Transgenic Animals for Agriculture: Current status and prospects





James D. Murray Department of Animal Science Department of Population Health and Reproduction University of California, Davis CA 95616 USA

The imperative is simple: Given the increasing world population

Animal production must be increased using less land, less water, and in a sustainable manner

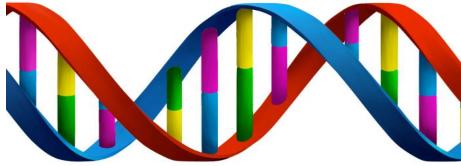
 We need to use all tools available: nutrition management vaccines
 ART (including cloning) selective breeding genetic engineering gene editing



AquAdvantage Salmon

GE: A perfect example of one such technology that is <u>NOT</u> being used!

Keep in mind - in the USA DNA is the regulated article



Currently for animals the insertion of DNA is the trigger for regulation

FDA defines transgene DNA as a New Animal Drug

Transgene inherited through normal breeding considered drug residue

BIOTECHNOLOGY IS NOT THE BOTTLENECK

- We can now, and indeed have, produced GE animals suitable for food
- The applications and potential benefits are real



As I see it:

Compared to plants, GE livestock (but not necessarily fish), pose essentially zero threat to the environment and biodiversity.

Experience with GE plants and animals indicate they pose little to no food safety risk to people.

GE crops widely embraced and their products have been consumed in billions of meals.

As of today

November 2015 - first GE animal product approved for food anywhere in the world – the AquAdvantage Salmon

But you still cannot buy it anywhere in the world

Since 2008, majority of lines of TG livestock for food produced in China, but none have been approved! Genetically engineered animals are available Deliver the intended benefits No identified negative effects

Some GE animals available today



the enviro-pig™







bα-lactalbumin pigs



flu resistant chickens

Transgenic animals produced and characterized for use in agriculture

			References
Species	Transgene*	Production	Characterization
Pig	ba-LA/ba-LA	Bleck et al., 1998	Wheeler et al., 2001; Noble et al., 2002; Marshall et al., 2006
	mPSP/APPA	Golovan et al., 2001	Forsberg et al., 2003, 2013
	ba-LA/hIGF-I	Monaco et al., 2005	Hartke et al., 2005
Cattle	bCsn/hLF	van Berkel et al., 2002	Thomassen et al., 2005; Simojoki et al., 2010; Cooper et al., 2012, 2014
Goat	bαS ₁ Csn/hLz	Maga et al., 2003	Maga et al., 2006a, b, c, 2012; Scharfen et al., 2007; Brundige et al. 2008, 2010; Jackson et al., 2010, Cooper et al., 2011, 2013, 2014a, b; Carvalho et al., 2012; Clark et al., 2014, McInnis et al., 2015; Garas et al., 2016

*Transgenes: ba-LA/ba-LA-bovine α-lactalbumin, mPSP/APPA-mouse parotid secretory protein/*E. coli* phytase, ba-LA/hIGF-1- bovine α-lactalbumin/ human insulin like growth factor-1, bCsn/hLF-bovine casein/human lactoferrin, bCsn/hLz-bovine αS₁casein/human lysozyme.

Presence of TG DNA and protein in food product

	Meat	Meat	Milk	Milk
	TG-DNA	TG-Protein	TG-DNA	TG-Protein
b-Lactalbumin-pig	yes	no	yes	yes
h-IGF-1 pig	yes	no	yes	yes
b-Csn/h-lactoferrin	yes	no	yes	yes
EnivroPig (E. coli phytase)	yes	no	yes	no
H-Lysozyme-goat	yes	no	yes	Yes
AquAdvantage salmon (csGH)	yes	yes	N.A.	N.A.

All of these proteins, have been, and are now consumed regularly – *i.e. when not GE are GRAS*

bovine alpha-lactalbumin pigs

- Express bovine α-lactalbumin only in lactating mammary gland
- Sows produce more milk
- Baby pigs grow faster, heavier at weaning = increased sustainability



Wean more pigs = improved animal welfare

Regulatory paradigm should reflect potential hazard and risk of harm



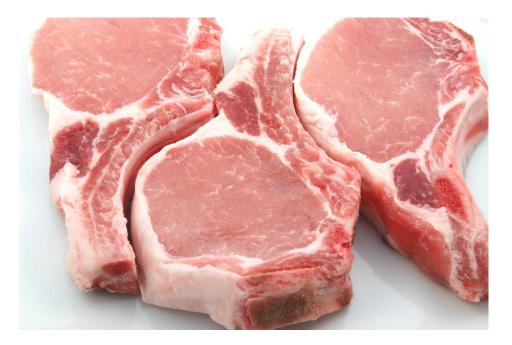
This we know: bovine lactalbumin is commonly consumed in:







Furthermore - meat from these animals does not contain alpha-lactalbumin –



only transgene DNA

and DNA is Generally Recognized As Safe to eat

Other GE animals produced for agriculture since 1990

PigmaP2/FAD2Saeki et al., 2004CAG/hfat-1Lai et al., 2006; Pan et al., 2010bCsn/hLzTong et al., 2011UG-RNA /PRRSV#RMALi et al., 2014CattlecASK/hERbCsn/hLFKrimpenfort et al., 1991bCSn/hLFKrimpenfort et al., 1991bSV/cc-skiBowen et al., 1994bbCsn/bbCsn & bk-CsnBrophy et al., 2003kO PrP ^{BSE} Richt et al., 2007hLA/hLAWang et al., 2008bLF/hLFYang et al., 2008bCsn/hLzYang et al., 2011?/fat-1Guo et al., 2011Pf1a/anti-GDF8 shRNATessanne et al., 2012mMCKE-cbA/mfat-1Wu et al., 2012mWAP-BLG-miRNAJabed et al., 2012bMSR1-lpr1Wang et al., 2004oCsn/hLFZhang et al., 2006ocsn/hLFZhang et al., 2008SheepRSV/CE, CK,oMT/CE, CKWard and Nancarrow, 1991mKER/olGF-1Damak et al., 1996aUG-RNA/MSTN*BRNAHu et al., 2013	Species	Transgene*	Reference	
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Conclusions:

Prospects for the use of transgenic animals in agriculture

- 1) Short term prospects seem unlikely
- World-wide "Long" Regulatory timeframe hampers innovation and industry investment
 a. regulatory issues are political
- 3) Process vs product-based regulation
- 4) Activist opposition in the absence of scientific or clinical data showing problems