MULTI-CRITERIA DECISION ANALYSIS OF FEED FORMULATION FOR LAYING HENS

AUNG MOE, KERRIANNE KOEHLER-MUNRO, ROGER BRYAN, TOM GODDARD, and LEN KRYZANOWSKI
Alberta Agriculture & Rural Development, Edmonton, Alberta, Canada *Contact. aung.moe@gov.ab.ca

INTRODUCTION

- Feed production is a major contributor to greenhouse gas emissions of egg production systems in Alberta. In addition, feed cost accounts for a significant portion of the total cost of egg production.
- Feed formulation is a complex process of assembling a blend of feed ingredients that meets the nutritional requirements of laying hens. Inadequate nutrition may lead to a reduction in egg size and production.
- This study focuses on the best compromise solution to the optimal combination of feed ingredients that meets nutritional requirements of laying hens at the lowest possible cost with minimum carbon footprint.

LIFE CYCLE ASSESSMENT OF FEED INGREDIENTS

- Carbon footprints of feed ingredients were assessed using ISO standards 14040/14044 (2006). The study included on farm crop production, subsequent drying, processing and the transport of feed grain to the farm. The functional unit used was 1 kg of feed ingredients at the gate of the feed mill.
- Background process associated with the input production, field operations and transport of feed grains to the feed mill were adapted from the ecoinvent database. Life cycle inventory data for wheat, barley, peas and canola were developed using Alberta crop production data. Corn, corn dry distiller grains (DDGS), soybean and soymeal was taken from United States production data.
- IPCC 2007 GWP 100a was selected from SimaPro 7.3.3 to evaluate the global warming potential (GWP) of feed ingredients.

MULTI-CRITERIA DECISION ANALYSIS OF FEED FORMULATION

- Two objectives – the least cost (LC) and the lowest carbon footprint (LI) were solved using a traditional linear programming model to find target values which were used in the multi-criteria decision analysis (MCDA).
- Crude protein, metabolizable energy, available phosphorus, calcium, methionine, methionine+cystine, lysine, threonine, tryptophan and isoleucine were considered as nutritional lower bound constraints based on diet specifications for layers (60-70 weeks) from commercial poultry nutrition (Leeson et al. 2008).
- Price data for wheat, barley, corn, corn DDGS, soymeal and canola meal were collected from the Alberta Pulse Growers Association.
- When the two target values for the least cost and the lowest carbon footprint were solved, a multiple objective programming was solved using the MINIMAX formulation which minimized the weighted percentage deviations from the target values for each of the two objectives (Tozer and Stokes 2001).
- For an equally weighted multiple objective scenario ($W_C W_I$), the weights for the target values were set to one (i.e. W_{LC}=W_{LI}=1). For cost heavily weighted multiple objective scenario ($2W_C 1W_I$), the weight for the cost was doubled (i.e. W_{LC}=2 and W_{LI}=1). For a carbon footprint heavily weighted multiple objective scenario ($1W_C 2W_I$), the weight for the carbon footprint was doubled (i.e. W_{LC}=1 and W_{LI}=2).

Fig. 1. Unit cost per crude protein (%) and energy (1000 kcal) of major feed ingredients

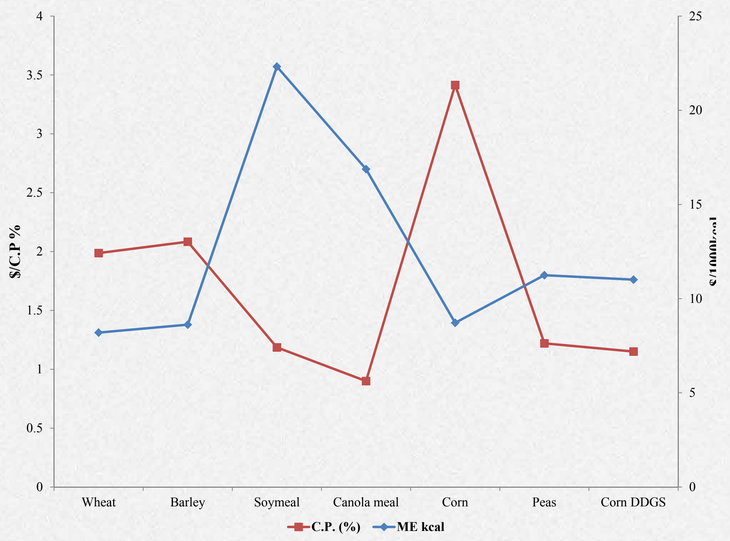


Fig. 2. Carbon footprint of major feed ingredients

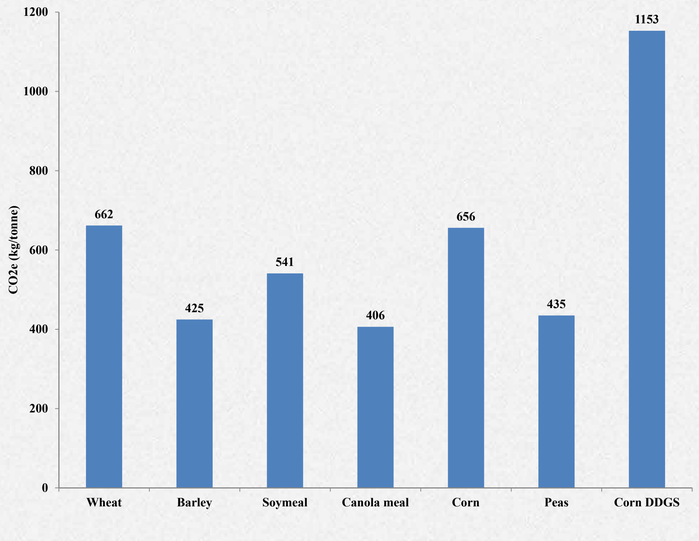


Fig. 3. Carbon footprint per crude protein (%) and energy (1000 kcal) of major feed ingredients

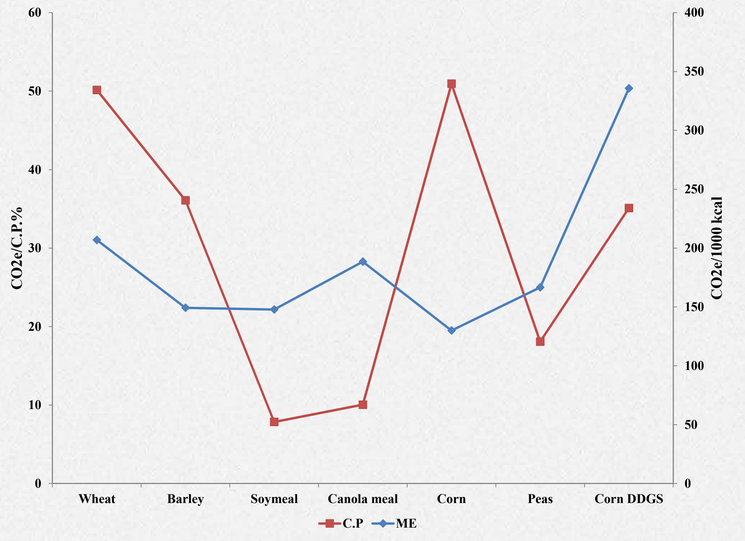


Fig. 4. Optimal feed formulations and costs for five scenarios

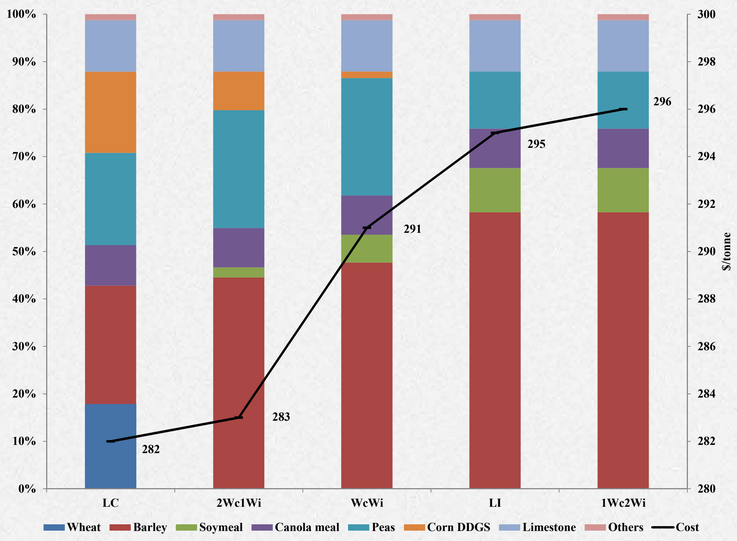


Fig. 5. Trade-off between costs and carbon footprints for optimal feed formulations

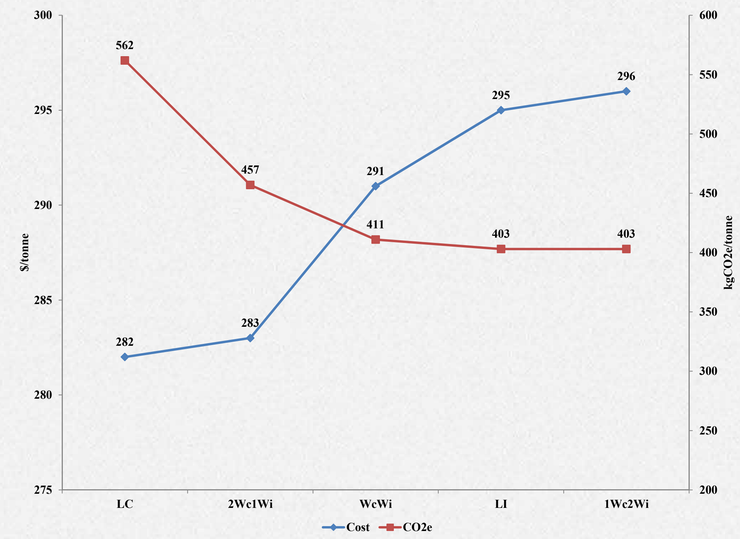
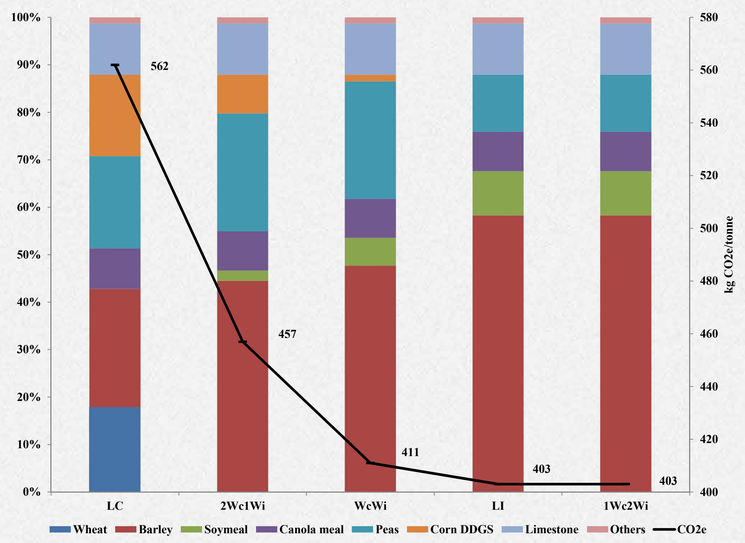


Fig. 6. Optimal feed formulations and carbon footprints for five scenarios



CONCLUSIONS

- The carbon footprint of feed formulations can be reduced using lower impact feed ingredients satisfying nutritional requirements of laying hens. The feed cost will be slightly higher in order to reduce the carbon footprint of the feed formulation. However it is possible to find a lower carbon footprint of formulated feed at a reasonable cost.
- Barley, peas and canola meal can play a major role in reducing the carbon footprint of the feed formulation in Alberta.
- Multi-criteria decision analysis can be used as a tool to achieve the best possible combination of feed ingredients at the lowest possible cost with the lowest carbon footprint.

REFERENCES

ISO 14040:2006 (2006) Environmental Management – Life Cycle Assessment – Principles and framework, the International Organization for Standardization, Geneva
ISO 14044:2006 (2006) Environmental Management – Life Cycle Assessment – Requirements and guidelines, the International Organization for Standardization, Geneva
Leeson S, Summers JD, (2008) Commercial Poultry Nutrition. Thrumpton, Nottingham: Nottingham University Press
Tozer PR, Stokes JR, (2001) A multi-objective programming approach to feed ratio balancing and nutrient management. Agricultural Systems 67:201-215

LCA Food 2014 Conference
October 8-10, 2014
San Francisco, CA, USA

Growing Forward 2
A federal-provincial-territorial initiative
Egg Farmers of Alberta
Alberta Government
Canada