Addressing the Weakened Immune Response in Modern Pig Farming

What's in modern pig farming?

Genetic selection of modern commercial pig breeds has focused mainly on the improvement of production traits and meat quality, which can lead to reduced or missing expression of some immune-related genes, making them susceptible to infection under intensive farming conditions (Zhao et al., 2025).

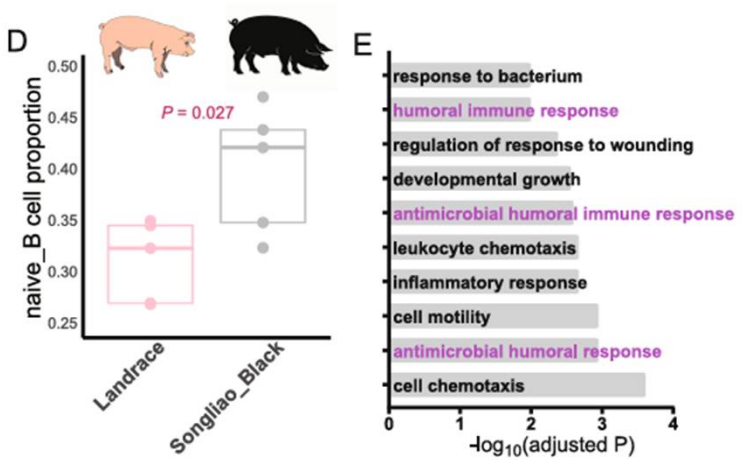
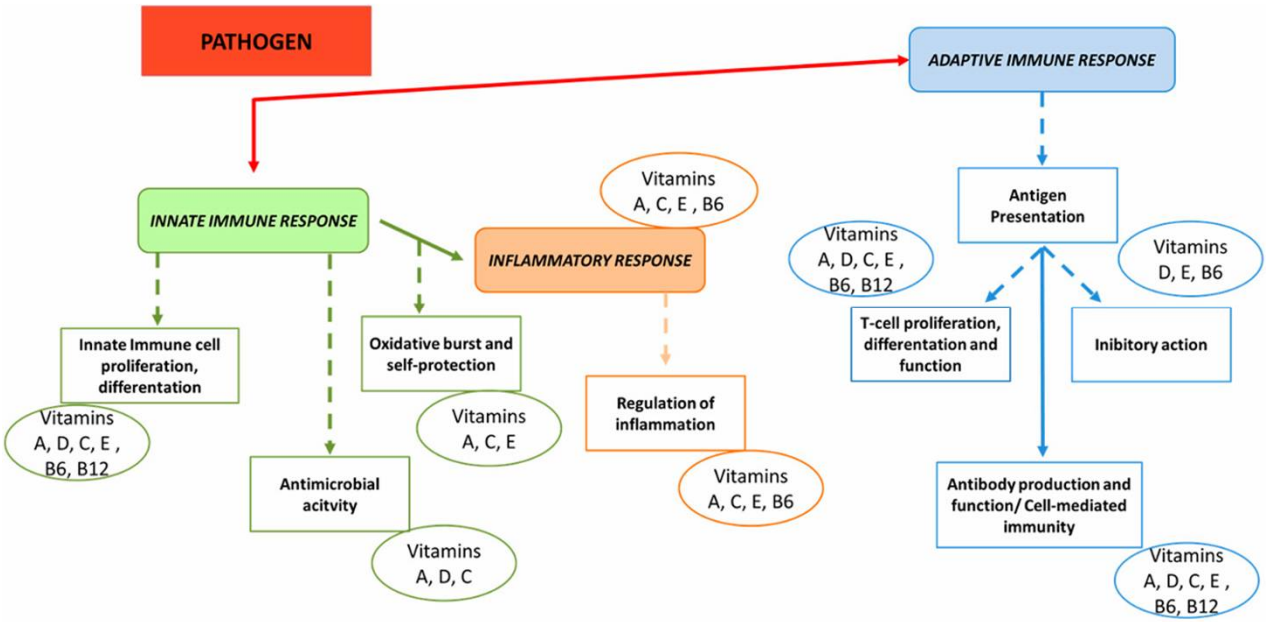


Fig. 5. (D) Box plot of the proportion of naive B cells and (E) GO enrichment analysis of DEGs in PBMC of Landrace pigs and Songliao Black pigs.

What's in modern pig farming?



- higher by 1.9-11.8x (using the US Pig Industry data)*
- higher by 6.5-15.6x (in piglets) and 2.4-5.7x (in sows) using OVN Guidelines*

** vs. NRC 2012*

Fig. 3. Vitamins involved in innate and adaptive immune response.

Adapted from Mainardi et al. (2024)

What's in modern pig farming?

Prolonged stress results to:

↓ Circulating monocytes
↓ proinflammatory cytokines TNF-α, IL-6 and IL-12
↓ humoral response, ↓ cellular response
↓ reactivity of lymphocytes
↓ Th1 lymphocyte differentiation and T cells (which could ↓ IL-2 production)

→ tail biting and aggression; reduced growth performance and vaccine responsiveness

→ impaired recruitment and activation of macrophages and T cells

→ poor immune responses to *Lawsonia intracellularis*, *Mycoplasma hyopneumoniae*, and PRRSV

Adapted from Pejsak (2022)

What's in modern pig farming?

Bidirectional immunotoxicity AFB1, OTA, and DON (Sun et al., 2023):

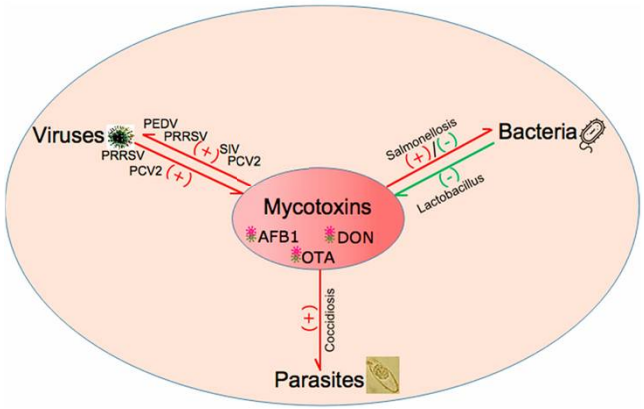
→ low-dose/short-term mycotoxin exposure = inflammation

→ high-dose/long-term mycotoxin exposure = immunosuppression

Low dose	High dose
↑ TNF-α production ↑ TNF-α and IL-6 expressions ↓ IL-2 production	↓ phagocytosis ↑ IL-10 expressions ↓ splenic and serum TNF-α, IL-2, IL-17 and IFN-γ production down-regulated Th1, Th2, Th17, and Treg gene expressions

What's in modern pig farming?

Mycotoxin-contaminated feed causes 1) increased susceptibility to infectious diseases, 2) reactivation of chronic infection, and 3) decreased vaccine efficacy (Pierron et al., 2016).



→ Promote virus replication, including PEDV, PRRSV, SIV and PCV2. In turn, PCV2 and PRRSV can aggravate the toxic effect of mycotoxins.

Fig. 3. The interaction between the three mycotoxins and microorganisms.

Adapted from Sun et al. (2023)

Immunomodulators

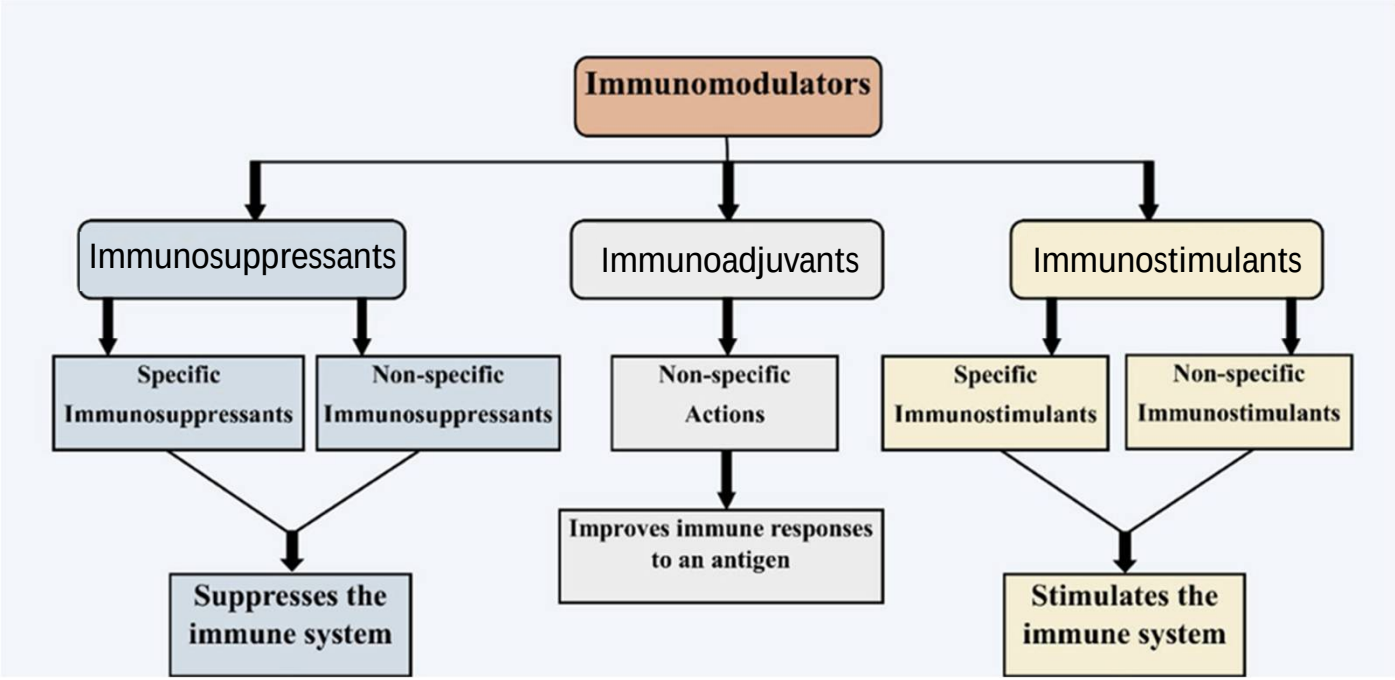


Fig. 2. Classification of immunomodulators and their mode of actions.

Adapted from Behl et al. (2024)

β-1,3/1,6-glucans

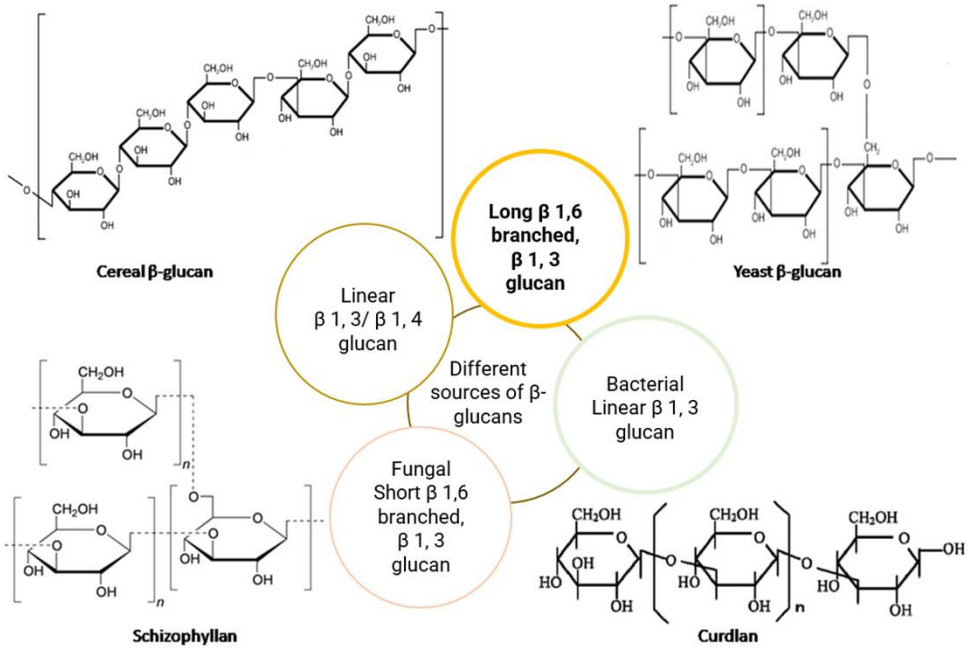


Fig. 1. Structure and branching degree of β-glucan from different sources.

Adapted from Du et al. (2019)

Insoluble β-1,3/1,6-glucans extracted from Baker's yeast (*Saccharomyces cerevisiae)*:

1) non-specific immunostimulant and
2) non-specific immunoadjuvant

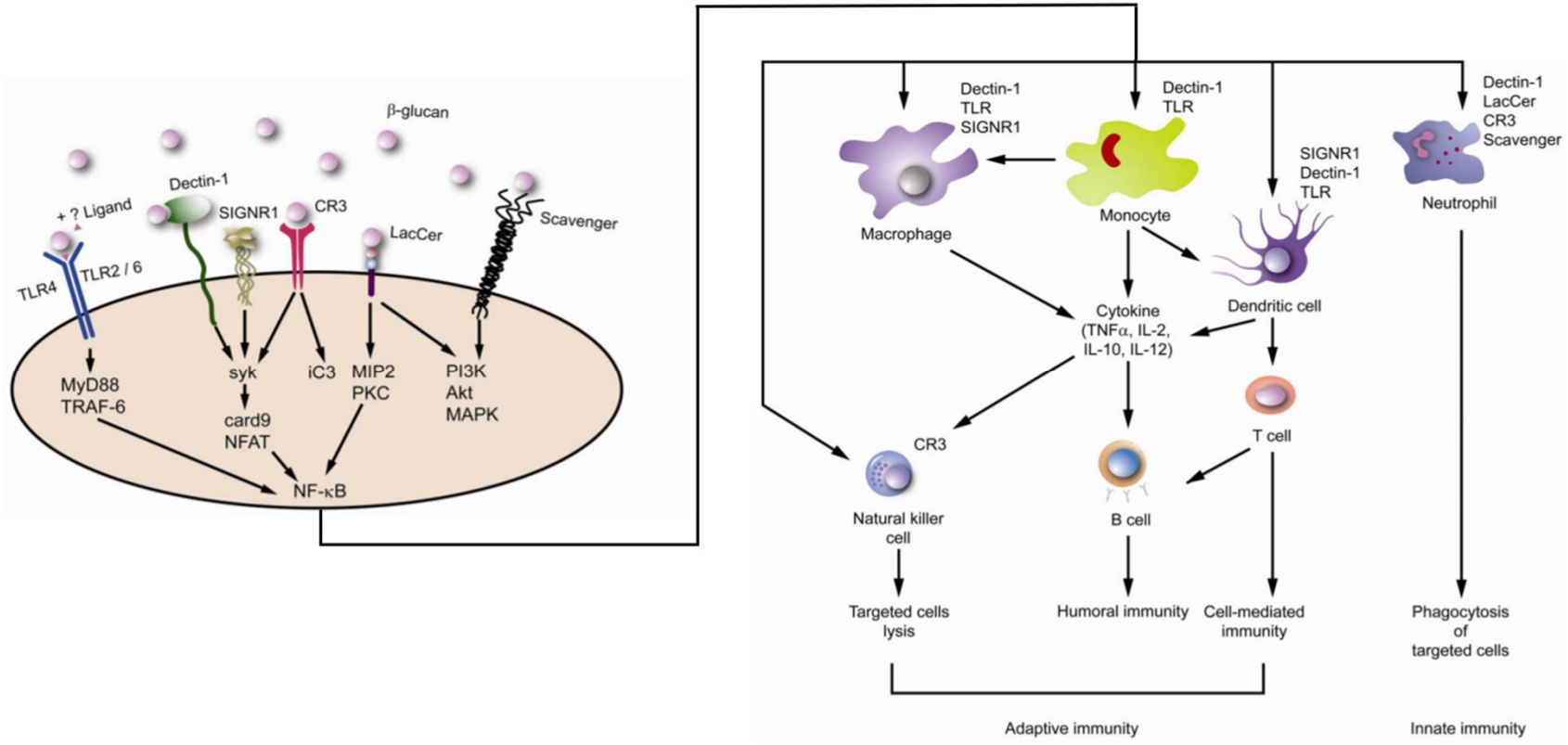


Fig. 3. Immune activation induced by β-glucans.

Adapted from Chan et al. (2009)

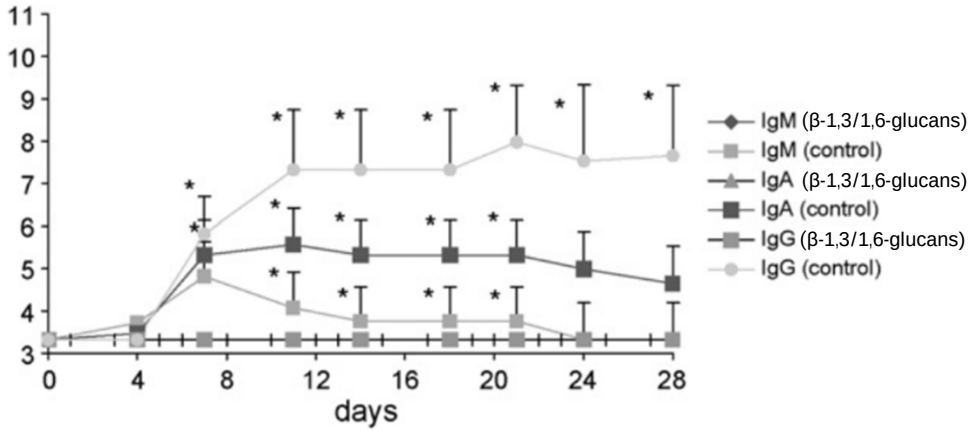


Fig. 2. Evolution of F4-specific IgM, IgA and IgG antibody titers in serum) in the control and β-1,3/1,6-glucans group after infection with F4+ ETEC (dpi: days post-infection).

	Control Group	**β-1,3/1,6-glucans Group**
Experiment no. 1		
Diarrhea score - median score* (range)	2.5 (1-3)	1.0 (0-1)
Diarrhea duration (range in days)	4.3 (2-6)	3.4 (3-4)
*on day 3 (P = 0.032)		
Experiment no. 2		
Diarrhea score - median score** (range)	(higher score)	(lower score)
Diarrhea duration (range in days)	3.7 (3-4)	1.6 (0-3)
**on days 4 and 5 (P = 0.042)		

(Stuyven et al., 2009)

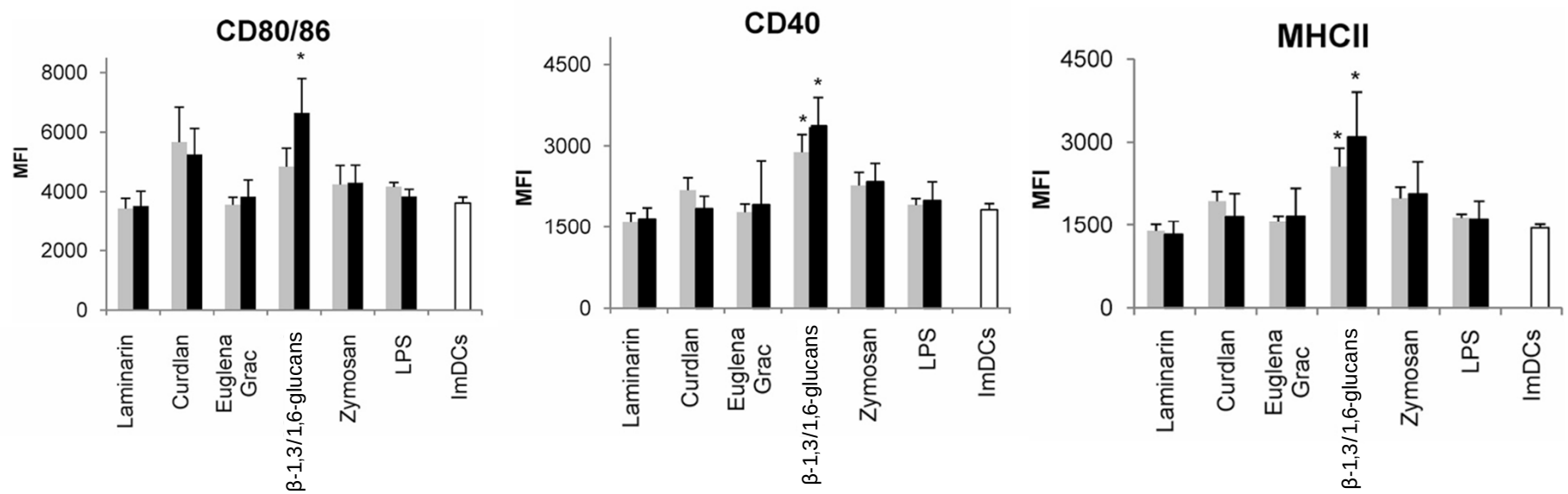


Fig. 1. Analysis of the expression of CD80/86, CD40, and MHCII after stimulation of immature porcine monocyte derived dendritic cells (MoDCs) with 5 mcg (▨) or mcg 10 g (■) of β-1,3/1,6-glucans per ml or LPS (1 and 10 g per ml).

(Sonck et al., 2011)

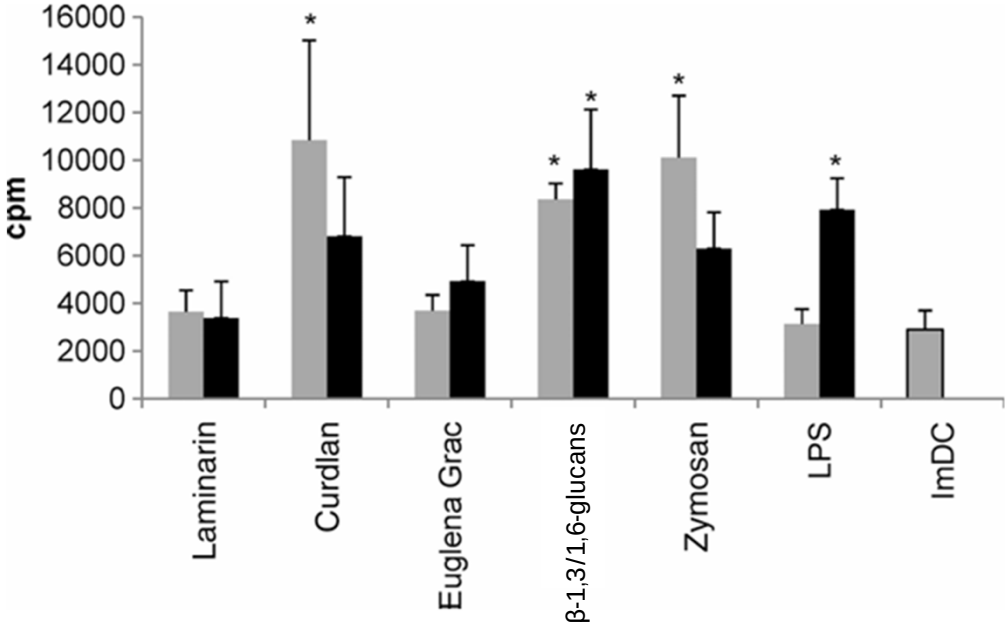


Fig. 3. Analysis of the ability of β-glucan-stimulated MoDCs to enhance T-cell proliferation. Porcine MoDCs were left untreated or stimulated for 24 h with 5 g (▨) or 10 g (■) of different β-1,3/1,6-glucans per ml or LPS (1 or 10 g per ml).

(Sonck et al., 2011)

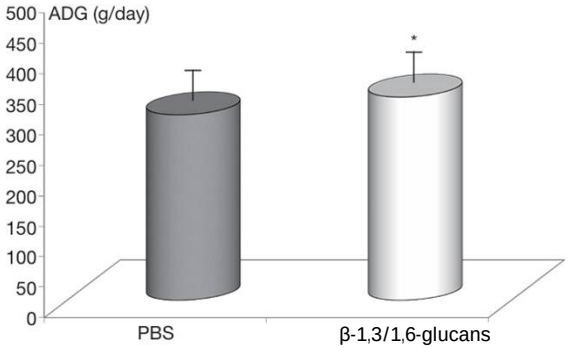


Fig. 1. Average daily gain.

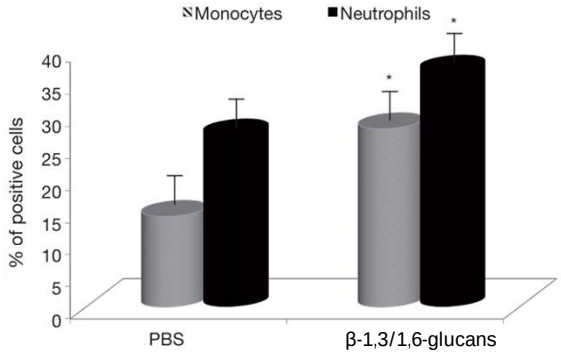


Fig. 2 Effect of dietary supplementation with β-1,3/1,6-glucans samples on phagocytosis by peripheral blood monocytes and neutrophils of pigs.

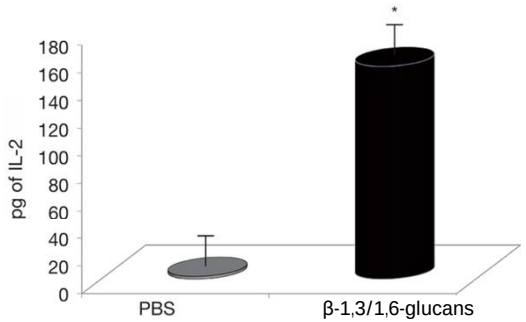


Fig. 3. Effect of dietary supplementation with β-1,3/1,6-glucans samples on Interleukin-2 (IL-2) level in serum of pigs.

(Vetvicka et al., 2014)

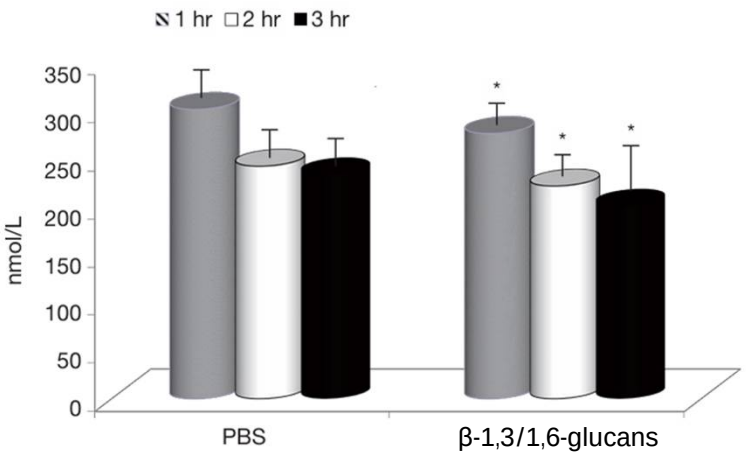


Fig. 4. Effect of addition of β-1,3/1,6-glucans to feed on lipopolysaccharides challenge-induced levels of cortisol in pigs.

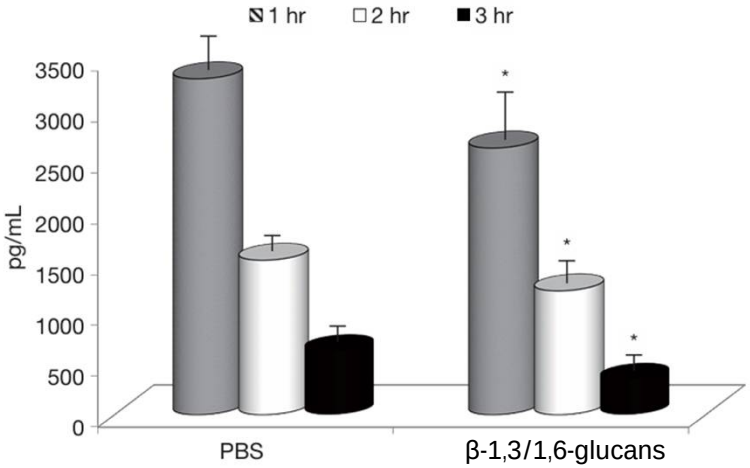


Fig. 5. Effect of addition of β-1,3/1,6-glucans to feed on lipopolysaccharide challenge-induced levels of TNF-α in pigs.

(Vetvicka et al., 2014)

Table 2. Production results of sows and their piglets

Indices		Experimental groups* I	II	III
Body weight of piglets, kg				
on the 45th day	x	14.27[a]	14.63	15.11[b]
	±	0.62	0.58	0.62
Daily gain of piglets, g				
2nd to 45th day	x	295.07[a]	302.22	312.73[b]
	±	17.33	16.33	16.18
Feed conversion ratio, kg · kg^{-1}				
21st to 45th day	x	1.48[A]	1.42[B]	1.43[B]
	±	0.02	0.02	0.01
Feed intake of mixture				
by sows during	x	7.69[a]	7.95	8.13[b]
lactation, kg/sow/day	±	0.32	0.30	0.27

* Experimental groups:
I – Control
II - β-1,3/1,6-glucans (100 ppm)
III - β-1,3/1,6-glucans (200 ppm)

Table 3. Total protein and its fraction in sows serum

Specification, g · l^{-1}		Experimental groups* I	II	III
21st day after parturition				
γ-globulin	x	13.52[a]	17.35	19.43[b]
	±	2.01	3.97	3.60

Table 5. Total protein and its fraction in sows milk

Specification, g · l^{-1}		Experimental groups* II	III
γ- globulin	x	4.05[A]	10.43[B]	9.09[B]
	±	2.75	2.07	2.02

(Szuba-Trznadel et al., 2014)

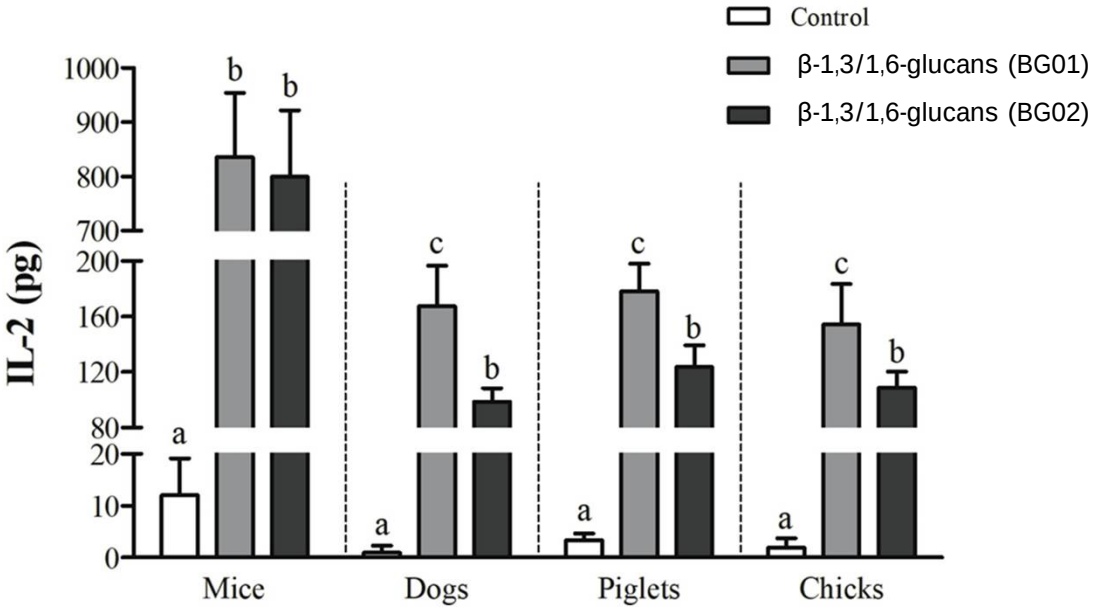


Fig. 1. Serum interleukin 2 of mice, dogs, piglets and chicks fed a control diet and one supplemented with 15mgkg^{-1} day^{-1} of BG01 or 25mgkg^{-1} day^{-1} of BG02.

(Oliveira et al., 2019)

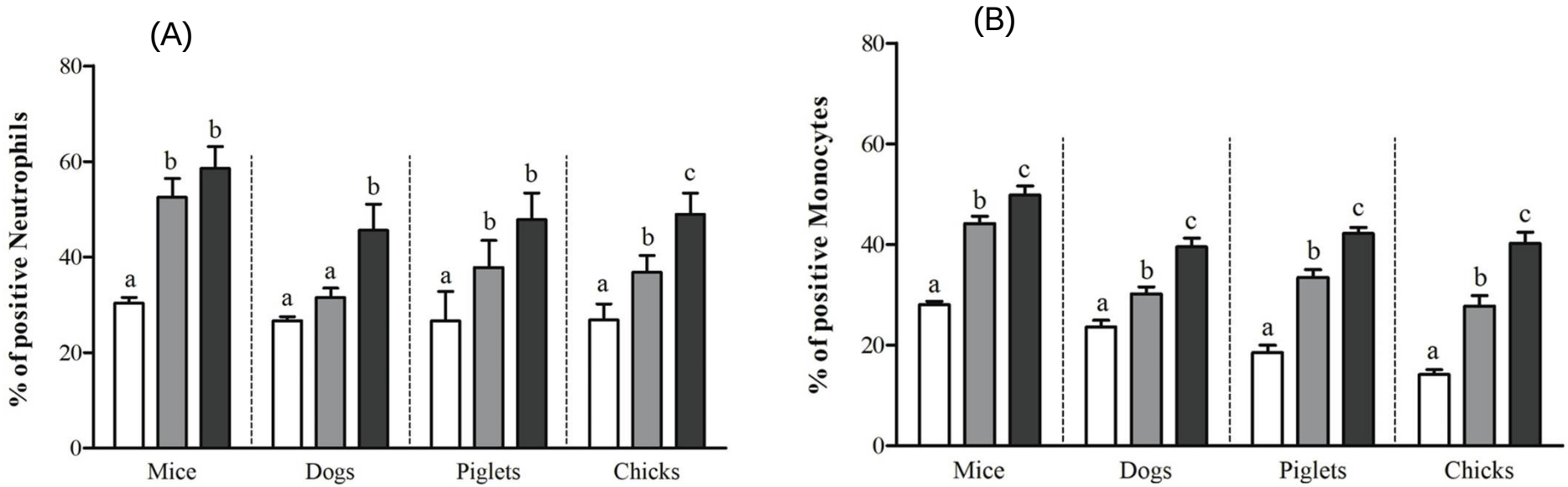


Fig. 2. Percentage of positive cells for phagocytosis of neutrophils (A) and monocytes (B) of mice, dogs, piglets and chicks fed a control diet and one supplemented with 15mgkg^{-1} day^{-1} of BG01 or 25mgkg^{-1} day^{-1} of BG02.

(Oliveira et al., 2019)

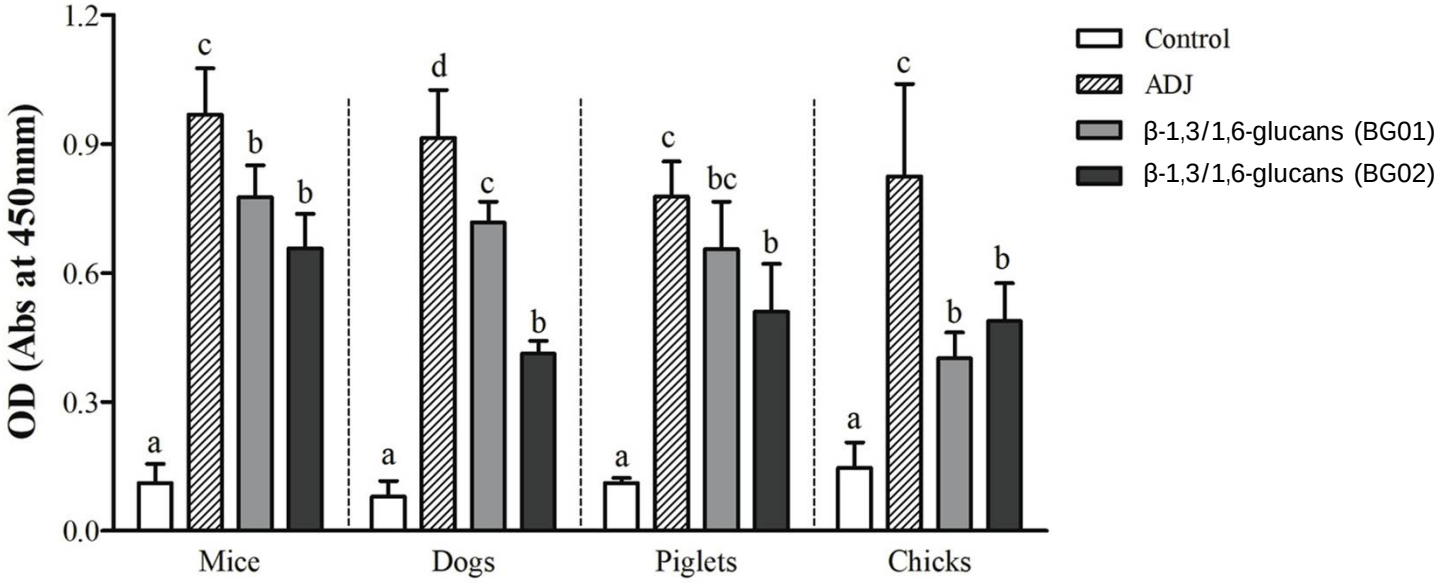
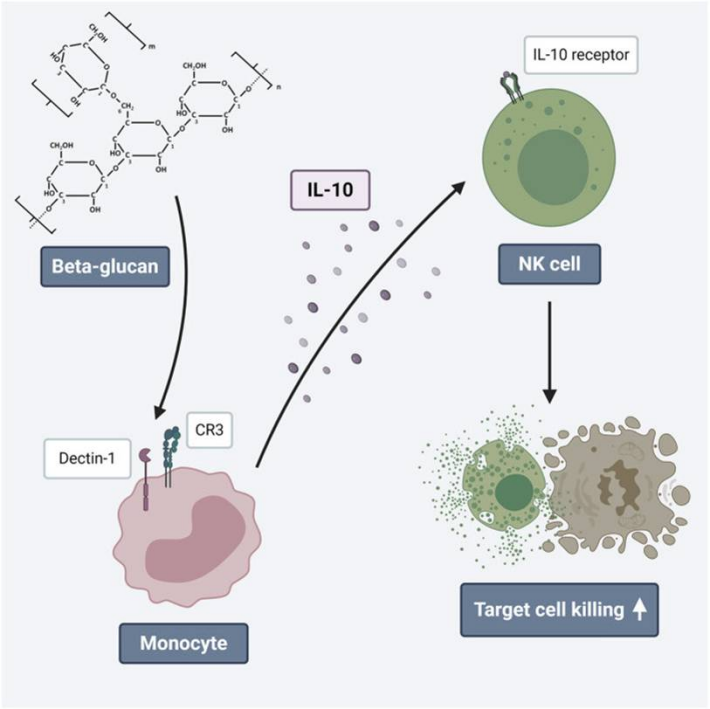


Fig. 3. Antibody production after stimulation with ovalbumin of mice, dogs, piglets and chicks fed a control diet. and one supplemented with 15mgkg^{-1}day^{-1}of BG01 or 25mgkg^{-1} day^{-1} of BG02. ADJ means adjuvant control.

(Oliveira et al., 2019)



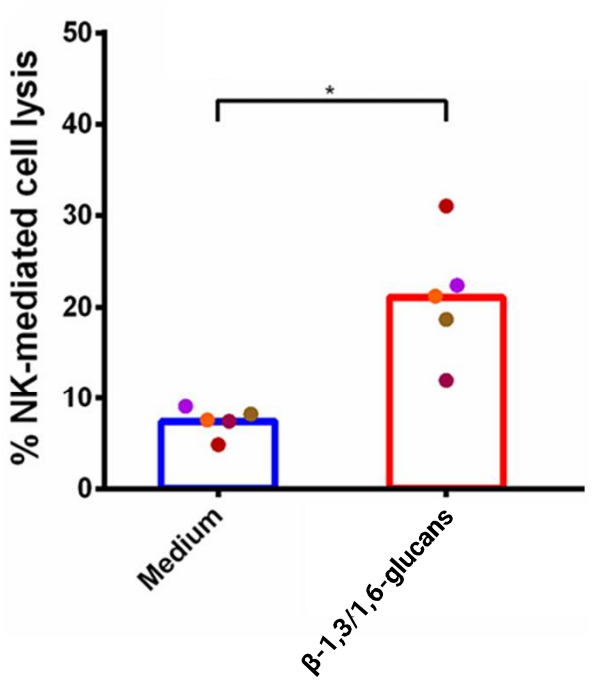


Fig. 2. β-1,3/1,6-glucans indirectly stimulate NK cell cytotoxicity via monocytes.

(Hermans et al., 2021)

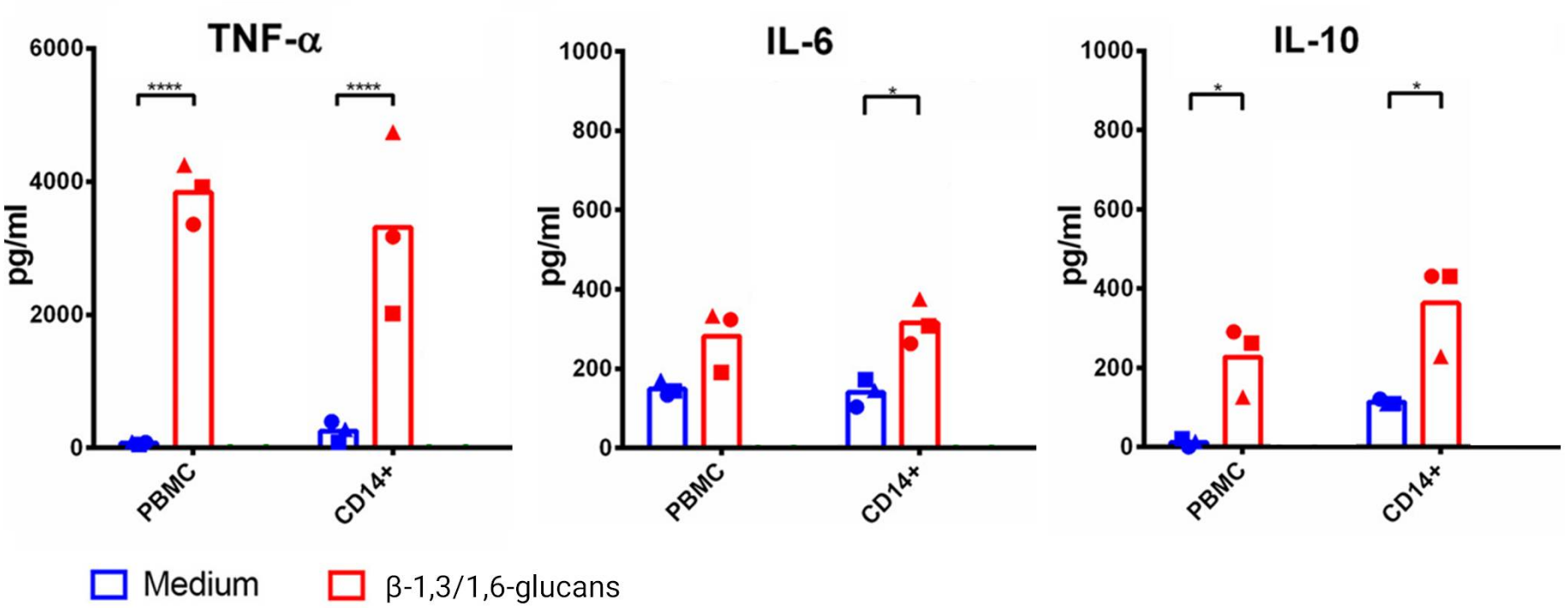


Fig. 3. TNF-α, IL-6, and IL-10 are upregulated in PBMC and monocytes after β-1,3/1,6-glucans stimulation.

(Hermans et al., 2021)

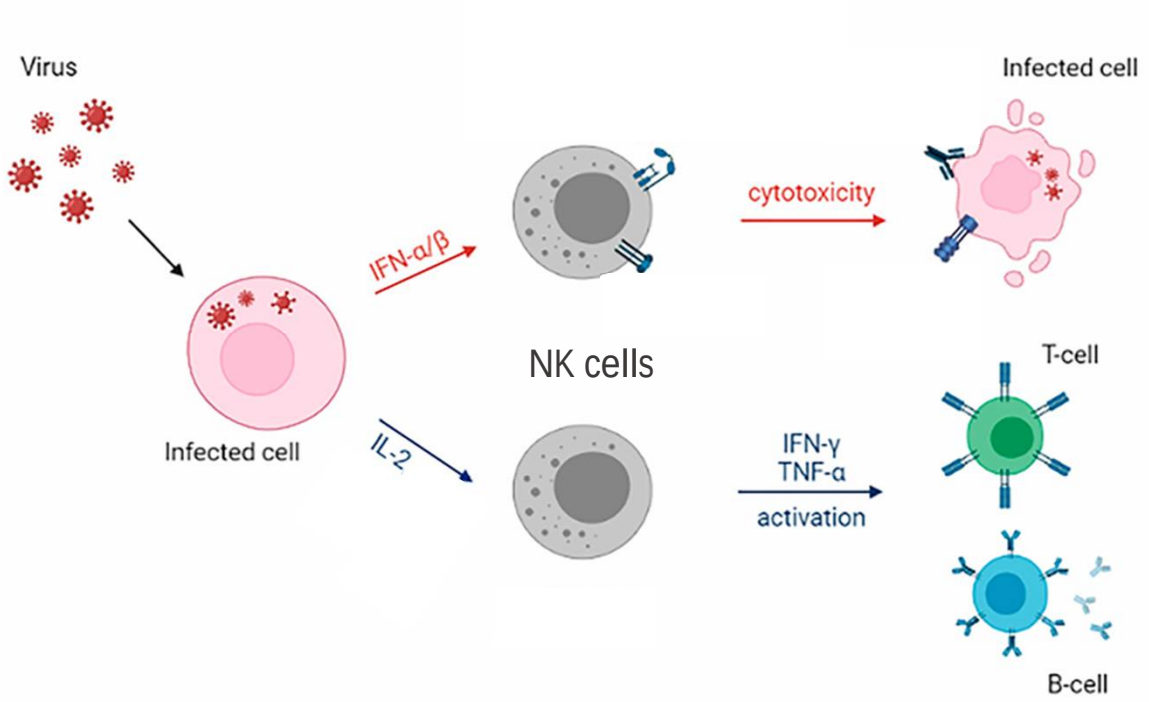


Fig. 1. NK cell activation during infection.

Adapted from Rizzo et al. (2021)

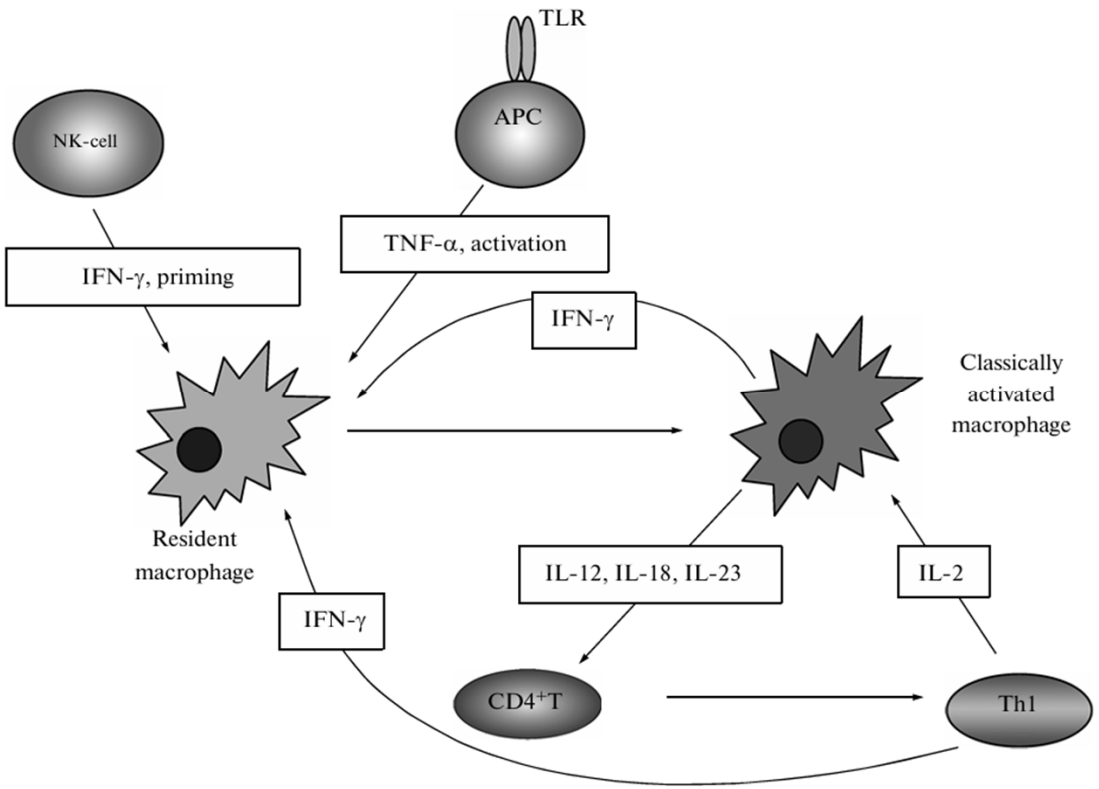
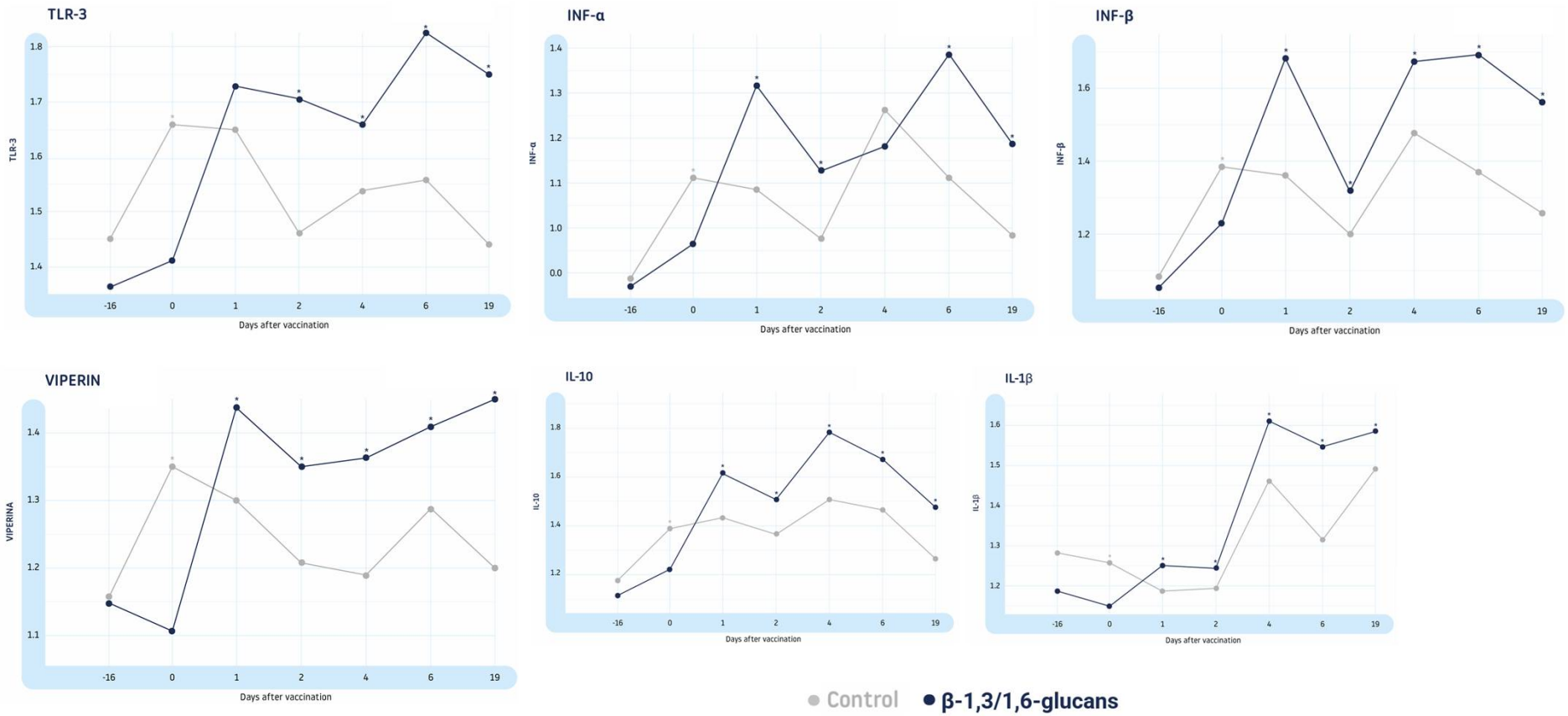


Fig. 2. Classical activation of macrophages.

Adapted from Onoprienko et al. (2011)


TLR-3
TLR-3
Days after vaccination
INF-α
INF-α
Days after vaccination
INF-β
INF-β
Days after vaccination
VIPERIN
VIPERINA
Days after vaccination
IL-10
IL-10
Days after vaccination
IL-1β
IL-1β
Days after vaccination
-16
0
1
2
4
6
19
Control
β-1,3/1,6-glucans

pathogens

MDPI

Article

A Highly Effective African Swine Fever Virus Vaccine Elicits a Memory T Cell Response in Vaccinated Swine

Sarah E. Attreed [1,2], Christina Silva [1], Sophia Abbott [1], Elizabeth Ramirez-Medina [1], Nallely Espinoza [1], Manuel V. Borca [1,*], Douglas P. Gladue [1,*] and Fayna Diaz-San Segundo [1,*]

[1] U.S. Department of Agriculture, Agricultural Research Service, Plum Island Animal Disease Center, Greenport, New York, NY 11944, USA
[2] PIADC Research Participation Program, Oak Ridge Institute for Science and Education (ORISE), Oak Ridge, TN 37830, USA
* Correspondence: manuel.borca@usda.gov (M.V.B.); douglas.gladue@usda.gov (D.P.G.); fayna.diaz-sansegundo@usda.gov (F.D.-S.S.); Tel.: +1-(631)-323-3131 (M.V.B.); +1-(631)-323-3035 (D.P.G.); +1-(631)-323-3012 (F.D.-S.S.)

→ results suggest that NK and memory T cells play a role in protective immunity and suggest that studying these cell populations may be a surrogate immunity marker in ASF vaccination.

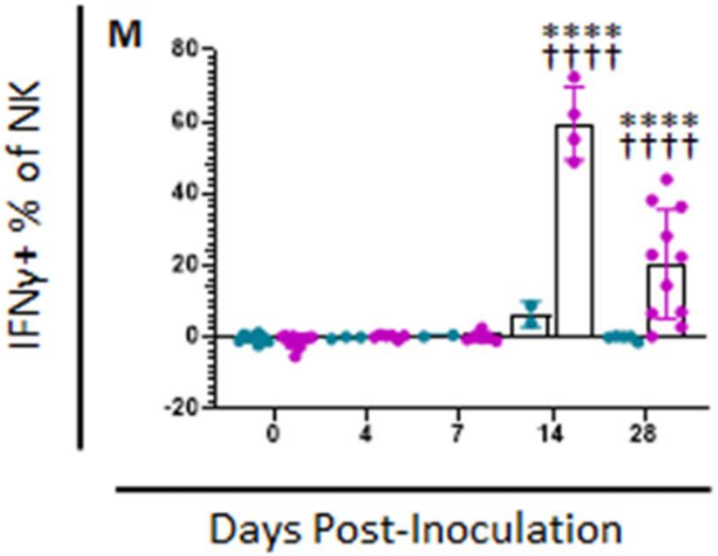


Fig. 3. Upon ex vivo stimulation with ASFV-G, the change in IFNγ+ NK cells as a proportion of NK cells was also calculated.

CANADIAN JOURNAL OF VETERINARY RESEARCH | REVUE CANADIENNE DE RECHERCHE VÉTÉRINAIRE

Infection with *Porcine reproductive and respiratory syndrome virus* stimulates an early gamma interferon response in the serum of pigs

Ronald D Wesley [1,✉], Kelly M Lager [1], Marcus E Kehrli Jr [1]

[1]Virus and Prion Diseases of Livestock Research Unit, National Animal Disease Center, Agricultural Research Service, US Department of Agriculture (USDA), PO Box 70, Ames, Iowa 50010, USA

→ the early production of IFN-γ in PRRSV-infected pigs might result from activation of NK cells; early systemic IFN-γ further activates additional NK cells via a positive feedback loop for rapid clearance of PRRSV from serum.

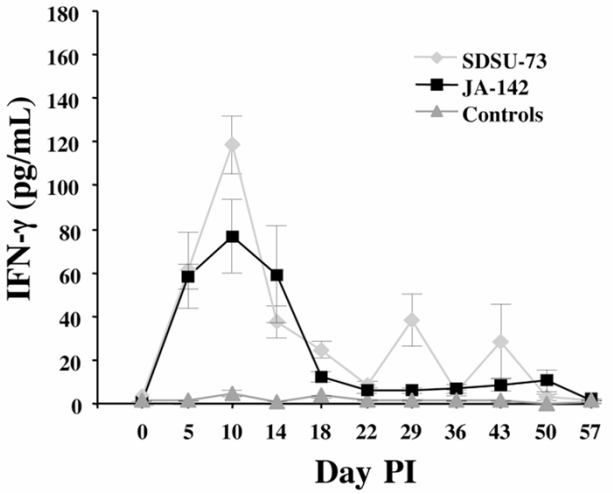


Fig. 1. Serum concentrations of IFNγ in pigs post inoculation (PI) with PRRSV, strain SDSU-73 or strain JA-142, or after sham inoculation.

frontiers in Microbiology

Immune cell early activation, apoptotic kinetic, and T-cell functional impairment in domestic pigs after ASFV CADC_HN09 strain infection

Yunfei Tian [1,†], Dongyue Wang [2,†], Shicheng He [3], Zhen Cao [2], Wencai Li [2], Fei Jiang [2], Yifan Shi [2], Yuxin Hao [2], Xinhao Wei [2], Qingqing Wang [2], Shuai Qie [2], Jiangtao Wang [2], Ting Li [2], Xiaoli Hao [1], Jianzhong Zhu [1,4], Jiajun Wu [2,*], Shaobin Shang [1,4,*], Xinyan Zhai [2]

[1]College of Veterinary Medicine, Institute of Comparative Medicine, Yangzhou University, Yangzhou, China

[2]The Biosafety High-Level Laboratory Management Office, China Animal Disease Control Center, Beijing, China

[3]Animal Disease Control Center of Hunan Province, Changsha, China

[4]Jiangsu Co-Innovation Center for Prevention and Control of Important Animal Infectious Diseases and Zoonosis, Yangzhou University, Yangzhou, China

→ the failure to develop an effective adaptive immunity to ASFV may be related to ASFV-induced immunosuppression or the impaired function of APCs, B cells, and T cells (including its capability to produce cytokines).

Conclusion

Insoluble, long β-1,6 branched 1,3 glucans from Baker's yeast with its potent immunomodulatory effect could:

1) support animals' natural defenses

2) alleviate the negative effects of stress

3) boost vaccine response

4) assist in the recovery of the animals

5) enhance growth and performance

araming salamat po!