

Characterization of White Lupin Seed Coats

Jada Shaw¹ & Harbans L. Bhardwaj¹

¹ Agricultural Research Station, Virginia State University, Petersburg, VA, USA

Correspondence: Harbans L. Bhardwaj, Agricultural Research Station, Virginia State University, Petersburg, Virginia 23806, USA. Tel: 1-804-524-6723. Fax: 1-804-524-5950. E-mail: hbhardwaj@vsu.edu

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Abstract

White lupin (*Lupinus albus* L.), a winter legume crop with tremendous potential as a food crop, has been evaluated at Virginia State University for several years. This effort has developed several winter-hardy, high-yielding lines, which vary in alkaloid concentration in the seeds. Current study was conducted to characterize various component of lupin seed especially seed coat and cotyledon portion in seeds of five lupin lines (VSU-1, VSU-1X, VSU-5, VSU-10, and VSU-101). Five hundred seeds of each line were separated into seed coats and cotyledons to record relative proportions. Whole seeds, seed coats, and cotyledons were analyzed to determine concentrations of protein, fiber, fat, iron and zinc. Significant differences were observed among five lines for seed coat proportion, which varied from 22.6 to 25.6 percent. Proportions of protein (7.8, 41.6, and 34.3 percent), fiber (44.7, 1.0, and 12.2 percent), fat (1.3, 10.4, and 8.6 percent), and zinc (14.5, 61.9, and 50.8 percent) concentrations varied significantly for seed coats, cotyledons, and whole seed, respectively but not for iron concentration. Results of this study indicate that separation of seed coats from white lupin seed could be used to develop value-added products; to increase nutritional quality of white lupin seeds; and enhance white lupin's suitability as a plant protein source.

Keywords: *Lupinus albus* L., seed composition, cotyledon composition, seed coat composition

1. Introduction

1.1 Problem

Pulses are historically important in both the human diet and cropping systems as crop rotations, due to their rich-protein and biological nitrogen fixation ability. Although most pulses are not traditionally typical Western-style foodstuffs, they are being promoted to be important human food world widely (Foyer et al., 2016; Zhong et al., 2018). White lupin (*Lupinus albus* L.) is one of the six most important pulses on a global basis (FAOSTAT, 2018; Zhong et al., 2018). Seeds of most pulses have 8-16% seed coat, 1-3% embryonic axe, and 80-90% cotyledons (Duenas et al., 2006); however, the proportions of seed coat differ based on genetic and environmental factors (Zhong et al., 2018). Even though, white lupin has been studied in Virginia for several years, information about its seed coats is unknown.

1.2 Justification

Seed coats are, generally, known to contain considerable amount of dietary fiber, which has antioxidant and anti-inflammatory properties in human nutrition (Zhong et al., 2018). Previous studies have indicated that seed coats account for different contents of seed dry weight in lupin: 18% in *L. albus*, 24% in *L. angustifolius*, 25% in *L. luteus*, and 13% in *L. mutabilis* (Cowling et al., 1998). Seed coat proportion in two most important lupin species (*albus* and *angustifolius*) has been observed to be greater than other (Zhong et al., 2018) pulses such as field pea (7.2-14.0%), faba bean (11.0-15.4%), chickpea 10.1-22.0% for *desi* type, and 4.5-9.5% for *kabuli* type), lentil (7.0-11.0%), and mungbean (8.6-23.5). However, composition and other traits of seed coats of white lupin are unavailable. Since seed coats are in integral part of the seed relative to germination and food value, it is important to understand seed coat characteristics of white lupin seed produced in Virginia.

1.3 Background

White lupin has been researched in Virginia for several years. The New Crops Program of Virginia State University (Harbans Bhardwaj as Principal Investigator) started lupin evaluations in 1998 with 79 lines/varieties of white lupin; over the years, the total genetic material tested has included about 400 white lupin lines/varieties.

A first report about white lupin seed produced in Virginia was published about 25 years ago (Bhardwaj, Hamama, & Merrick, 1998). Several field experiments were conducted in the last 25+ years at Randolph Farm of Virginia State University (Petersburg, Virginia, USA). These studies supported development of winter hardy, high-yielding varieties that are suitable for production in Virginia and adjoining areas. However, information about seed coats of seeds of these lines is not available. Therefore, objective of this study was to characterize seed coat proportion in winter-hardy white lupin lines, determine their chemical composition, and compare nutritional quality of white lupin seed coats to that of other pulses.

2. Methods

2.1 Plant Material

Seeds from five white lupin lines (VSU-1, VSU-1X, VSU-5, VSU-10, and VSU-101) were used in this study. These five lines were selected from ten white lupin breeding lines that were grown in the field at Randolph Farm of Virginia State University during 2020-2021 crop season. The main criterions for selection were winter-hardiness and seed productivity.

2.2 Experimental Details

The plots consisting of four 3-meter long rows spaced 37.5 cm apart, were planted on September 29, 2020 using a Randomized Complete Block Design with three replications. Each row was planted with about 100 seeds. Experimental area received a preplant incorporated treatment of Trifluralin herbicide at the rate of 1 L·ha⁻¹. The plots were manually weeded once. The plots were harvested on June 22-24, 2021 with a research combine (Almaco, 99 M Ave., Nevada, IA 50201). Upon harvest, seeds were weighed to record yield and other data.

2.3 Analytical Details

Seeds from five white lupin lines with winter-hardiness and highest seed yields (VSU-1, VSU-1X, VSU-5, VSU-10, and VSU-101) were used to determine seed coat characteristics. Five hundred seeds of each line were manually separated into seed coats and cotyledons (by gently cracking individual seeds with a small hammer and pulling the seed coats away from cotyledons) to record relative proportions. Mineral concentrations, including nitrogen (N), in whole seeds, seed coats, and cotyledons were analyzed by a commercial laboratory (Waypoint Analytical Laboratory, Richmond, Virginia, USA) according to AOAC methods (AOAC, 2016). Total protein concentrations were calculated by multiplying N content with protein factor 6.25.

2.4 Statistical Analysis

All data were analyzed using SAS (2014) using 5% level of significance.

3. Results

3.1 Proportions of Seed Coats in Winter-Hardy White Lupin Seed Produced in Virginia

Results indicated that white lupin seeds averaged 24.3% seed coat (Table 1). Seed coat proportions in the five lines included in this study were not statistically different: 25.6, 25.6, 23.8, 22.6, and 23.9 respectively for VSU-1, VSU-1X, VSU-5, VSU-10, and VSU-101 (Table 1).

Table 1. Comparisons of seed coat proportions in White lupin and other legume crops

Crop	Seed coat (%)
White lupin (<i>Lupinus albus</i> L.) ^x	24.3
Chickpea <i>desi</i> ^y	10.1-22.0
Chickpea <i>kabuli</i> ^y	4.5-9.5
Faba bean ^y	11.0-15.4
Field pea ^y	7.2-14.0
Lentil ^y	7.0-11.0
Mungbean [<i>Vigna radiata</i> (L.) R. Wilczek] ^y	8.6-23.5

Note. x: Values from the current study.

y: Zhong et al. (2018).

3.2 Composition of Seed Coats in Winter-Hardy White Lupin Seed Produced in Virginia

Composition of white lupin seed differed significantly for whole seed, cotyledons, and seed coats except for concentrations of Fe and Mn (Table 2). Seed coats contained significantly more fiber than whole seeds (3.7 times) and cotyledons (45%). Whole seeds and cotyledons contained significantly more protein than seed coats (3 and 5 times more, respectively) and fat (6.6 and 8 times, respectively).

Table 2. Composition of whole seeds, cotyledons, and seed coats (Means over five white lupin grown in Virginia during 2020-21)

	Whole seed	Cotyledons	Seed coats
Protein (%)	24.3 b ^x	41.6 a	7.8 c
Fat (%)	8.6 b	10.4 a	1.3 c
Fiber (%)	12.2 b	1.0 c	44.7 a
Ca (%)	0.2 b	0.18 c	0.59 a
P (%)	0.46 a	0.56 a	0.13 b
K (%)	1.22 a	1.29 a	0.79 b
Mg (%)	0.17 a	0.18 a	0.10 b
S (%)	0.27 b	0.33 a	0.08 c
Cu (ppm)	7.10 a	8.32 a	2.85 b
Fe (ppm)	42.2 a	40.9 a	52.0 a
Mn (ppm)	1130 a	1337 a	271 a
Zn (ppm)	50.8 b	61.9 a	14.5 c

Note. x: Means followed by similar letters within columns were not statistically different at 5% level. Proportions of seed coats among five lupin lines were not statistically different.

A comparison of composition of seed coats of white lupin, bean, and soybean is presented in Table 3. Seed coats of white lupin had considerably higher protein concentration as compared to that of bean and soybean. Concentration of Fe was greater in white lupin seed coats than soybean seed coats but lower than that in bean seed coats whereas concentration of Zn in white lupin seed coats was approximately equal to that in soybean seed coats but almost double than that in bean seed coats.

Table 3. Composition of seed coats of white lupin, bean, and soybean

	White lupin	Bean (<i>Phaseolus vulgaris</i> L.) ^x	Soybean (<i>Glycine max</i> L. Merr.) ^z
Protein %	41.6	14.3	12.19
Fat %	10.4	0.89	21.0
Fiber %	44.7	12.0	9.3
P %	0.13	0.73	0.09
K %	0.79	1.27	1.30
Ca %	0.59	1.99	0.56
Mg %	0.10	0.98	0.26
Cu ppm	2.85	0.98	9.8
Fe ppm	40.9	69.8	38.2
Zn ppm	61.9	32.4	68.0

Note. x: Mullin, W.J. and W. Xu. 2001.

z: Ribeiro, et al., 2012.

4. Discussion

The average proportion of seed coat in white lupin is greater than that reported from Australia (Cowling, Huyghe, & Swiecicki, 1998)—18% for white lupin and 13% for yellow lupin but smaller than 25% for narrow-leaf lupin. We expect that a greater variation for seed coat proportion in white lupin seed would be available if the material

consisted of seeds from more than five lines. White lupin seed coat proportion was greater than several other pulses such as chickpea, faba bean, field pea, lentil, and mungbean.

Our results indicate that white lupin cotyledons can be a better source of plant proteins as compared to whole seeds to satisfy increased demand for plant proteins (CSIRO, 2022). Most plant proteins are currently derived from soybean and yellow pea, two plants with considerably lower protein as compared to white lupin cotyledons. Use of white lupin cotyledons as a protein source will result in considerable production of fiber for use in various health related products. Concentrations of most components were greater in either whole seeds or cotyledons in comparisons to seed coats.

Seed coats contain a wide assortment of novel compounds. Upon water imbibition, a complex mixture of chemicals is released from the seed coat. These chemicals may consist of flavonoids, proteins, peptides, amino acids, alkaloids, terpenoids, steroids, etc. (Moise et al., 2005). There are indications that seed coat consumption may benefit cardiovascular and gastrointestinal markers in humans (Zhong et al., 2018) due to multiple mechanisms caused by the high dietary fiber in the seed coat. White lupin in our study contained highest proportion of fiber in its seed coat (44.7%) as compared to 9.3 % in soybean seed coats and 12 % in bean seed coats. We did not study health issues related to chemical composition of white lupin seeds but suggest that white lupin seed coats may have considerable positive value in human nutrition. On the other hand, such a high proportion of fiber in seed coats of white lupin may also have some disadvantages for whole seed consumption.

Based on our results, white lupin can be developed as a source of fiber, which can be used to add value to meats as indicated by Verma et al. (2012, 2015); high concentration of fiber in white lupin seed coat may be desirable as an economical source of fiber. This use could also help with white lupin's use as a food and feed given its' high concentration of protein.

5. Conclusions

Results of this study indicate that separation of seed coats from white lupin seed could be used to develop value-added products; to increase nutritional quality of white lupin seeds; and enhance white lupin's suitability as a plant protein source.

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Disclaimer

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