HEAT SHOCK PROTEINS EXPRESSION IN ASSOCIATION WITH THERMAL STRESS IN CATTLE BREEDS

Sabina A. Neculai-Văleanu[2], M. Ciorpac[1,2], Mădălina A. Davidescu[1,2*], Bianca M. Mădescu[1,2], Ioana Poroşnicu[2,3], A.C. Matei[1], Şt. Creangă[1,2]

[1]Faculty of Animal Sciences, University of Agricultural Sciences and Veterinary Medicine of Iasi, Romania
[2]Research and Development Station for Bovine Iaşi, Şos. Iaşi-Ungheni 9, Iaşi, Romania
[3]Romanian Academy, The "Stefan S. Nicolau" Institute of Virology, Street "Mihai Bravu", Bucharest, Romania

Abstract

This paper reviews the most important aspects of the literature on heat shock proteins specific to the genus Bos taurus. Heat shock proteins (HSPs) are unique proteins that are formed when cells are exposed briefly to temperatures beyond their normal temperature of development. Based on molecular weight heat shock proteins are grouped into families: low molecular weight heat shock proteins, homologous proteins GroES or HSP10 (~ 10 kDa), DnaJ-homologous proteins or HSP40 (~ 40 kDa), GroEL-proteins homologous or HSP60 (~ 60 kDa), homologous proteins DnaK or HSP70 (~ 70 kDa), proteins HptG or HSP90 homologues (~ 90 kDa), and ATP Clp-dependent proteases (HSP100) (Oyeyemi O Ajayi et. Al., 2018). In recent years, global warming has become a major concern for the agricultural sector. Heat stress became a topical issue and a major cause of low fertility in dairy cattle, the impact being observed even in northern European countries.

Key words: heat shock protein, dairy cattle, heat stress

INTRODUCTION

The most important heat shock proteins studied in cattle are: HSP-60, HSP-70 and HSP-90. The 60 kDa heat shock protein (named Chaperonin) is implicated in mitochondrial protein import and macromolecular assembly. Together with Hsp10, facilitates the correct folding of imported proteins.

May also prevent misfolding and promote the refolding and proper assembly of unfolded polypeptides generated under stress conditions in the mitochondrial matrix.

The functional units of these chaperonins consist of heptameric rings of the large subunit Hsp60, which function as a back-to-back double ring [3], [4].

This leads to sequestration of the substrate protein in the inner cavity of Hsp60 where, for a certain period of time, it can fold undisturbed by other cell components [5].

Heat shock 70 kDa protein is implicated in a wide variety of cellular processes, including protection of the proteome from stress, folding and transport of newly synthesized polypeptides, activation of proteolysis of misfolded proteins and the formation and dissociation of protein complexes and also, plays a pivotal role in the protein quality control system, ensuring the correct folding of proteins, the re-folding of misfolded proteins and controlling the targeting of proteins for subsequent degradation. Negatively regulates heat shock-induced HSF1 transcriptional activity during the attenuation and recovery phase period of the heat shock response [5].

Heat shock 90kDa protein is a cluster of highly conserved molecules involved in various cellular processes. Their distribution in different cellular compartments underscores their significant roles in cellular homeostasis [1].

*Corresponding author: mada.davidescu@gmail.com
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MATERIALS AND METHODS

For all three major class of thermal shock proteins (HSP-60, HSP-70 and HSP-90), were calculated through the program ProtParam (a tool which allows the computation of various physical and chemical parameters for a given protein stored in Swiss-Prot or TrEMBL or for a user entered protein sequence), the computed parameters include the molecular weight, theoretical isoelectric point (pI), amino acid composition, atomic composition, extinction coefficient, estimated half-life, instability index, aliphatic index and grand average of hydropathicity.

RESULTS AND DISCUSSIONS

Each protein corresponds to a specific code in the database UniProtKB (HSP-60, code P31081, located on CH60_BOVIN; HSP-70, code Q27975 located on HS71A_BOVIN and HSP-90, code Q7M2S3).

60 kDa heat shock protein, encodes the gene HSPD1 and is located subcellular (fig. 1). For this protein, the parameters in the table 1 were calculated using the ProtParam application.

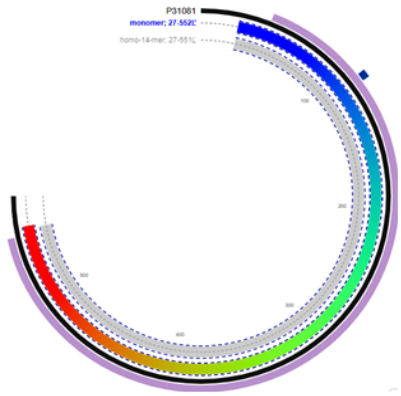

Fig.1 60 kDa heat shock protein (Bos taurus-Bovine)

Table 1 The physical and the chemical parameters for HSP-60 protein, calculated using the application ProtParam

Protein	HSP-60
Number of amino acids	573
Molecular weight	61,108 Da
Theoretical pI	5.60
Total number of atoms	8751
Grand average of hydropathicity (GRAVY)	-0.079

This protein has a length of 573 amino acids and a molecular weight of 61,108 Da. The instability index (II) is computed to be 29.91 and this classifies the protein as stable. Heat shock 70 kDa protein encodes the gene HSPA1A and is located subcellular (fig. 2).

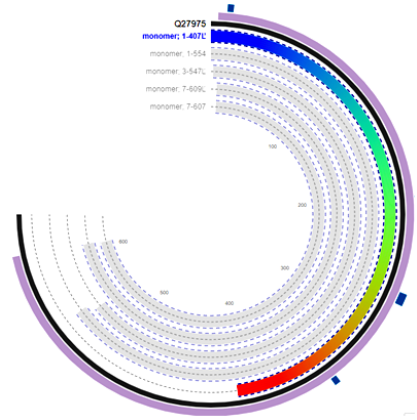

Figure 2 70 kDa heat shock protein (Bos taurus-Bovine)

For HSP-70 protein, the parameters in the table 2 were calculated using the same application.

Table 2 The physical and the chemical parameters for HSP-70 protein, calculated using the application ProtParam

Protein	HSP-70
Number of amino acids	641
Molecular weight	70,259 Da
Theoretical pI	5.67
Total number of atoms	9906
Grand average of hydropathicity (GRAVY)	-0.398

HSP-70 protein has a length of 641 amino acids and a molecular mass of 70,259 Da. The instability index (II) is computed to be 32.54 and this classifies the protein as stable [6].

HSP-90, heat shock protein, encodes the gene N/A and has a subcellular location. The parameters in the table 3, for HSP-90 protein, were calculated identically to the other two proteins.

HSP-90 protein has a length of 109 amino acids and a molecular mass of 12,822 Da. The instability index (II) is computed to be 55.24 and this classifies the protein as stable.

Table 3 The physical and the chemical parameters for HSP-90 protein, calculated using the application ProtParam

Protein	HSP-90
Number of amino acids	109
Molecular weight	12,822 Da
Theoretical pI	3.92
Total number of atoms	1206
Grand average of hydropathicity (GRAVY)	-1.168

HSP in cattle breed research

Heat shock proteins consist of highly conserved stress proteins, expressed in response to stress, and play a key role in the tolerance and adaptation of environmental stress. The present study was conducted to identify major gene types within the HSP70 family and other HSPs and to evaluate their pattern of expression in the Sahiwal and Tharparkar breeds of Zebu cattle (Bos indicus) and Murrah buffalo (Bubalus bubalis) for different seasons. This study suggests that heat shock protein genes can be conveniently used as biomarkers for the assessment of stress response in cattle and buffalo and that the expression is species-specific and the expression variation is associated with thermal tolerance and adaptation to different climatic conditions [5].

In a study carried out by Kishore et. In 2013, the HSPs were most highly regulated at 2 h after the heat stress. Among the HSPs, HSP70 was relatively more expressed, followed by HSP60 indicating the action of molecular caperones to stabilize the native protein conformation. The expression level of HSPs during the heat stress period was highest in buffaloes, followed by HF and Sahiwal cows. Higher abundance of HSP70 mRNA at each point of time after heat stress showed a prolonged effect of heat stress in HF PBMCs [2].

CONCLUSIONS

Expression of HSPs may be induced by several stressors, such as fever, oxidative stress, inflammation and heavy metals, and by conditions causing injury and necrosis, such as infection, trauma and ischemic reperfusion. They serve to attenuate the damage and misfolding of proteins caused by these various stressors. HSPs bind to exposed hydrophobic sites on polypeptides and mediate conformational changes, prevent misfolding of peptides and facilitate transport across membranes, thus maintaining the function of crucial cellular pathways during stress.

In addition, HSPs contribute to maintaining cell homeostasis under physiological and stress conditions.

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