

Identification, mRNA Expression and Characterization of a Novel *CENPP* Gene from Chinese Banna Mini-Pig Inbred Line (BMI)

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Abstract: The complete CDS sequence of Banna Mini-pig Inbred line (BMI) gene *CENPP* was amplified using the Reverse Transcriptase Polymerase Chain Reaction (RT-PCR) based on the conserved sequence information of the cattle or other mammals and known highly homologous swine ESTs. This novel gene was then deposited into NCBI database and assigned to Accession No.: JF944894. Sequence analysis revealed that the BMI *CENPP* encodes a protein of 291 amino acids that has high homology with the Centromere Protein P (*CENPP*) of seven other species-horse (85%), cattle (83%), human (77%), orangutan (76%), monkey (76%), mouse (70%) and rat (68%). The phylogenetic tree analysis revealed BMI *CENPP* has a closer genetic relationship with the horse *CENPP* than with those of cattle, human, orangutan, monkey, mouse and rat. Analysis by RT-PCR showed that BMI *CENPP* gene was over-expressed in midbrain, ovary, spleen, lung, skin, muscle, moderately expressed in diencephalon, heart, nerve fiber, stomach, small intestine, large intestine and almost not expressed in other 6 tissues. Two microRNA target sites were predicted in the CDS of BMI *CENPP* mRNA for further studying this gene in the future. The experiment will establish a foundation for further insight into this swine gene.

Key words: Banna Mini-pig Inbred line (BMI), pig, *CENPP*, tissue expression, bioinformatics analysis, China

INTRODUCTION

CENPP gene encodes the centromere protein P which is a subunit of a CENPH-CENPI associated centromeric complex that targets CENPA to centromeres and is required for proper kinetochore function and mitotic progression (Okada *et al.*, 2006). The centromere of higher eukaryotes was first defined as the primary constriction on mitotic chromosomes (Rattner, 1987; Ris and Witt, 1981) which is essential for faithful chromosome segregation during mitosis and meiosis (Pluta *et al.*, 1995). The histone H3 variant CENP-A is a component of centromeric chromatin and defines active centromere regions by forming centromere-specific nucleosomes (Ando *et al.*, 2002). Overexpression in this gene may indirectly be associated with aneuploidy which is the hallmark of many human cancers (Tomonaga *et al.*, 2003). In particular as a member of CENP-H-I complex,

CENPP plays an role in chromosome congression, maintenance of stable chromosome alignment and timely progression from metaphase to anaphase (Okada *et al.*, 2006).

Swine are generally considered to be the most ideal biomedical laboratory animals, for their anatomical, physiological and metabolic characteristics are similar to human's. The inbred animals are good enough to be used as experimental animals, owing to their clear genetic background, high homozygosity, stable inheritance and so on. Inbred animals can also make less experimental errors using in biological research than noninbred ones (Wright, 1921; Harris, 1997). In 1980, the Banna Mini-pig Inbred line (BMI) was exploited by Yunnan Agricultural University based on the small-ear pigs at Xishuangbanna, Yunnan province, China. A pair of progenitors was a sow and her son with some degree inbreeding background. Then, the propagation was conducted by means of highly

full sibling or parent-offspring inbreeding and each generation underwent the strict selection. As heterozygotic genes were separated and recombined in the process of inbreeding, BMI has already owned six families and eighteen substrains with different phenotypes and genotypes. Due to their consistent genetic background and minor interindividual differences, BMI is considered as an ideal model organism for biological studies (Yu *et al.*, 2004; Zeng and Zeng, 2005).

Based on the description of about the *CENPP* gene, it is necessary to isolate this gene from pig for it is associated with energy metabolism, health and other important biological functions of animals. But until today the porcine *CENPP* has not been reported yet. The objective of this study was to isolate the full length coding sequence of BMI *CENPP* gene according to the conserved sequence information of cattle or other mammals and highly homologous swine ESTs sequence information, conduct sequence analysis and some necessary function analysis of established nucleotide sequence, finally examine the expression in a range of BMI tissues. These will provide a primary foundation for further research on this porcine gene.

MATERIALS AND METHODS

Samples collection, RNA extraction and first-strand

cDNA synthesis: Three matured female BMI were slaughtered for sampling. Fresh tissues (lymph node, midbrain, ovary, diencephalon, cerebrum, liver, kidney, spleen, heart, lung, nerve fiber, stomach, small intestine, large intestine, pancreas, skin, muscle and fat) were instantly frozen in liquid nitrogen and stored at -80°C before use. Total RNA was extracted using the RNAiso Plus (TaKaRa, Dalian) according to the manufacturer's instructions. To remove genomic DNA contamination, total RNA was digested with RNase-free DNase I (TaKaRa, Dalian). The 3 μg of RNA were reverse transcribed with oligo (dT)₁₈ primer and M-MLV reverse transcriptase (Invitrogen, USA).

Isolation of the BMI *CENPP* gene: The GenBank *CENPP* sequences for cattle (Accession No.: NM_001105615), human (Accession No.: NM_001012267) and their highly homologous pig ESTs sequences: EW133717, CX063676, CN157364, CX063924, CV870136, BX665631, CN159311 and BX666162 were used to design a primer pair to amplify the complete coding sequence of *CENPP* by using Primer Premier 5.0 Software. The primers for BMI *CENPP* gene were: 5'-CAC ACA CCT CTA GGT ACA GC -3' and 5'-AAT TCC GAT AAC GAA CGA GAC T -3'. RT-PCR was performed to isolate the BMI *CENPP* using the pooled

cDNAs from different tissues above. The 25 μL reaction system was: 2.0 μL cDNA (25 ng μL^{-1}), 2.0 μL^{-1} 2.5 mM mixed dNTPs, 2.5 μL 10 \times Taq DNA polymerase buffer (Mg²⁺ plus), 0.5 μL 10 μM forward primer, 0.5 μL 10 μM reverse primer, 0.25 μL Taq DNA polymerase (5 U μL^{-1} , TaKaRa, Dalian) and 17.25 μL sterile water. The PCR program initially started with 94°C denaturation for 2 min followed by 35 cycles of $94^{\circ}\text{C}/30$ sec, $55^{\circ}\text{C}/40$ sec, $72^{\circ}\text{C}/1.5$ min then 72°C extension for 10 min, finally 4°C to terminate the reaction. After the PCR the gene product was cloned into pMD18-T vector (TaKaRa, Dalian) and sequenced bidirectionally with the commercial fluorometric method. At least five independent clones were sequenced.

Bioinformatics analysis: Sequence analysis of BMI *CENPP* gene was performed using software in NCBI (<http://www.ncbi.nlm.nih.gov>) and ExPaSy (<http://www.expasy.org>). The cDNA sequence were predicted using the GenScan Software. The Blastp program and Conserved Domain Architecture Retrieval Tool were used to search for similar proteins and conserved domain, respectively (<http://www.ncbi.nlm.nih.gov/Blast>). The alignment of the nucleotide sequences and deduced amino acid sequences were computed using ClusterX and the phylogenetic trees were computed using the Mega 4.0 Software with standard parameters. The theoretical Isoelectric point (pI) and Molecular weight (Mw) were predicted using the Compute pI/Mw Tool (http://us.expasy.org/tools/pi_tool.html). The putative signal peptide was predicted using the SignalP 4.0 server. The putative protein subcellular localization was predicted using PSort II (<http://psort.hgc.jp/>). Transmembrane topology prediction was performed using TMHMM-2.0 server. Second-order structures of deduced amino acid sequences were predicted with SOPMA. Web-based microRNA (miRNA) predicting programs were used to locate conserved potential miRNA targets (<http://www.mirbase.org/>). The 3D structures was predicted based on the existed 3D structures by the amino acids homology modeling on Swiss server (<http://swissmodel.expasy.org/>).

Semi-quantitative RT-PCR: To characterize the *CENPP* gene further, RT-PCR was conducted to determine its expression in 18 BMI tissues. To eliminate the effect of cDNA concentration, researchers selected the housekeeping gene 18S rRNA (NR_002170) as a positive control. The control primers used were: 5'-GGA CAT CTA AGG GCA TCA CAG -3' and 5'-AAT TCC GAT AAC GAA CGA GAC T -3'. The BMI *CENPP* primers which were used to perform the semi-quantitative RT-PCR for tissue expression profile analysis were the same as the

primers for isolation RT-PCR before. The PCR reactions were optimized for a number of cycles to ensure product intensity within the linear phase of amplification.

RESULTS AND DISCUSSION

Cloning and identification of BMI CENPP cDNA: An CENPP fragment 920 bp of including the entire 876 bp coding region plus 3 bp of 5'-UTR and 41 bp of 3'-UTR was amplified (Fig. 1). This cDNA nucleotide sequence analysis using the BLAST software at NCBI server revealed that BMI CENPP gene was not homologous to any of the known porcine genes and it was then deposited into the GenBank database (Accession No.: JF944894). The sequence prediction was carried out using the GenScan Software and results showed that the 876 bp cDNA sequence represent a single gene which encoded 291 amino acids. The complete CDS and the encoded amino acids were shown in Fig. 2.

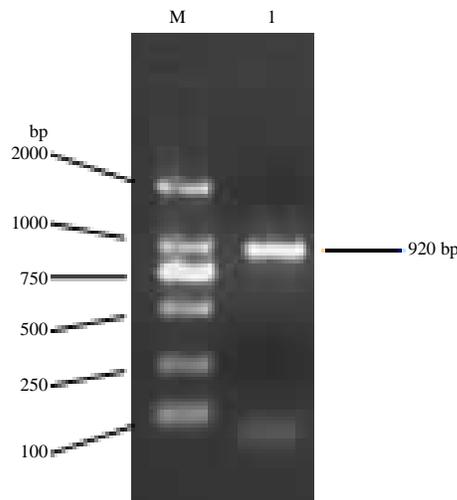


Fig. 1: RT-PCR result for BMI CENPP gene; M: DL2000 DNA marker, 1: PCR product

Physical and chemical characteristics of BMI CENPP:

The theoretical Isoelectric point (pI) and Molecular weight (Mw) of CENPP were computed using the compute pI/Mw tool. The theoretical pI and the molecular weight of BMI CENPP are 5.43 and 33579.29, respectively. The result from SignalP revealed that there is no putative signal peptide in BMI CENPP and indicated that it was probably a non-secretory protein (Petersen *et al.*, 2011). The potential protein subcellular localization prediction by Reinhardt's method showed that BMI CENPP was probably located in the nuclear with up to 52.2% probability (Nakai and Horton, 1999). Using a hidden Markov Model Algorithm, transmembrane topology prediction made by TMHMM program (Moller *et al.*, 2001) showed that BMI CENPP was not a potential transmembrane protein.

Prediction and analysis of structures and conserved domains of BMI CENPP:

Proteins often contained several domains, each of which had their own evolutionary origins and functions. Examined using the Conserved Domain Architecture Retrieval Tool of Blast at the NCBI server (<http://www.ncbi.nlm.nih.gov/BLAST>) indicated that BMI CENPP had not putative conserved domains. The putative protein was also analyzed using prosite (<http://expasy.org/prosite/>).

Six kinds sites were found which were protein kinase C phosphorylation sites (3-SIR-5, 52-SIK-54, 77-SiR-79, 82-SkK-84, 94-TeK-96, 183-TfK-185, 261-SfR-263), Leucine zipper pattern (4-25), Casein kinase II phosphorylation sites (38-SfQD-41, 45-SdsE-48, 52-SlkD-55, 89-TstE-92, 155-SrtE-158, 212-SrpE-215, 245-SalE-248), N-glycosylation sites (80-NYSK-83, 130-NLSS-133), cAMP- and cGMP-dependent protein kinase phosphorylation site (180-RKrT-183) and N- myristoylation sites (200-GAssSY-205, 270-GIeaTL-275). The prediction of secondary structure

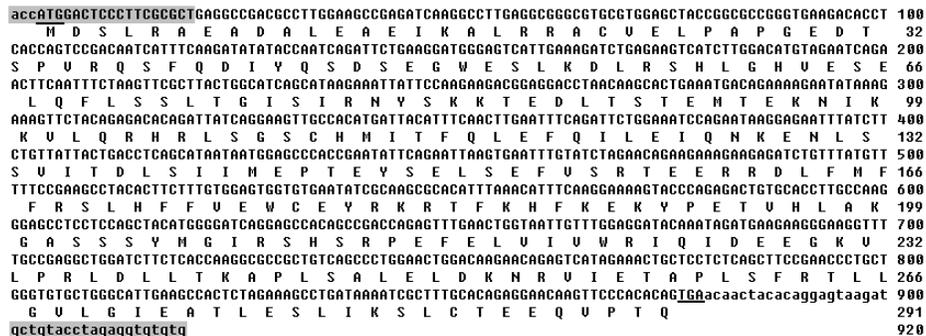


Fig. 2: The complete cDNA sequence and amino acid sequence of the protein encoded by CENPP (GenBank Accession No.: JF944894). ATG: Start codon; TGA: Stop codon and gray highlighted nucleotide sequence, primers


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BMI-pig      MDSLRAEADALEAEIKALRRACVELPAPGEDTSPURQSFQDIYQSDSEGWESLKDRLRSHL
Horse       -----MAQNSVUEYSRS-----KSFQEIYQSDSEGWESSKDLRSHL
Cattle     MDSQRARARALEAEIAALRRACIETQAPGDDDSQURKSFQETHQSHSEEWGLSKDLRSHL
Human      MDAELAEURALQAEIAALRRACEDPPAPWEEKSRVQKSFQAIHQFNLEGWKSCKDLKNQL
Orangutan MDAELAEURALQAEIAALRRACEPPAPWEEKSRVQKSFQAIHQFNLEGWKSCKDLKNQL
Monkey    MDAELAEERULQAEIAAVRRACENPPAPWEEKSGVQKSFQAIHQFTSEGWKSCKDLKNQL
Mouse     MDSETRELRALEEUVAALQRECRMLQNHAGEKASGAWKSFQKISQSDSEEWESLKDRLRSQL
Rat       MDPETRELRALEEUVAALQRECRMLQNHLEEKTSQAWKSFKFSQSDSEEWESLKDRLRSQL
          :   : .                               : * * * * * * * * * * * * * * * *
BMI-pig    GHVESELQFLSSTLGTGSIARNYSKKTEDLTSTEMTEKNIKKULQRHRLSGSCHMITFQLEF
Horse     GHLESEILFLSTLTGKIRNYSKKTDLTSTEMTEKSIKKULQRHRLSGNCHMITFQLEF
Cattle    GSLESELQFLSRLTGTGSIARNYCKNTEDLTNTEMAEKSIKKULQRHRLSGNCHMITFQLEF
Human     GHLESELQFLSSTLGTGSIARNHKSQTEDLTSTEMTEKSIKKULQRHRLSGNCHMITFQLEF
Orangutan GHLESELQFLSSTLGTGSIARNHKSQTEDLTSTEMTEKSIKKULQRHRLSGNCHMITFQLEF
Monkey   GHLESELQFLSSTLGTGSIARNYSRQTEDLTSTEMTEKSIKKULQRHRLSGNCHMITFQLEF
Mouse    EHLRSEHSFLSKLTGFNIARNYS-KMEDIVNTEETEKDTKKULQRHRLSGNCHMITFQLEF
Rat      GHLSSELQFLSKLTGFNIARNYS-KMEDIGNTEQTENDTKKULQRHRLSGNCHMITFQLEF
          : . * * * * * * * * * * * * * * * * : * : * * * * * * * * * * * * * * * *
BMI-pig    QILEIQNKESLSSUITDLSIIMEPTEYSELSEFUSRTEERRDLFMFFRSLHFFVUEWCEYR
Horse     QILEIQNKESLSSUITDLSIIMEPTEYSELSEFUSRAEERRDLFMFFRSLHFFVUEWCEYR
Cattle    QILEIQDKESLSSUITDLSIIMEPTEYSELSEFUSRAEERKDLLMFFRSLHFFVUEWCEYR
Human     QILEIQNKERLSSAUTDLNIIMEPTEYSELSEFUSRAEERKDLFMFFRSLHFFVUEWCEYR
Orangutan QILEIQNKERLSSAUTDLNIIMEPTEYSELSEFUSRAEERKDLFMFFRSLHFFVUEWCEYR
Monkey   QILEIQNKERLSSAUTDLNIIMEPTEYSELSEFUSRAEDRDLFMFFRSLHFFVUEWCEYR
Mouse    EULEMETKEKSSIIITDLSIIMEPTEYSELSEFASRAEERKDLLMFFRSLHFFVUEWCEYR
Rat      EULEMETKEKSSIIITDLSIIMEPTEYSELSEFASRAEERKDLLMFFRSLHFFVUEWCEYR
          : * * * * * * * * * * * * * * * * : * : * * * * * * * * * * * * * * * *
BMI-pig    KRTFKHFKEKYPETUHLAKGASSYMGIRSHSRPEFELVIUWRIQIDEEGKULPKLDLLT
Horse     KRTFKHFKEKYPEAVHLAEGAASSCHGURSASQPGFEVUIUWRIQIDDEGKULPKLDLLT
Cattle    KRTFKHFKEKYPEAVQLSEGASSCHGIRNPSQPGFELVIUWRIQIDEEGKULPKLDLLT
Human     KRTFKHLKEKYPDAUYLSEGPSSCSMGIRASRPGFELVIUWRIQIDEDGKVPKLDLLT
Orangutan KSTFKHLKEKYPDAUYLSEGPSSCSMGIRASQPGFELVIUWRIQIDEDGKVPKLDLLT
Monkey   KRTFKHFKEKYPDAUYLSEGPSSCSMGIRASRPGFELVIUWRIQIDEDGKVPKLDLLT
Mouse    ENTFKHFKEKYPDTUYLLEGTCSHCHEIRSTRQPGFELVIUWRIQIDEEGKVPKLDLLT
Rat      ENTFKHFKEKYPDSUYLSEGTCSHCHEIRNARLPGFELVIUWRIQIDEEGKVPKLDLLT
          : * * * * * * * * * * * * * * * * : * : * * * * * * * * * * * * * * * *
BMI-pig    KAPLSALELDKNRUIETAPLSFRTLLGULGIEATLESLIKSLCTEEQUPTQ-
Horse     QUPQRULELDKNRUIETAPLGFRLLLGULGIEATLESLIKSLCTEEHARSRH
Cattle    KUPLRALELDKNRUIETAPLSFRTLLGULGIEATLESLIKSLFCTEES----
Human     KUPQRALELDKNRAIETAPLSFRTLLGULGIEAALESLIKSLCAEENN----
Orangutan KUPQRALELDKNRAIETAPLSFRTLLGULGIEAALESLIKSLCAEENN----
Monkey   KUPQRALELDKNRAIETAPLSFRTLLGULGIEAALESLIKSLCAEENN----
Mouse    KUPERALGLDKNRUIETAPLSFRSLLGULGIEAALDSLIRLFGDNN----
Rat      KUPEQALEMDKNRUIETAPLSFRSLLGULGIEAALDSLIRLFTDK-----
          : . * . * * * * * * * * * * * * * * : * : * * * * * * * * * * * * * * * *
    
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Fig. 4: Alignment of the protein encoded by the BMI CENPP and seven other types of CENPP from horse (XP_001491590), cattle (NP_001099085), human (NP_001012267), orangutan (XP_001146410), monkey (NP_001181730), mouse (NP_079771) and rat (XP_002725285)

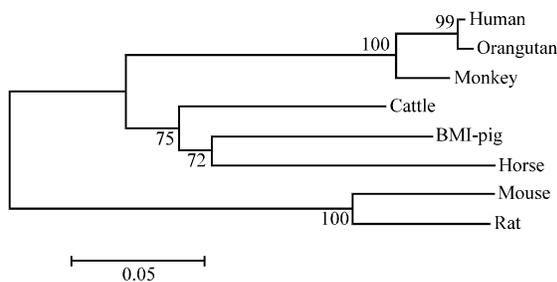


Fig. 5: Phylogenetic tree for CENPP proteins from 8 species

that swine CENPP is highly homologous with CENPP of horse, bovine, human and other mammals. This further validated that comparative genomics method is one useful tool to isolate the unknown genes especially the conserved coding region of genes for pig. From the alignment analyses for swine CENPP protein we also find BMI CENPP protein was not completely identity to horse or other mammals. This implied that BMI CENPP will have some differences in functions to those of horse, cattle, human and other mammals. In this study, we not only cloned the CDS sequences of the BMI CENPP gene but also conducted the sequence analysis and tissue

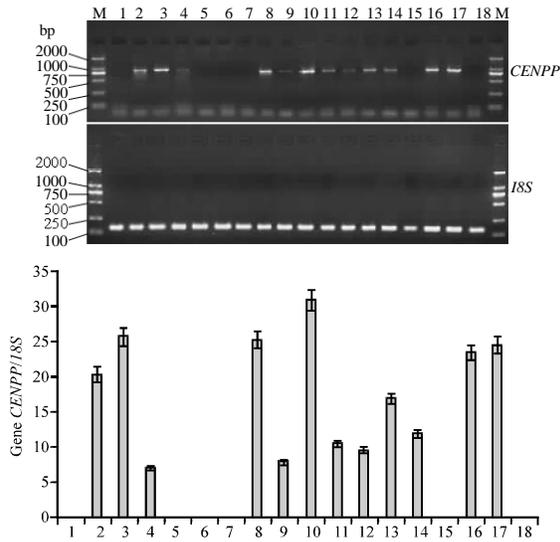


Fig. 6: Tissue expression distribution of BMI *CENPP* gene. The 18S expression is the internal control; 1: Lymph node; 2: Midbrain; 3: Ovary; 4: Diencephalon; 5: Cerebrum; 6: Liver; 7: Kidney; 8: Spleen; 9: Heart; 10: Lung; 11: Nerve fiber; 12: Stomach; 13: Small intestine; 14: Large intestine; 15: Pancreas; 16: Skin; 17: Muscle and 18: Fat

expression profiles analysis. From the tissue expression profile analysis it can be seen that the gene was obviously differentially expressed in various tissues. As the researchers did not study functions at protein levels, there might be many possible reasons for differential expression of this porcine gene. The suitable explanation for this under current conditions is that the biological activities associated with the functions of the gene was demanded to a different extent in different tissues at the same time.

CONCLUSION

In this study, the research first isolated BMI *CENPP* gene and performed necessary functional analysis and tissue expression profile analysis. Furthermore, two miRNAs were found to have the corresponding target sites in the coding sequence of BMI *CENPP* by theoretical prediction. The cDNA clone, sequence information and function analysis of BMI *CENPP* gene will be extremely important in elucidating the essential physiological function of CENPP protein using BMI and other miniature swines as experimental animal models in the future.

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