REVIEW PAPER

Utilisation of coniferous non-wood tree biomass – short history

Māris Daugavietis*, Ilona Vanaga and Uģis Klētnieks

Latvian State Forest Research Institute "Silava", Rigas Str. 111, Salaspils, Salaspils nov., LV-2169 Latvia*

SIA "Silv EXPO", Alberta Str. 12-2, Riga, LV-1010, Latvia

Abstract

The article contains information on the use of conifer tree foliage and its development starting from the 50s of the 20th century and until today. Brief information about the pertinent research works and the main tree foliage use directions is given. A thesis is submitted that the foliage use can become an essential part of the forest sector's further development and also a raw material base for the acquisition of biologically active products for other sectors of economy as well.

Key words: Tree foliage utilization, biologically active substances, coniferous foliage products.

Introduction

The forest is so much more than just timber. The growing demand for plant origin organic raw materials is the driving force for research in the area of the complete utilisation of plant biomass, including the non-wood biomass.

According to the FAO definition (Wong et al. 2011) the non-wood tree products (NWP) are goods of biological origin other than wood - derived from forests, other wooden lands and trees outside forests. The main types of NWP in forest ecosystems are the tree foliage and bark, the usage of which is very low. From the viewpoint of biomass studies the tree foliage (TF) accounts for 30-50% of the tree's crown biomass (comprises needles, buds and young non-lignified shoots). With the mechanised TF harvesting we are able to get a product known as commercial tree foliage (CTF), containing no more than 20% of other tree biomass components – bark, wood and other organic admixtures (lichens, seeds etc.) and not more than 0.2% inorganic admixtures.

In felling residues for each prepared wood stem (m^3) there are up to 100-120 kg Norway spruce tree foliage (FTF) left. In various studies the TF has been evaluated by the chemical composition as well as for the possibilities of its use as a biologically active compound in feed, food, pharmaceutical, cosmetics, household chemicals and plant protection products.

Products for organic agriculture

In this article, based on relevant publications and the authors' experience, a brief overview of the CTF use, development, current situation and outlook is provided.

The fact that most of the wild animals' - elk, deer, grouse - feed base is coniferous non-wood biomass gave scientists the idea to examine the use of CTF for domesticated animal feed.

Research on the chemical composition of coniferous trees shows that 1 kg of dry matter of spruce needles contains up to 4000 IU's of vitamin C, up to 600 mg of beta-carotene (provitamin A), around 920 – 2600 mg of flavonoids and up to 560 mg vitamin E in the form of alpha-tocoferol (Valdman 1955).

Apart from vitamins needles also contain chlorophyll, free amino acids, fatty acids, sterols, including beta-sitosterol, sugars, micro- and macroelements, as well as other substances necessary for animal feed (Kalninsh et al. 1978).

The literature indicates that the TF feed also contains some undesirable components - tannins, resin acids, large amounts of lignin, which restricts the use of TF mainly in bird and pig feeding (Kalninsh et al. 1978).

In the 50s - 60s of the previous century in Latvia the technology was developed and accordingly in the 1955 the first needle vitamin meal plant with a production capacity of 45 tonnes of product per year was established (Kalninsh et al. 1978).

Needle vitamin meal use efficiency was equivalent to grass meal use and production in the late 80's in the Soviet Union amounted to 190,000 tons per year (Kalninsh et al. 1978).

In the beginning of the 90s the rapidly rising price of fuel interrupted the fodder preservation by artificially drying plant biomass, including the coniferous meal production.

In parallel with the vitamin meal production technology in 1955 Leningrad (St. Petersburg) a TF extractive technology was also developed, which in turn resulted in the first Latvian extractive factory. The main product was chlorophyll - carotene paste (HKP), which was widely used as a feed ingredient in the amount of 0.3-0.4% from the animal feed base. HKP efficacy has been substantiated by extensive laboratory trials and in production conditions (Ebele et al. 1954, Solodkiy et al. 1969, Solodky et al. 1971, Fisher 1971).

The studies go on to develop a resin acid-free forage component on the base of the coniferous extractives (Daugavietis et al. 2012).

A certain period in the research area of animal feed from processed needle products ended in 2013 with the defence of a related doctoral thesis in economics, confirming the use efficiency of the coniferous extractives (Cerina 2013).

Another type of agriculture-related studies on the use of tree foliage are plant protection products; some of these products perform in accordance with the hypothesis that the transfer of plant biomass components from one plant species to another - genetically distinct plant species, makes monophagous pests lose the ability to distinguish between host plants and thusly prevents damage to the host. The efficiency of this method increases with the variety of plant ecosystems, which take part in the transfer of substances between different plants. According to this hypothesis on the coniferous resin base an environmentally friendly herbal plant protection product „Fitoekols" has been developed and has been successfully used in the fight against fungal diseases and putrefaction type pests (Daugavietis et al. 2000).

Development of products and technologies

Studies on the TF use and processing technologies developed especially rapidly in the 70s-80s of the last century. Several books were published (Tomchuk et al. 1976, Kalninsh et al. 1978, Yagodin 1981, Anon 1983).

Number of publications in the 70s amounted to 70 and in the 80s – to 80 articles. A number of doctoral dissertation were defended, which contributed significantly to the development of the future research, such as Vasiljeva S.M. work on the processing technologies of neutral substances (Vasilyev 1989); technologies for mechanised harvesting of the TF also developed (Kevinsh et al. 1983).

In the 1986 IUFRO (International Union of Forest Research Organisations) world congress a new structural group was incorporated into the project "Harvesting and utilisation of tree foliage", whose coordinator was the first author of this review.

In the 80s a technology for extraction of the specific TF substances and their applications were developed. In the 1989 IUFRO oraganized project team P305-00 conference in Riga a number of reports were devoted to the medicinal properties of the extractives (Bluger at al. 1989, Zhilevic et al. 1989).

In the 80s former Soviet Union several groups of scientists actively working on TF use issues were formed.

Leningrad (St. Petersburg) Forest Technical Academy developed a research direction established by prof. Solodkija students - Agranat H.L., Jagodin V.I., Roschin V.I. and others (Solodkiy et al. 1971, Antonov 1983, Roschin et al. 1986).

In Riga on the basis of the Forestry Research Institute "Silava" a workgroup lead by prof. Ievinsh including M. Daugavietis, J. Kevinsh, O. Polis, etc. carried out research on the tree foliage processing as well (Kevinsh et al. 1980, Kevinsh et al. 1983)

In the 60s-80s of the 20th century research on tree biomass resources and their utilisation was carried out in many countries: Finland, USA, Canada, Slovakia, China (Hakkila 1971, Young 1973, Keays 1975, Yagodin 1981, Ilavsky 1989, Weichun 1981, Weichun 1989, Daugavietis et al. 2000).

Krasnoyarsk research group managed by prof. Levins E.D. and Repjahs S.M. was focusing on Sibirian tree species (Repyah et al. 1977, Karepova et al. 1979).

In the 90s the main research direction was the biologically active compounds of TF: utilisation possibilities (Kuznetsovs et al. 1991, Kuznetsovs et al. 1993, Kuznetsovs et al. 1994, Kuznetsovs et al. 1995) and formulation development.

According to the available literature data currently full foliage extractive mining and processing cycle with the acquisition of the pure extractives is carried out by the company "Solagran", which has registered coniferous polyprenols with the Russian pharmacopoeia as "Ropren" - a hepatoprotector (‘Anon’ last viewed online 08.06.2015.)

Latvian polyprenols as dietary supplements are registered by JSC "Biolat". Latvian experience shows that using accumulated expertise and technologies developed for the TF processing is economically viable and processing 1 ton of foliage can yield production goods worth 1200 to 1300 EUR (Daugavietis 2013).

Though some research has been done in the area of coniferous foliage products, extensive and continuous research is still neccessary. Currently with the co-finansing of the European Regional Development Fund one project: “Num. 1.7: Fir needles' isoprene alcohol effects on the mevalonic acid metabolism and production of dolichols, as well as the research of Norway spruce needles isoprene alcohols' biological activity" has been successfully completed; another project “Num. P29: The conifer isoprene alcohol biological activity studies in pathology models" is currently being carried out”. For the active compounds such as “isoabienol” and “epimanool” and also Sodium chlorophyllin, which are derived from the TF, in the recent years potential anticancer activity *in vitro* has been investigated (Ferruzzi et al. 2007).

Summary

A wide range of study materials for the chemical composition of the most important coniferous tree foliage of the Northeastern region and Siberia has been accumulated; fragmentary information about the chemical composition of conifers in other regions is also available. All the research shows that conifer TF contains virtually all organic compounds necessary for human and animal survival.

Technology for the acquisition of valuable biologically active compounds and products such as animal feed, food, pharmaceutical, cosmetics and plant protection has been developed.

Unfortunately, high-quality, ecologically pure TF use is fragmentary and in small amounts.

The availability of raw material resources and biologically active natural substances, as well as the unsaturated market offers tremendous opportunities to develop economically efficient production in rural areas on environment-friendly technologies and clean raw material forest bases.

Taking into consideration that in many countries people refer to their forests as the green gold, we will assume that the tree foliage is the green gold of the green gold and the basis for the further development of the industry.

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