-soluble and acid insoluble lignin (20%), lipids (1%) and ash (6%) on dry basis [9,10].The lipid fraction of potato peel includes long chain fatty acids, alcohols, triglycerides and sterol esters. Potato peel is rich in starch (52% dry weight), but the content of fermentable reducing sugar is limited (0.6% dry weight). For this purpose, fermentation of potato peel is not practically possible, thus initial hydrolysis (enzymatic or acidic) of carbohydrates is required to increase the content of fermentable reducing sugar [11]. The array of nutritionally and pharmacologically beneficial compounds, like cell wall polysaccharides, dietary fibre, antioxidants, dietary fibre, cellulose, hemicellusose, lignins, phenolic compounds, vitamins and minerals; make potato peel a very useful waste that can be utilized for various purposes (**Table 3**) [14]. Some of the important constituents of potato peel and their chemical structures are shown in Figure 1.

Table 2: Phenolic acids present in potato peel waste [12].

Sl. no.	Phenolic acids	mg/100g
1	Gallic acid	58.6–63.0 mg/100 g
2	Protocatechuic acid	216.0–256.0 mg/100 g
3	Vanillic acid	43.0–48.0 mg/100 g
4	Caffeic acid	278.0–296.0 mg/100 g
5	Chlorogenic acid	753.0–821.3 mg/100 g
6	*p*-hydroxybenzoic acid	82.0–87.0 mg/100 g
7	*p*-coumaric acid	41.8–45.6 mg/100 g

Table 3: Chemical composition of raw potato peel, g per 100 g [13]

Sl. no.	Compound	Range
1	Water	83.3–85.1
2	Protein	1.2–2.3
3	Total lipids	0.1–0.4
4	Total carbohydrate	8.7–12.4
5	Starch	7.8
6	Total dietary fibre	2.5
7	Ash	0.9–1.6
8	Total phenolic content	1.02–2.92
9	Total flavonoids	0.51–0.96

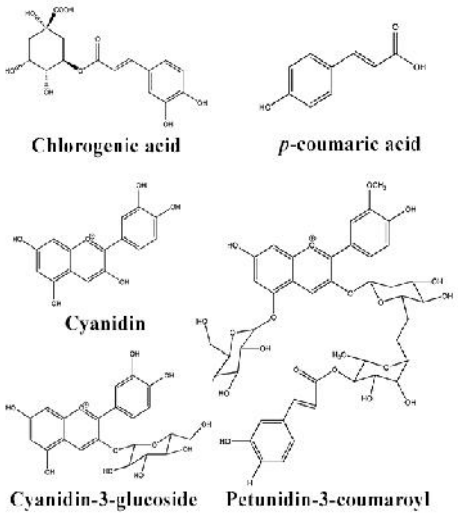

Fig 1: Some important structures present in potato and its peel

Dietary fibre is a bulking mediator, enhancing intestinal mobility and faecal hydration. In numerous studies, the benefits of dietary fibres are well documented [15]. Dietary fibre, a broad term, includes various carbohydrates, hemicelluloses, cellulose, pectin, lignin, gum etc. having chief pharmaceutical application as well. Camire, Zhao and Violette [16] documented the insolubility of fibre extracted from potato peel and its ability of binding bile acids during the in-vitro study which contribute as one of the key mechanisms in which specific source of dietary fibre potentially reduces the plasma cholesterol. Lazarov and Werman [17] reported the dietary fibres extracted from potato peel showed a hypocholesterolemic effect when experimented with rats, feeding them fibre of potato peels, revealed the fact that rats ultimately showed 40% reduced plasma cholesterol while 30% reduction in hepatic fat cholesterol was detected when compared with controlled rats. Additionally, high levels of low-density lipoprotein (LDL), cholesterol, a high concentration of triglyceride, dyslipidemia, contributed to the aggregation of blood platelets, increasing the risk for hypertension and cardiovascular diseases (CVD) [18]. In addition, dietary fibres contribute to the lowering of blood glucose level and related health problems in both types of diabetic patients. Dietary fibre enhances other sugars absorption by altering the emptying time of the gastric system and encourages insulin response as well so that they can be promoted as ant-diabetic drug extracted from potato peel with reduced preparation cost and efficient utilization. Camire, *et al.* [19] reported the potential effect of potato peel as anti-carcinogenic substance. Potato peel dietary fibres are believed to impart certain protective roles against carcinogenesis and mutagenesis through various mechanisms including the binding of mutagenic and carcinogenic materials, increasing faecal bulk and water absorption, reducing the intestines-transit time, and lowering the faecal pH via fermentation process through intestinal microflora. The potatoes peel waste has been proved to be an environmentally friendly and economical choice to be considered for use as adsorbents for pharmaceutical effluents treatment [20]. There have been certain toxic compounds as environmental pollutants originated from pharmaceutical preparations that ultimately get penetration into drinking water supplies, groundwater, and surface waters reasoned to inadequate wastewater processing. In this context, activated carbon has been reported to be the most likely adsorbent material with higher adsorption ability for various pollutants (metals and dyes etc.). In another instance, potato peel waste was used for the production of carbon samples after pyrolysis/hydrothermal treatment. Afterwards, with slight modification with oxidation agents and activation with KOH, the above-mentioned substances were used to remove the pharmaceutical compounds (specifically pramipexole and dorzolamide) from the effluents [21].There are varying amounts of nutritional composition of raw potato with skin like potassium, iron, riboflavin, folate, and vitamins are found primarily in the thick periderm of the potato skin. The concentrations of some minerals were found to be greater in the skin than in the flesh of the tuber **(Table 4)** [22].

Table 4: Nutritional value of unpeeled raw potato

Sl. no.	Raw potato with skin	Nutritional value per 100 g
1	Energy	321 kJ (77 kcal)
2	Carbohydrates	17.47 g
3	Starch	15.44 g
4	Dietary fiber	2.2 g
5	Fat	0.1 g
6	Protein	2 g
7	Thiamine (B1)	0.08 mg
8	Riboflavin (B2)	0.03 mg
9	Niacin (B3)	1.05 mg
10	Pantothenic acid (B5)	0.296 mg
11	Vitamin B6	0.295 mg
12	Folate (B9)	16 µg
13	Vitamin C	19.7 mg

Being a natural reserve of tremendous medicinal and industrial potential; this mini-review article is aimed to compile the information regarding the same into one single, concise document. This document will serve as a ready reference for the researchers, academicians and students who wish to study potato peel and its potential utilization for various beneficial purposes.

2. UTILIZATION OF POTATO PEEL WASTE

2.1. Potato peels for skin care

Potato peel is a very good source of vitamin C and vitamin K and it contain 24% of vitamin C in 100g of potato peel and 2% of vitamin K which prim the skin cells and make the skin more glowing and shining and is very good for skin problems. Potato peel can be used to get rid from dark circles. It also whitens the skin due to the presence of various minerals and vitamins. It also treats acne by applying the potato peel juice at the affected area when the juice is applied with a cotton ball over affected area and kept for 15 - 20 minutes and then wash with lukewarm water to remove blackheads, whiteheads and reduce excessive oil [23].

2.2. Potato peel for biogas production

Food wastes for biogas production has a high potential. Fruit and vegetable such as potato peel wastes produce biogas in anaerobic condition and takes about 55 days to get completely digested. These processes can be carried out in biogas plants which also give bio-manure, thereby solving problems of waste management and maintaining a clean surrounding [24].With chemical pre-treatments, potato peel produce biogas and methane by anaerobic fermentation by the utilization of starch. The process is a low cost and simple method that could be conducted in the same area where

potato peel waste is collected. It has been reported that each ton of starchy potato peel waste produces 250 cubic metres of biogas. In another study, the potential of anaerobically digested Potato peel and its residue of lactic acid fermentation was investigated for methane production. The analytical results revealed the production of 60-70% methane. The digester using potato peel fermentation residue as feedstock showed maximum cumulative methane production of 273 L/kg with good performance, followed by 239 L/kg production by using potato peel waste in the same conditions [25].

It is also found that considerable amount of energy (2.8 kW/h) can be produced with significant reduction in Carbon Oxygen Demand (COD) when cow manure is co-digested with potato peel waste in a continuously stirred tank reactor (CSTR) [26].

2.3. Bio-oil and biochar production from potato peel waste

Both biochar and bio-oil can be prepared from the fermentation of potato peel waste and its residue by using auger pyrolyzer at the temperature of 450℃. The bio-oils produced from potato peel waste and its fermentation residue using the above method have been found to have higher levels of suberin-derived organic matter and lipid components; along with better absorption performance when compared to other bio-oils produced by different methods [27].

2.4. Biofuels and bio-hydrogen from potato peel

The demand for the development of tools to access alternative energy sources has gained more attention due to the reduction of oil reserves. Pyrolysis can be one of those tools to access a liquid fuel under atmospheric pressure on a large scale. The liquid fuels i.e., bio-oils are considered more environmentally friendly as compared to the petroleum sources. Such bio-oils are mainly comprised of phenols, aldehydes, organic acids, ketones, esters, furans, alcohols, alkenes and numerous oxygenated complexes. Maloncy, et al. [28] reported that the main idea for this type of environmentally friendly fuel is the transformation of wastes into more valuable energy sources. Thus, Potato peel waste can be converted to the biofuels via pyrolysis. Liang and McDonald [29] stated that the waste obtained after potato peel fermentation possessed tremendous potential to be used as a biofuel.

Similarly, another biofuel i.e., bioethanol can also be retrieved by using Potato peel due to the presence of a high amount of starch content. The fermentation of ethanol can occur as a result of the saccharification process. i.e., conversion of starch into fermentable sugars. As an alternative to petroleum-derived fuels, bioethanol is considered as an important energy source. As an energy source hydrogen gas also gained the attention as its burning generates a significant amount of energy per unit of weight. The combustion of hydrogen releases environmentally friendly gases as compared to the petroleum sources which emit greenhouse gasses in the environment. More recently, the production of bio-hydrogen gas by the use of agricultural waste and microbes has fetched more attention [30]. Despite microbes, the combination of photo fermentation followed by the sequential dark fermentation results in more production of biohydrogen gas through the potato's peel waste as compared to any other fermentation process.

2.5. Potato peel for wound healing

The natural product enhances the wound healing in common practice because of their antibacterial property. Wound occurs when the normal structure of skin, is disrupted and in order to ensure proper healing of such wounds it is necessary to keep the wound tissue clear of infection and maintain a moist environment. Wound dressings should possess the ability to reduce dead tissue, absorb exudate and prevent bacterial overgrowth. Potato peel is one of the natural wound healer herbal plants that have ability to provide high tensile strength to the wounded skin. Potato peel is also used in burn healing the outer surface in contact with the burn can be used to cover the burn and boiled potato peel have been used to cover the fresh burns wound. An ointment containing2.5% of potato peel extracts induced cutaneous wound healing through enhancement of cell migration. Sterile potato peel dressings are proven to be a better alternative to gauze alone dressings during the healing phase; and since it enjoys the benefit of being cheap, easy to apply, readily available; it has the potential of being an alternative for wound dressing in developing nations. Potato peel dressings fulfils all the requirements of an ideal dressing of being non-allergic, non-adherent, non-antigenic; with an antimicrobial activity [31].

2.6. Potato peel as animal feed

The potato peel from industries is the disposal problem for the industries which have a tremendous potential to reduce feed and disposal cost along with reduction in environment pollution. Potato peel wastes due to its high nutritional value can serve as a livestock feed in developing nations, where there is an ever-increasing demand for livestock feed products. Fruits and vegetable which generate a huge number of wastes are an excellent source of nutrients for livestock. It is estimated that around 35% of the weight of potato are found in the peel which can be used as an alternative cattle feed due to its natural source of energy and fiber. Therefore, the potential of potato peel being used as alternative food source for animals is very high[32].

3. CONCLUSION

Potato (*Solanum tuberosum*) is an annual herbaceous, self-pollinated species, belongs to family Solanaceae and the genus Solanum. Potato peels are considered as waste in many households and in the industries. There is an increase in growth production and consumption of potato per year and therefore the annual increase in potato peel waste is also

observed. The problem of management of potato peels' waste cause considerable concern to the potato industries in worldwide. However, the peels contain an array of nutritionally beneficial compounds, and therefore it can be utilized in many ways. For an economic boost of developing countries, proper utilization of agriculture wastes is a must to elevate the economic position and decrease poverty. In this regard, potato peel waste can be utilized for numerous beneficial activities such as bio-hydrogen; biogas and bio-fertilizer which serve as a base for developing linkages among industry and sharing new ideas, technologies and future trails for sustainable economic growth.

4. REFERENCES

1. de Haan S, Rodriguez F. Potato origin and production. In: Advances in potato chemistry and technology. Academic Press, 2016: 1-32.
2. Knapp S, Jarvis CE. The typification of the names of New World Solanum species described by Linnaeus. Botanical Journal of the Linnean Society 1990; 104(4):325-67.
3. Reddy BJ, Mandal R, Chakroborty M, Hijam L, Dutta P. A review on potato (Solanum tuberosum L.) and its genetic diversity. International Journal of Genetics; 2018:0975-2862.
4. Gosden C, Hather JG. Food processing technology: its role in inhibiting or promoting change in staple foods. In: The Prehistory of Food. Routledge, 2004: 145-154.
5. Thamburaj S, Narendra S. Text book of vegetables, tubers and spices. New Delhi: Indian Council of Agriculture Research; 2016: 320-341.
6. Jeddou KB, Chaari F, Maktouf S, Nouri-Ellouz O, Helbert CB, Ghorbel RE. Structural, functional, and antioxidant properties of water-soluble polysaccharides from potatoes peels. Food Chemistry. 2016: 97-105.
7. Camire ME, Violette D, Dougherty MP, McLaughlin MA. Potato peel dietary fiber composition: effects of peeling and extrusion cooking processes. Journal of Agricultural and Food Chemistry; 1997; 45(4): 1404-1408.
8. Arapoglou D, Varzakas T, Vlyssides A, Israilides CJ. Ethanol production from potato peel waste (PPW). Waste Management. 2010; 30(10): 1898-902.
9. Maldonado AF, Mudge E, Gänzle MG, Schieber A. Extraction and fractionation of phenolic acids and glycoalkaloids from potato peels using acidified water/ethanol-based solvents. Food Research International; 2014; 65: 27-34.
10. Liang S, McDonald AG. Chemical and thermal characterization of potato peel waste and its fermentation residue as potential resources for biofuel and bioproducts production. Journal of agricultural and food chemistry; 2014; 62(33): 8421-8429.
11. Liang S, McDonald AG, Coats ER. Lactic acid production with undefined mixed culture fermentation of potato peel waste. Waste management; 2014; 34(11): 2022-2027.
12. Onyeneho SN, Hettiarachchy NS. Antioxidant activity, fatty acids and phenolic acids compositions of potato peels. Journal of the Science of Food and Agriculture; 1993; 62(4): 345-50.
13. Sepelev I, Galoburda R. Industrial potato peel waste application in food production: a review. Res Rural Dev; 2015; 1: 130-136.
14. Camire ME, Violette D, Dougherty MP, McLaughlin MA. Potato peel dietary fiber composition: effects of peeling and extrusion cooking processes. Journal of Agricultural and Food Chemistry; 1997; 45(4): 1404-1408.
15. Camire ME, Zhao J, Violette DA. In vitro binding of bile acids by extruded potato peels. Journal of Agricultural and Food Chemistry; 1993; 41(12): 2391-2394.
16. Ballesteros MN, Cabrera RM, Saucedo MS, Yepiz-Plascencia GM, Ortega MI, Valencia ME. Dietary fiber and lifestyle influence serum lipids in free living adult men. Journal of the American College of Nutrition; 2001; 20(6): 649-655.
17. Lazarov K, Werman MJ. Hypocholesterolaemic effect of potato peels as a dietary fibre source. Medical science research; 1996; 24(9): 581-582.
18. Erkkilä AT, Lichtenstein AH. Fiber and cardiovascular disease risk: how strong is the evidence?. Journal of Cardiovascular Nursing; 2006; 21(1): 3-8.
19. Camire ME, Zhao J, Dougherty MP, Bushway RJ. In vitro binding of benzo [a] pyrene by extruded potato peels. Journal of Agricultural and Food Chemistry; 1995; 43(4): 970-973.
20. Kyzas GZ, Deliyanni EA. Modified activated carbons from potato peels as green environmental-friendly adsorbents for the treatment of pharmaceutical effluents. Chemical Engineering Research and Design; 2015; 97: 135-44.
21. Abd-El-Magied MM. Effect of dietary fibre of potato peel on the rheological and organoleptic characteristics of biscuits. Egyptian Journal of Food Science; 1991: 1-5.
22. Al-Weshahy A, Rao VA. Potato peel as a source of important phytochemical antioxidant nutraceuticals and their role in human health-A review. IntechOpen; 2012; 1-4.
23. Schieber A, Saldaña MD. Potato peels: a source of nutritionally and pharmacologically interesting compounds-a review. Food; 2008; 3(Special Issue 2): 23-29.
24. Fu BR, Sun Y, Wang YX. Construction of biogas fermentation system based on feedstock of potato residue. J Northeast Agric Univ. 2013; 44: 102-106.
25. Sanaei-Moghadam A, Abbaspour-Fard MH, Aghel H, Aghkhani MH, Abedini-Torghabeh J. Enhancement of

biogas production by co-digestion of potato pulp with cow manure in a CSTR system. Applied biochemistry and biotechnology. 2014; 173(7): 1858-1869.
26. Muhondwa JP, Martienssen M, Burkhardt M. Feasibility of Anaerobic Digestion of Potato peels for Biogas as Mitigation of Greenhouse gases Emission Potential. International Journal of Environmental Research; 2015; 9(2).
27. Liang S, Han Y, Wei L, McDonald AG. Production and characterization of bio-oil and bio-char from pyrolysis of potato peel wastes. Biomass Conversion and Biorefinery. 20151; 5(3): 237-246.
28. da Silva Batista M, Guimarães CO, Marra LC, Maloncy ML. Bio-oil production from waste potato peel and rice hush. RevistaEletrônicaemGestão, Educação e Tecnologia Ambiental. 2015; 19(1): 220-227.
29. Liang S, McDonald AG. Chemical and thermal characterization of potato peel waste and its fermentation residue as potential resources for biofuel and bioproducts production. Journal of agricultural and food chemistry; 2014; 62(33): 8421-8429.
30. Panagiotopoulos IA, Karaoglanoglou LS, Koullas DP, Bakker RR, Claassen PA, Koukios EG. Technical suitability mapping of feedstocks for biological hydrogen production. Journal of Cleaner Production. 2015; 102: 521-528.
31. Subrahmanyam M. Treating Minor Burns with Potato Peel Dressings. Journal of Basic and Clinical Research; 2017; 4(1): 16.
32. Ncobela CN, Kanengoni AT, Hlatini VA, Thomas RS, Chimonyo M. A review of the utility of potato by-products as a feed resource for smallholder pig production. Animal Feed Science and Technology; 2017; 227: 107-117.

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