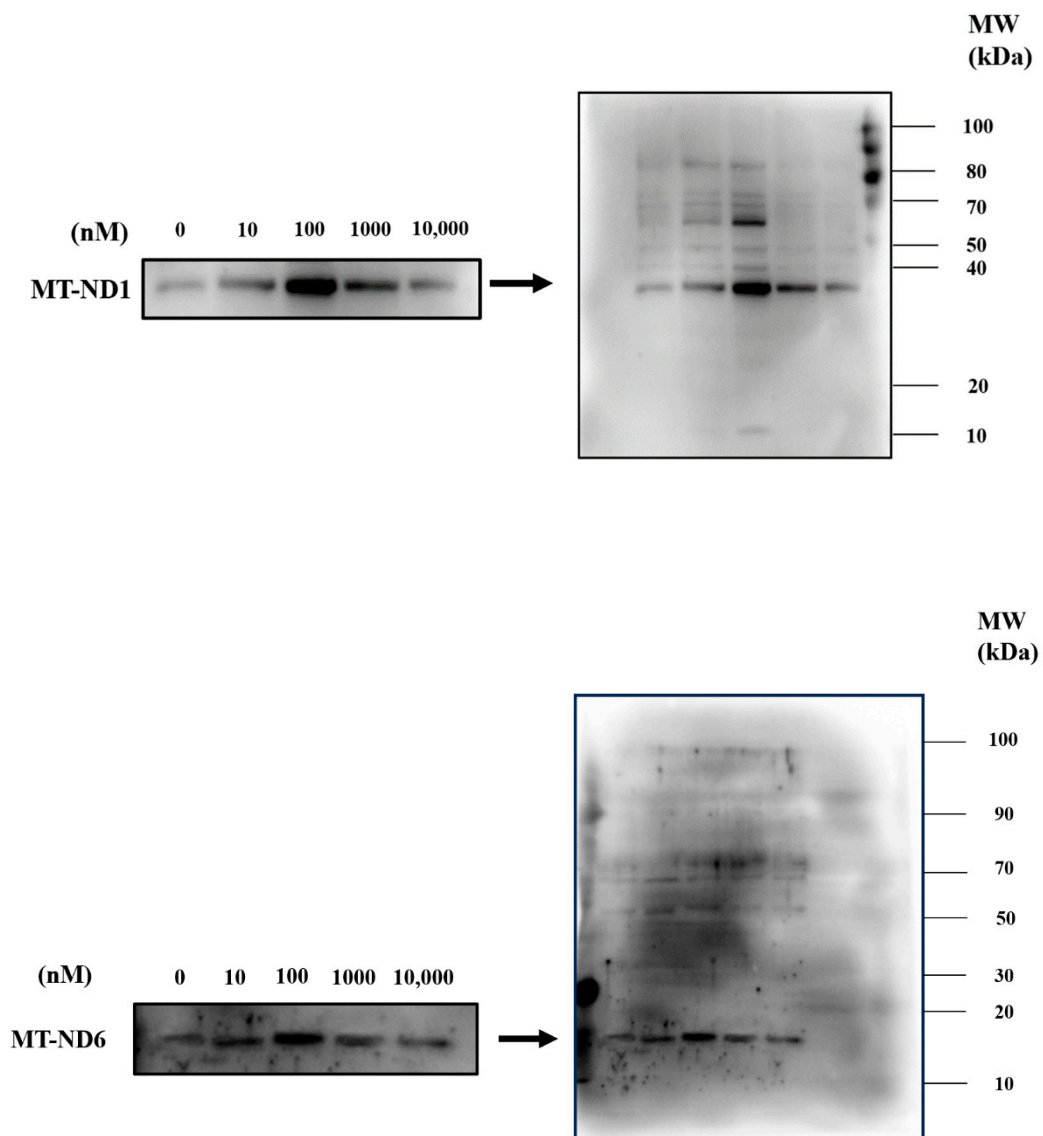
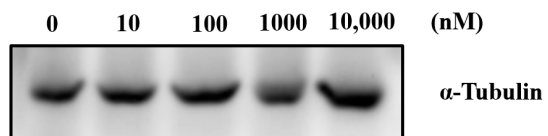
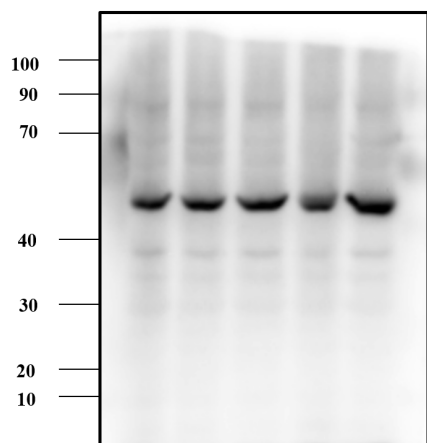


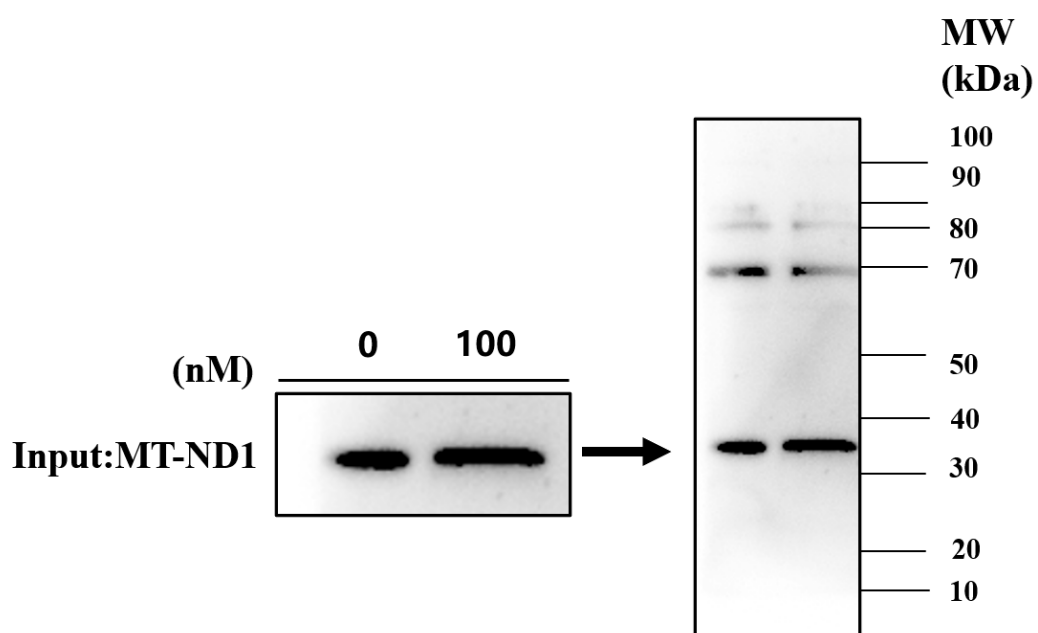
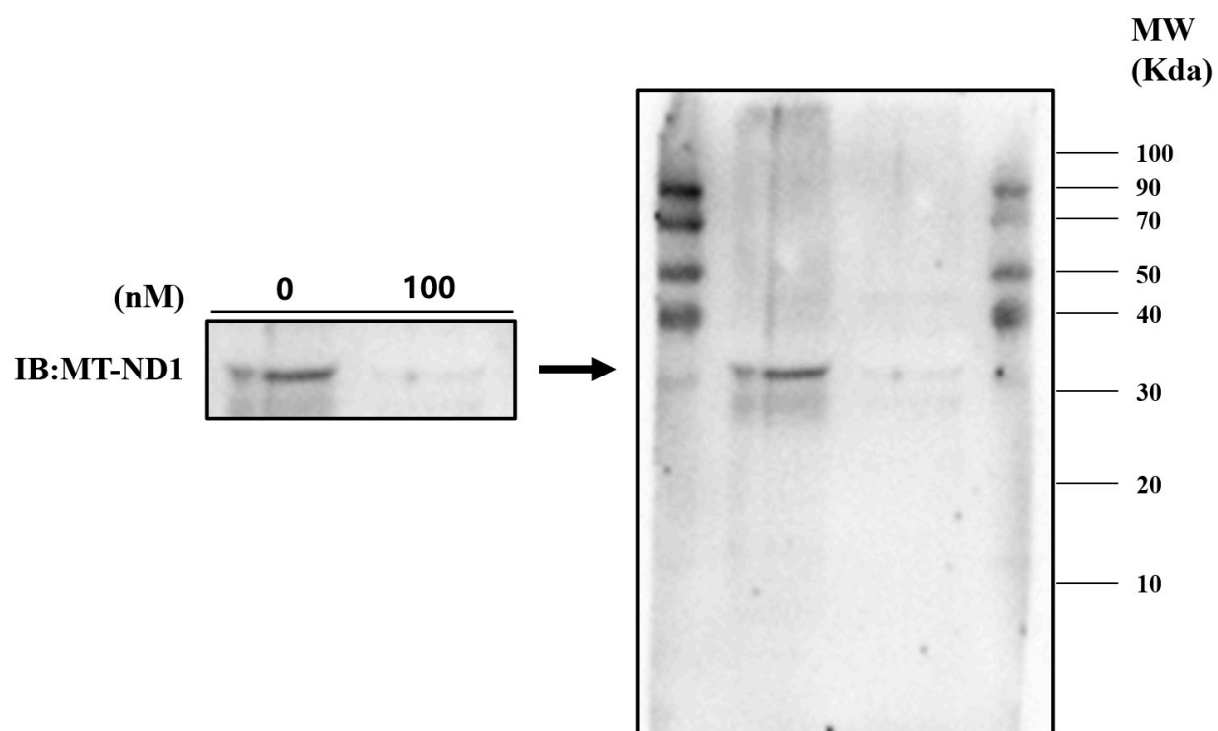
**Supplementary Figure S1.** Different concentrations of PQQ on the expression of proteins (MT-ND1、MT-ND6) in ram sperm stored at 4°C.

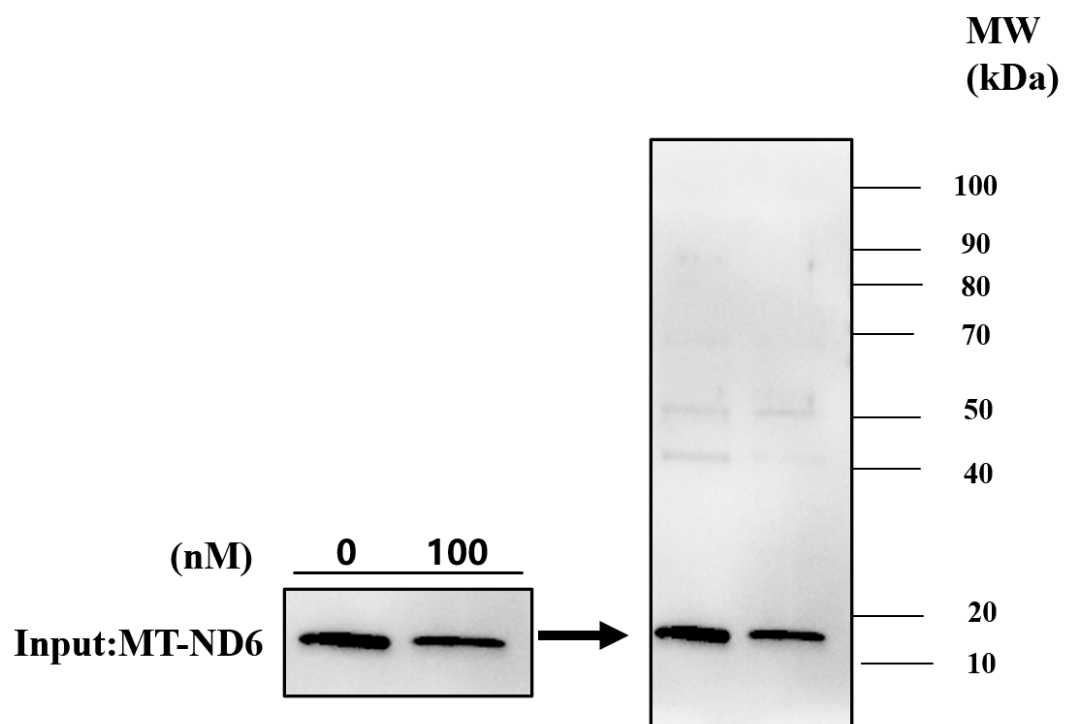
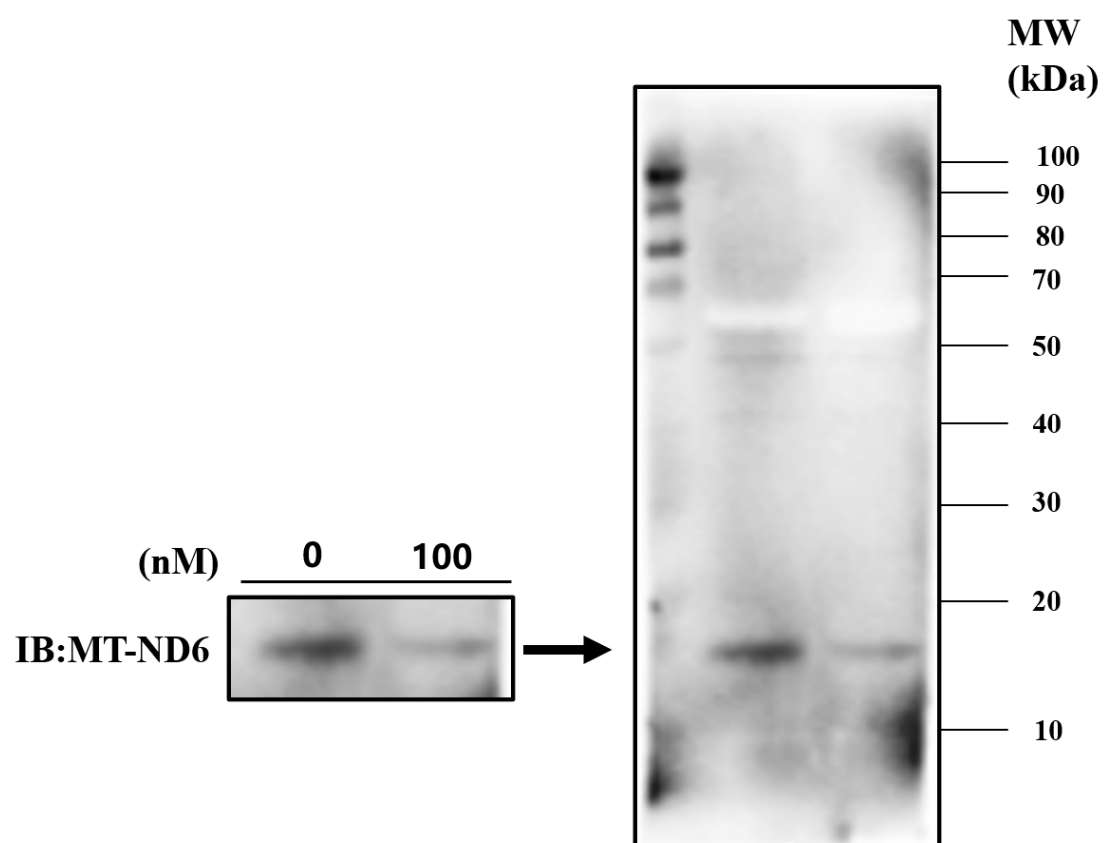


**MW  
(kDa)**

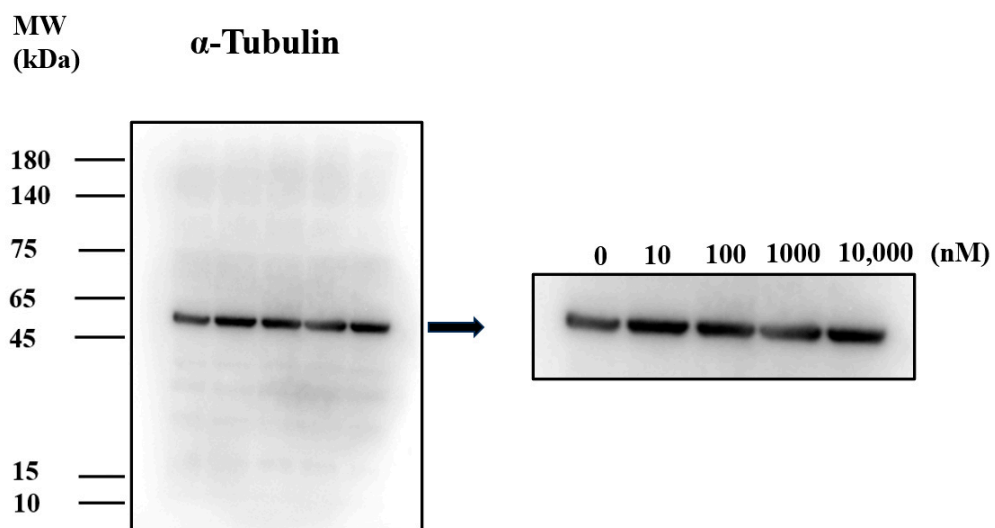
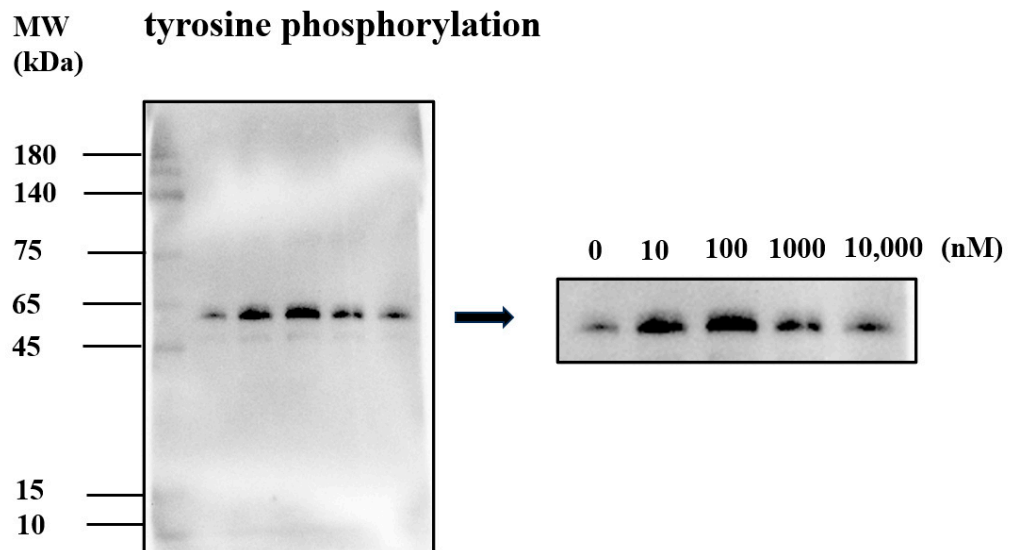


**Supplementary Figure S2.** PQQ decreased the ROS damage of mitochondrial proteins (MT-ND1 and MT-ND6).

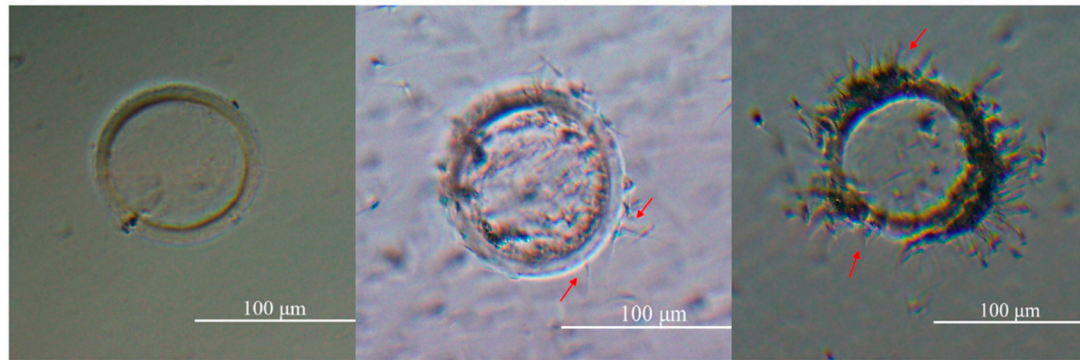




**Supplementary Figure S3.** Different concentrations of PQQ on the expression of tyrosine phosphorylation proteins in ram sperm stored at 4°C



**Supplementary Figure S4.** Effect of PQQ on sperm-zona pellucida (ZP) binding capacity after sperm treated with PQQ. (A) zona pellucida. (B) Control group sperm-zona pellucida complex, (C) 100 nM PQQ group sperm-zona pellucida complexes, red arrow indicate the sperm tightly bound to zona pellucida. Bars=100  $\mu$ m.



**A** Original appearance of zona pellucida

**B** 0 nM PQQ group

**C** 100 nM PQQ group