

Computational Algorithm to Assess Genetic Relationship and Functional Analysis of Non-Synonymous Substitution of HSP 70 Gene of Cattle, Sheep and Goat

Abstract

This study was carry out using heat shock protein 70 (HSP 70) sequences comprising goat (5), sheep (5) and cattle (5) which was obtained from the GenBank (NCBI). Protein Variant Effect Analyzer (PROVEAN) tool was used to check the non-synonymous single nucleotide polymorphism of the HSP 70 gene of amino acid substitution for cattle, goat and sheep. The study observed that some amino acid substitution returned neutral/beneficial while some deleterious/harmful. Molecular evolutionary genetics analysis (MEGA) 7.0 was used to perform both Tajima's test and phylogenetic relationship for cattle, goat and sheep. The Tajima's test (D) for all the species revealed positive values, an indication of purifying selection. The phylogenetic relationship followed bovidae family speciation. The study concluded that information emanating from this research is significant for further dry and wet laboratory experiment.

Keywords: Amino Acid; Gene; HSP 70; Nonsynonymous; Molecular; Speciation; Substitution

Research Article

Volume 5 Issue 6 - 2017

Dauda A¹, Abbaya HY², Shettima SM³, Sinodo S³, Adekoya AA⁴, Asiamah S⁴ and Malgwi IH^{4*}

¹Department of Animal Science, University of Calabar, Nigeria

²Department of Animal Science, Adamawa State University, Nigeria

³Department of Animal Science, University of Maiduguri, Nigeria

⁴Faculty of Agricultural and Environmental Sciences, Kaposvar University, Hungary

***Corresponding author:** Malgwi IH, Faculty of Agricultural and Environmental Sciences, Kaposvar University, Hungary, Email: zeekofficial@yahoo.com

Received: July 27, 2017 | **Published:** September 11, 2017

Introduction

Heat shock protein 70 (HSP 70) is significant in providing protection for cells against many stresses. HSP 70 proteins are most available and aware among all the HSPs [1]. Any time cells are under stress stimuli HSP tend to be active [2]. The HSP families consist of HSP 110, HSP 100, HSP 90, HSP70, HSP 60, HSP 40, HSP 10, and small HSP families [3]. Among HSPs, heat shock protein 70 is the most significant because it helps the protein chain to fold correctly into their tertiary shapes, protect and stabilize them. These processes occur in all mammalian cells [4]. With the development of technologies in animal genomics have generated many sequence data of many species. Even with The development these technologies is still challenging to differentiate neutral/beneficial amino acid substitution from the pool of single nucleotide polymorphism [5]. Thus, use of computer to determine harmful non-synonymous amino acid substitution of variant in the sequence exome is important [6]. A large number of computer determinations for amino acid substitutions depend on the basis that protein sequences notice in all living organisms have survived natural selection [7]. Thus, the physical and chemical changes protect amino acid positions across many species are likely to be useful, and amino acid substitutions noticed at determined positions will be deleterious in future on gene functions [7]. In developing countries, such as Nigeria, some quantitative and qualitative measurements have been used for selection and breeding purposes against disease infestation with little or no meaningful improvement in the stocks [8]. This has necessitated the paradigm shift to computational genomics to facilitate the

analysis and interpretation of the vast array of molecular data [8]. The reason for this study is to find out non-synonymous single nucleotide polymorphism, evolutionary relationship and test for selection of HSP 70 gene in some selected ruminants animals (cattle, sheep and goats).

Materials and Methods

This study was carry out using heat shock protein 70 (HSP 70) sequences comprising goat (5), sheep (5) and cattle (5) which was obtained from the GenBank (NCBI) (www.ncbi.nlm.nih.gov). The amino acid numbers of the protein are ACR56335, AHX42590, AHX42593, AHZ20721 and AHZ20724 (goat) ABP88261, AEX55799, AOF27447, AOF26313 and AOF25738 (sheep) NP_776975, CCO75577, NP_872592, CCO75576 and NP_001035697 (cattle). Sequences arrangement, changing and comparing of the HSP 70 gene of cattle, goat and sheep were carried out with Clustal W [9] by setting, gap open penalty of 15 and gap extension penalty of 6.66. Computer method was used to determine missense mutations using PROVEAN (Protein Variant Effect Analyzer) with separating value of -2.5. PROVEAN uses a set of similar and distantly related sequences from the NCBI NR protein database using BLASTP (ver.2.2.25) with an E-value separation of 0.1. The sequences were grouped on the basis of sequence similarity of 80% to remove redundancy using the CD-HIT program (ver.4.5.5) [10]. PROVEAN score that is smaller than or equal to a given separating value, the polymorphism is predicted as harmful [7]. Evolutionary analyses were conducted in MEGA7. The evolutionary relationship was carried out using

the Maximum Likelihood method based on the Equal Input model [11]. The tree revealed the highest log likelihood (-708.1487). The sequence that are similar are group together is shown next to the branches. Initial tree(s) for the heuristic search were obtained automatically by applying Neighbor-Join and Bio NJ algorithms to a matrix of pair wise distances estimated using a JTT model, and then selecting the topology with superior log likelihood value. The analysis involved 15 amino acid sequences. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. All positions containing gaps and missing data were deleted. There were a total of 27 positions in the final dataset [12]. The evolutionary distances were computed using the Poisson correction method [13]. The Tajima test statistic [11] was also estimated using MEGA7 was carryout by measuring the difference between two estimators of the population mutation rate, q_w and p [11]. Under neutrality, the means of q_w and p were approximately equal to one another. Therefore, the expected value of Tajima's D for populations conforming to a standard neutral model is zero. Significant deviations from zero indicate a skew in the allele frequency distribution relative to neutral expectations. Positive values of Tajima's D arise from an excess of intermediate frequency alleles and can result from population bottlenecks, structure and/or balancing selection. Negative values of Tajima's D indicate an excess of low frequency alleles and can result from population expansions or positive selection [14]. The abbreviations used are as follows: m = number of sites,

S = Number of segregating sites, $p_s = S/m$, $\theta = p_s / a_1$, and π = nucleotide diversity. D is the Tajima test statistic [11].

Results

The non-synonymous single nucleotide polymorphism (nsSNP) of HSP 70 gene cattle, goat and sheep are presented in Table 1-3 respectively. Fifteen (15) amino acid substitutions variant were observed from after arrangement of deduced protein sequence of Cattle. The amino acid substitutions variant (V20L) appeared to be neutral, while the remaining fourteen amino acid substitutions variants were returned as deleterious. Amino acid substitutions in goat revealed that variants (K25E, V26V, E27D, M5Y and A2S) appeared neutral, while variants (D10G, L11G, T13G, Y15S, S16G, C17S, V20G, Q22T and H23I) appeared to be harmful. Amino acid substitutions in sheep showed only two substitutions variants (E23D and C25V) are neutral while the rest of the variants appeared to be harmful. Tajima's test of neutrality for testing selection of cattle, goat and sheep are presented in Table 4. The result revealed that Tajima's test of neutrality (D) is positive for all the species but sheep have the highest nucleotide diversity value (0.923387). The molecular phylogenetic analysis by Maximum Likelihood method is shown in Figure 1. The genetic or evolutionary relationships of the amino acid nucleotides of cattle, goat and sheep as revealed that goat and sheep tend to be closer than cattle. This study concurred with the result of [9,15].

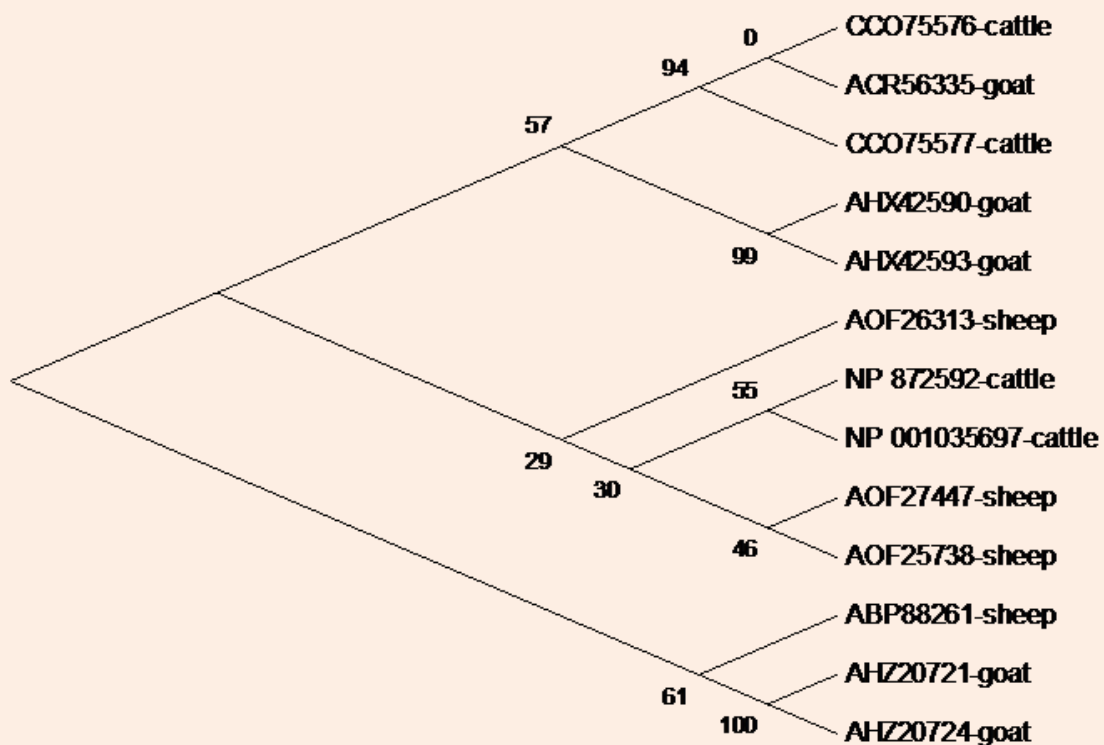


Figure 1: Molecular Phylogenetic analysis by Maximum Likelihood method.

Table 1: Functional analysis of coding nsSNP of the HSP 70 gene of cattle using PROVEAN.

Variant	PROVEAN Score	Prediction
V26R	-4.699	Deleterious
G24V	-4.329	Deleterious
F21P	-5.866	Deleterious
V20L	-1.834	Neutral
V18F	-3.427	Deleterious
S16R	-3.155	Deleterious
Y15S	-5.591	Deleterious
T13L	-3.708	Deleterious
G12A	-3.734	Deleterious
DO10V	-5.570	Deleterious
L11P	-4.261	Deleterious
H23D	-3.369	Deleterious
C17A	-5.659	Deleterious
I9R	-4.295	Deleterious
I7P	-3.538	Deleterious

Default threshold is -2.5, that is; Variants with a PROVEAN score equal to or below -2.5 are considered “deleterious” while Variants with PROVEAN score above -2.5 are considered “neutral”. G: glycine; A: Alanine, L: Leucine; M: Methionine; F: Phenylalanine; W: Tryptophan; Q: Glutamine; E: Glutamic Acid; S: Serine; P: Proline; V: Valine; Y: Tyrosine; R: Arginine; N: Asparagine; T: Threonine; C: Cysteine

Table 2: Functional analysis of coding nsSNP of the HSP 70 gene of goat using PROVEAN.

Variant	PROVEAN Score	Prediction
D10G	-4.313	Deletrious
L11G	-4.928	Deletrious
T13G	-4.333	Deletrious
Y15S	-5.591	Deletrious
S16G	-2.526	Deletrious
C17S	-6.287	Deletrious
V20G	-4.515	Deletrious
Q22T	-3.288	Deletrious
H23I	-5.308	Deletrious
K25E	-1.872	Neutral
V26V	-0.000	Neutral
E27D	-1.668	Neutral
M5Y	-0.660	Neutral
A2S	-0.033	Neutral

Default threshold is -2.5, that is; Variants with a PROVEAN score equal to or below -2.5 are considered “deleterious” while Variants with PROVEAN score above -2.5 are considered “neutral”. G: Glycine; A: Alanine, L: Leucine; M: Methionine; F: Phenylalanine; W: Tryptophan; Q: Glutamine; E: Glutamic Acid; S: Serine; P: Proline; V: Valine; Y: Tyrosine; R: Arginine; N: Asparagine; T: Threonine; C: Cysteine

Table 3: Functional analysis of coding nsSNP of the HSP 70 gene of sheep using PROVEAN.

Variant	PROVEAN Score	Prediction
T6E	-5.541	Deleterious
A7N	-4.258	Deleterious
G8Q	-7.454	Deleterious
T10L	-5.566	Deleterious
H11P	-9.255	Deleterious
G13S	-5.721	Deleterious
G14K	-7.553	Deleterious
D16P	-6.718	Deleterious
D18P	-6.721	Deleterious
L21Q	-4.090	Deleterious
E23D	-0.201	Neutral
C25V	-1.142	Neutral
Q27G	-4.339	Deleterious

Default threshold is -2.5, that is; Variants with a PROVEAN score equal to or below -2.5 are considered “deleterious” while Variants with PROVEAN score above -2.5 are considered “neutral”. G: Glycine; A: Alanine; L: Leucine; M: Methionine; F: Phenylalanine; W: Tryptophan, Q: Glutamine; E: Glutamic Acid; S: Serine; P: Proline; V: Valine; Y: Tyrosine; R: Arginine; N: Asparagines; T: Threonine; C: Cysteine

Table 4: Results from Tajima’s Neutrality test.

Species	M	S	P_s	θ	Π	D
Cattle	4	191	0.989637	0.539802	0.784111	4.746763
Sheep	5	27	1.00000	0.480000	0.740741	4.051175
Goat	4	124	1.00000	0.545455	0.923387	7.256215

m: Number of Sites; S: Number of segregating sites; p_s : S/m, θ : p_s/a_1 , and π : nucleotide diversity. D is the Tajima test statistic

Discussion

Major histocompatibility (MHC) genes are the most polymorphic genes described in vertebrates, with polymorphisms occurring predominantly at residues involved in peptide binding (antigen binding sites) [16]. Variation at these sites may affect the antigen binding groove and antigenic-peptide binding ability, and hence peptide specificity [17]. HSP70 genes are located within the major histocompatibility complex class I [18]. The present finding revealed that the HSP 70 gene of bovine, caprine and ovine is highly polymorphic in nature. The amino acid substitution in showed both variants that are neutral and deleterious for all the three species. The neutral substitution is a clear indication that the substitution did not impair the protein structure in terms of structure and function which will help in prevention of susceptibility to disease and also give hope for future selection while the deleterious dose the opposite [15]. Since the amino acid substitution in this study revealed both neutral and deleterious variants, this implies that any attempt to increase the number of beneficial allele there is high frequency of also increasing deleterious allele. The modern

genetic analysis of determining singly nucleotide polymorphism offer great hope for future selection stock as it enable to chosen molecular markers for selection. A positive Tajima's D observed for all the species under study signifies low levels of low and high frequency polymorphisms, an indications of a decrease in population size and/or balancing selection [19]. This might aid in purifying selection i.e. selection against deleterious amino acids substitution variants. This is also an indication that the breeds have not undergone any recent bottleneck or any recent reduction in the effective population size and are at mutation drift equilibrium. The presence of many alleles at a certain Major histocompatibility complex (MHC) locus is prove of long term physical and chemical changes that occur at locus [8]. This is suggesting by frequency with which some alleles in one species are more closely related to the alleles in a closely related species than to the alleles in the same species [20]. The closeness of a gene among ruminants may be as a result of threshold in physical and chemical changes due to the same selection pressure which the ruminants undergo during physical and chemical changes. Information emanating from this research may pave a way for subsequent dry and wet laboratory experiment in order to increase cattle, goat and sheep production in developing country like Nigeria [21-23].

Conclusion

The level of molecular diversity showed at the HSP 70 locus of cattle, goat and sheep, the beneficial amino acid substitution, the Tajima test of neutrality for selection and phylogenetic relationship revealed in this study is significant in selection for thermoregulation especially in tropical country like Nigeria.

Acknowledgement

We wish to appreciate NCBI for putting huge and significant data for researcher. The gene under study was retrieve from ncbi National Center for biotechnology information.

Conflict of Interest

None

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