Biotechnology Journal International

19(3): 1-5, 2017; Article no.BJI.35210
ISSN: 2456-7051
(Past name: British Biotechnology Journal, Past ISSN: 2231–2927, NLM ID: 101616695)

Impact of High Glycine Tyrosine KAP Genes on Cashmere Fibre Trait Characteristics

Aadil Ayaz[1,2*], Zaffar Iqbal[2], Basharat Ahmad[2], Nazir Ahmad Ganai[2], N. Singh[1], Aarif Ali[3], Tajamul Mumtaz[4], Mashooq Ahmad Dar[3], Mir Shabir[2], Syed Shanaz[2] and Suheel Yousuf Wani[2]

[1]Department of Zoology and Biotechnology, HNBG University, Srinagar, Uttarakhand-246174, India.
[2]Division of Animal Genetics and Breeding, FV.Sc. & A.H. SKUAST, Kashmir-190006, India.
[3]Department of Biochemistry, University of Kashmir, Kashmir -190006, India.
[4]Department of Biochemistry, Jaipur National University, Rajasthan-302017, India.

Authors' contributions

This work was carried out in collaboration between all authors. Author Aadil Ayaz drafted the manuscript. Authors NAG and NS overall coordinated the project. Authors ZI, BA, Aarif Ali, TM, MAD and MS helped in writing and data collection. Authors SS and SYW helped in proof reading of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJI/2017/35210
Editor(s):
(1) Ghousia Begum, Toxicology Unit, Biology Division, Indian Institute of Chemical Technology, Hyderabad, India.
(2) Kuo-Kau Lee, Department of Aquaculture, National Taiwan Ocean University, Taiwan.
Reviewers:
(1) R. Bharathesree, Tamil Nadu Veterinary and Animal Sciences University, India.
(2) Zeliha Selamoglu, Nigde Ömer Halisdemir University, Turkey.
(3) Sabri Gül, Mustafa Kemal University, Turkey.
(4) Tamer Çağlayan, Selcuk University, Turkey.
Complete Peer review History: http://www.sciencedomain.org/review-history/20639

Mini-review Article

Received 30th June 2017
Accepted 31st July 2017
Published 24th August 2017

ABSTRACT

Cashmere goat (*Capra hircus*) represents a world renowned goat famous for production of superfine downfibre "Cashmere". The worldwide total production of cashmere fibre is about 10000-15000 tonnes per annum. Among all the fibres cashmere is the finest fibre of animal origin, produced in fairly large quantity in the world derived from goat breed indigenous to Asia. The physical properties of cashmere fibres can be attributed to proteins from Keratin family which are primary constituents of the fibre. Keratin proteins (KP) and keratin-associated proteins (KAPs) constitute about 90% of cashmere fibre, the said proteins are encoded by the keratin family genes.

**Corresponding author: E-mail: aadil_molecular@rediffmail.com;*

Keratin-associated protein is one of the major structural proteins of the fibre, whose percentage in fibre has significant effect on its quality. Summing up, the evidence presented in past studies indicated that in the formation of cashmere fibre, there is important role of HGTKAPs in fineness of the fibre. This review summarises the information regarding keratin and keratin associated proteins in a national and international research programme designed to identify and utilize KAP genes of importance in the fibre quality.

Keywords: Cashmere goat; cashmere; KAP; HGTKAP; fibre fineness; KIF.

1. INTRODUCTION

Cashmere, the world's most costly natural fibre, locally known as Pashmina is produced from cashmere goat (*Capra hircus*) as a superfine downfibre, from its secondary hair follicles. There are about 68 breeds of goats from 12 different countries that produce cashmere fibre. Changthangi goats raised in the Ladakh region of India produce Pashmina, which is internationally known as "cashmere" is a fine, lustrous and softest fibre of domestic animal origin [1]. Pashmina producing goats in world have remarkable reputation for uplifting the economy. The Chanthangi breed produces world famous "Pashmina" as super fine fibre. Superfine non-medullated cashmere fibre (mean diameter of 11-18 microns) is produced from the specialized structure of a secondary hair follicle with the outer medullated guard hair (mean diameter of 50-150 microns). The hair of almost all of the single coated species (sheep and non-cashmere goat breeds viz, Bhakerwaal, Boer, Jamunapuri, Beetal etc.) being derived from primary follicle. Primary hair follicles are larger in size and are associated with secondary structures viz, sweat glands, sudoriparous glands and arrector pili muscles. Secondary hair follicles are much smaller in size and are devoid of these associated structures. The physical properties of cashmere and other hair fibres can be attributed to proteins from Keratin family which are primary constituents of the fibre [2]. Keratins and Keratin associated proteins (KAPs) are a large heterogeneous group of proteins comprising about 90% of the fibre [3]. Type 1 and type 2 keratins form micro fibrils of the wool fibre, the microfibrils are embedded in a matrix formed by KAPs and consist of Keratin intermediate filaments (KIF). KAPs are the major component of the matrix between KIF are thought to form the rigid hair shaft through a cross linked network with KIF. The KAP are classified into three major groups on the basis of their protein sequences, (i) the high sulphur group (16-30% cysteine content), (ii) the ultra-high sulphur group (>30%cysteine content) and (iii) the high glycine tyrosine group which significantly varies within and between the species [4].

2. KERATIN ASSOCIATED PROTEIN GENES

Keratin Associated Protein are encoded by a large number of multigene families, till date more than 100 KAP genes have been isolated from human and other mammalian species and more than 50 genes have been found to encode keratin proteins. The variation in the family of these genes in cashmere goats play an key role in defining different properties of cashmere fibre quality (fineness, lustre, warmth, curvature) and production of fibre. The keratin proteins are found in two places in wool, namely the cuticle and the cortex, as in the cortex they are in microfibrils which are in turn embedded in a matrix of KAPs. The keratin proteins belong to either of two types, keratin type I (K31-40) or keratin type II (K81-87), which are coded by multi-gene families [5].

There are three major groups of KAPs which are categorized on the basis of primary protein structures namely high glycine-tyrosine KAPs which are encoded by KAP6.n, KAP7 and KAP8 genes, the high sulphur KAPs coded by the KAP1.n, KAP2.n and KAP3.n multi-gene families, KRTAP4.n and KRTAP5.n gene families specify the ultra-high sulphur KAPs [3].

3. ROLE OF KAP GENES

Keratins and keratin-associated proteins (KAPs) are the main structural components of the hair and wool fibres. The extensive disulfide bonding link keratin intermediate filaments (KIFs) with KAPs, located in the matrix [4,6]. The effect of KAP on the assembly of keratins into KIFs is considered to be very crucial as it affect specific attributes of hair and wool fibres (strength, inertness, and rigidity) [7]. KAPs are composed of either a high cysteine or glycine, tyrosine content. Across the range of species, 27 families of KAPs have been found. KAP1-3, KAP10-16, and KAP23-27 are high-sulphur families (HS-KAPs) and possess less than 30 mol% cysteine. KAP4, KAP5, KAP9, and KAP 17 are ultra-high-sulphur families (UHS-KAPs), and they possess greater than 30mol% cysteine. KAP6-8 and KAP18-22 are high- glycine-tyrosine families (HGT-KAPs) [8]. The KAPs are encoded by a large number of multi-gene families, which appear to be organized into domains and generally contain a single exon. Polymorphism in the caprine KAP13-1 gene has profound effect on some fibre traits [9].

4. HIGH GLYCINE TYROSINE KERATIN ASSOCIATED PROTEIN GENES

The high glycine–tyrosine (HGT) KAPs are the smallest of wool keratins which are encoded by KAP6, KAP7 and KAP8 gene families, which are intron less of 0.6-1.5 kb in size [10], whose expression differs to a great extent in cashmere goat of different species [5]. KAP6 is encoded by a multigene family whereas KAP7 and KAP8 are each coded by a single gene, [11]. Past studies showed that the polymorphism of KAP 6, KAP7 and KAP8 genes in different species attributes to the variation in physiochemical properties of fibre [12].

5. HIGH GLYCINE-TYROSINE KERATIN ASSOCIATED PROTEIN GENES AND FIBRE FINENESS

The understanding of the expression mechanisms of these genes are a key in understanding the cashmere production at molecular level. There is a significant variation of high glycine-tyrosine (HGT) proteins in fibre both within and between species ranging from 1% to 12% in sheep wool, 18% in mouse hair to more than 30% in echidna quill [13]. The broad range in the content of high glycine tyrosine proteins in fibre raises fascinating questions concerning the regulation and function of these proteins in the matrix structure of the fibre. The variation in KAPs is due to a variety of genetic, nutritional and physiological factors [13].

5.1 KAP6 Gene

KAP6 is a member of high glycine-tyrosine KAP and contain multiple-family members. Till date, five different ovine KAP6 sequences were detected, and these sequences were divided into three groups: KAP6-1, KAP6-2, and KAP6-3 [8]. KAP6.1 is an important gene from group of high glycine /tyrosine which are smallest among the keratin proteins having single exon of less than 1000bp and is located in the type II keratin gene cluster on sheep chromosome 1 [14]. These proteins are rich in glycine, tyrosine, serine, and phenylalanine. The HGT KAP varies in abundance from less than 3% in human hair and Lincoln sheep wool to 13% in Merino wool and up to 30% in Echidna quill. Genetic variations in wool keratin and keratin associated proteins (KAP) are responsible in the variation of wool and fibre in different species/breeds [4,12,15].

KAP 6.2 is significant member of high glycine/tyrosine and being the smallest among the keratin proteins, most having molecular weight below 10,000. The KAP6 gene is known to be a complicated and shows high polymorphism in family of sheep HGTPs as numerous protein spots were separated from total glycine/tyrosine-rich HGTPs using auto-radio graphs of two-dimensional polyacrylamide gels [16]. Subsequently, Northern blot analysis showed that more than one member of the KAP6 family was expressed in sheep skin [17]. Therefore, it was suggested that the proportions and spatial arrangement of orthocortical and paracortical fibers, which are believed to be highly relevant to the crimps and curls of wool fibre, are the two major types of cortical keratinocytes [16]. The results of an in situ hybridization study suggested that the KAP6 gene family was expressed in cells of the hair shaft cortex after transcription of the hair keratin intermediate filament gene [3]. KAP6 family genes might play a domineering role in determining wool trait characteristics, such as diameter and crimps, as indicated by their spatial and timely arrangement and their expression pattern.

5.2 KAP 7

Another variant of HGT gene KAP7.1 which is involved in the development of hornification and inner root sheath (IRS) of villi hence is the structural components of cortex and inner root sheath. KAP plays an important role in determining the cashmere growth and quality. Expression signals of KAP7.1 also appears from the matrix which reflects that KAP 7.1 is the important component of matrix of second hair follicles, moreover, has significant effect on the growth and development of cashmere. Studies have shown that expression pattern of KAP7.1 gene is identical in the cashmere goat and in human, sheep and rabbits, which predominantly expressed in the cortex but the difference, is that KAP7.1 in IRS of primary and secondary follicle is also expressed. This could be a possible reason for different cashmere quality in the different species [18-20].

5.3 KAP 8

KAP8 is member of HGT family, genes coding for HGT proteins and are located on chromosome 21q22.1 in humans [21]. The KAP 8 gene has been mapped to ovine chromosome 1 [22]. The keratin-associated protein 8.2 (KAP8.2) is one among two members of the HGTKAP8 proteins that belong to one of the three classes of KAP proteins [23]. The KAP8.2 gene has a coding sequence of 192bp, which lacks introns and mainly is expressed in the wool follicle cortex. KAP 8.2 shows specific expression in hair follicles and expresses differentially in primary and secondary hair follicles of Liaoning cashmere goat but the expression is significantly higher in secondary hair follicles [18]. It has been reported that allelic variation at the KAP8 locus and fibre diameter was significant associated in sheep [24]. This suggests that the KAP8 gene may play an important role in determining the phenotypes for different cashmere quality and production traits.

6. CONCLUSION

With the recent development of molecular science and technology, the KAP genes controlling important traits of fibre have been found which are believed to be useful for selecting novel molecular markers associated with the fineness of fibre, so there is a need of more work on these markers by which fine fibre producing animals can be introduced at large scale by which economic sector of livestock will get developed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Shakyawar DB, Raja ASM, Kumar Ajay, Pareek PK, Wani SA. Pashmina fibre-Production, characteristics and utilization. Indian J Fibre Textile Res. 2013;38: 207-14.
2. Itenge-Mweza TO, Forrest RH, McKenzie GW, Hogan A, Abbott J, Amoafo O, et al. Polymorphism of the KAP1.1, KAP1.3 and K33 genes in Merino sheep. Mol Cell Prob. 2007;21:338-42.
3. Powell BC, Rogers GE. Differentiation in hard keratin tissues: Hair and related structures. In: Leigh F, Watt RF, Lane B (Eds), Keratinocyte handbook. Cambridge: Cambridge University Press, 1994;401-36.
4. Powell BC, Rogers GE. The role of keratin proteins and their genes in the growth, structure and properties of hair. EXS. 1997; 78:59–148.
5. Schweizer J, Bowden PE, Coulombe PA, Langbein L, Lane EB, Magin TM, et al. New consensus nomenclature for mammalian keratins. J Cell Biol. 2006; 174:169–74.
   DOI: 10.1083/jcb.200603161
6. Langbein L, Rogers MA, Winter H, Praetze S, Schweizer J. The catalog of human hair keratins II Expression of the six type II members in the hair follicle and the combined catalog of human type I and type II keratins JBC papers in press. Published on July 9, 2001 as Manuscript m103305200.
7. Parry DA, Steinert PM. Intermediate filament structure. Curr Opin Cell Biol. 1992;4:94-8.
8. Gong H, Zhou H, Hickford JGH. Diversity of the glycine/tyrosine-rich keratin-associated protein 6 gene (KAP6) family in sheep. Mol Biol Rep. 2011;38:31–5.
9. Fang Y, Liu WJ, Zhang FQ, Shao YG, Yu SG. The polymorphism of a novel mutation of KAP13.1 gene and it's associations with cashmere traits on Xinjiang local goat breed in China. Asian J Anim Vet Adv. 2010;5(1):34-42.
10. Cockett NE, Shay TL, Smit M. Analysis of the sheep genome. Physiol Genom. 2001; 7:69-78.
11. Kuczek ES, Rogers GE. Sheep wool (glycine + tyrosine)-rich keratin genes. A family of low sequence homology. Eur J Biochem. 1987;166:79-85.
12. Beh KJ, Hulme DJ, Callaghan MJ, Leish Z, et al. A genome scan for quantitative trait loci affecting resistance to *Trichostrongylus colubriformis* in sheep. Anim Genet. 2002; 33:97-106.
13. Gillespie JM. The proteins of hair and other hard α- keratins. In: (Goldman RD, Steinert PM, eds), Cellular and Molecular Biology of Intermediate Filaments. New York: Plenum Press. 1990;95-128.

14. Rogers GE. Hair follicle differentiation and regulation. Int J Dev Biol. 2004;48:163-70.
15. Beh K, Callaghan M, Leish Z, Hulme D. A genome scan for QTL affecting fleece and wool traits in Marino sheep. Wool Technol Sheep Breed. 2001;49:88-9.
16. Powell BC, Rogers GE. Cyclic hair-loss and regrowth in transgenic mice over expressing an intermediate filament gene. EMBO J. 1990;9:1485-93.
17. Fratini A, Powell BC, Rogers GE. Sequence, expression, and evolutionary conservation of a gene encoding a glycine tyrosine-rich keratin-associated protein of hair. J Biol Chem. 1993;268:4511–8.
18. Jin M, Wang L, Li S, Xing MX, et al. Characterization and expression analysis of KAP7.1, KAP8.2 gene in Liaoning new-breeding cashmere goat hair follicle. Mol Biol Rep. 2011;38:3023-8.
19. McLaren RJ, Rogers GR, Davies KP, Maddox JF, Montgomery GW. Linkage mapping of wool keratin and keratin-associated protein genes in sheep. Mamm Genome. 1997;8:938-40.
20. Liu YX, Shi GQ, Wang HX, Wan PC, Tang H, Yang H, et al. Polymorphisms of KAP6, KAP7, and KAP8 genes in four Chinese sheep breeds. Genet Mol Res. 2014; 13(2):3438-45.
21. Rogers, MA, Langbein L, Winter H, Eemann C, Praetzel S, Schweizer J. Characterization of a first domain of human high glycine-tyrosine and high sulfur keratin-associated protein (KAP) genes on chromosome 21q22.1. J Biol Chem. 2002; 277:48993-9002.
22. Wood NJ, Phua SH, Crawford AM. A dinucleotide repeat polymorphism at the glycine-rich and tyrosine-rich keratin locus in sheep. Anim Genet. 1992;23:391.
23. Aoki N, Ito K, Ito M. Isolation and characterization of mouse high-glycine/tyrosine proteins. J Biol Chem. 1997;272:30512-8.
24. Parsons YM, Cooper DW, Piper LR. Evidence of linkage between high-glycine-tyrosine keratin gene loci and wool fibre diameter in a Merino half-sib family. Anim Genet. 1994;25:105-8.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/20639