| **Supplementary Table X: Immune gene panel used for expression analysis** | | | |
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| **Gene Symbol** | **Full Gene Name** | **Functional Category** | **Primary Role** |
| RETNLB | Resistin-like beta | Mucosal barrier | Goblet cell defense factor, mucus production |
| MUC2 | Mucin 2 | Mucosal barrier | Major secretory mucin in gastrointestinal tract |
| MUC5AC | Mucin 5AC | Mucosal barrier | Surface goblet cell mucin production |
| NCR1 | Natural killer cell p46-related protein | NK cell marker | Natural killer cell activation and cytotoxicity |
| MPO | Myeloperoxidase | Neutrophil marker | Neutrophil-mediated oxidative pathogen killing |
| MYD88 | Myeloid differentiation primary response 88 | TLR signaling | TLR-mediated NF-κB activation, inflammation |
| CASP1 | Caspase 1 | Inflammasome | IL-1β and IL-18 production, pyroptosis |
| IL1RN | Interleukin 1 receptor antagonist | Anti-inflammatory | Natural IL-1β antagonist, infection control |
| TNF | Tumor necrosis factor alpha | Pro-inflammatory cytokine | Inflammation, immune cell activation |
| IL.6 | Interleukin 6 | Pro-inflammatory cytokine | Inflammation regulation, acute phase response |
| CXCL9 | C-X-C motif chemokine ligand 9 | Chemokine | Immune cell migration, Th1 activation |
| CXCR3 | C-X-C motif chemokine receptor 3 | Chemokine receptor | CXCL9/CXCL11 receptor, T cell trafficking |
| IFNy | Interferon gamma | Th1 effector cytokine | Macrophage activation, pathogen clearance |
| IL.13 | Interleukin 13 | Th2 cytokine | Alternative macrophage activation, mucus production |
| IRGM1 | Immunity-related GTPase M1 | Intracellular defense | Autonomous cell defense, parasite clearance |
| TICAM1 | TIR domain-containing adaptor molecule 1 | TLR signaling | Type I IFN production, antiviral response |
| SOCS1 | Suppressor of cytokine signaling 1 | Immune regulation | JAK/STAT pathway regulation, T-cell differentiation |
| IDO1 | Indoleamine 2,3-dioxygenase 1 | Immune regulation | T-cell activity regulation via tryptophan depletion |
| PRF1 | Perforin 1 | Cytotoxic effector | Cytotoxic granule protein, target cell lysis |