Soybean meal in Poultry Feed; Nutrition and Prospectus

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Indian Animal Husbandry - Poultry

- No 1 in Milk production -**221 Mmt** per year.
- No 3 in Egg production- **129 billion** eggs per year.
- No 5 In chicken meat production- **4.3 Mmt** per year.

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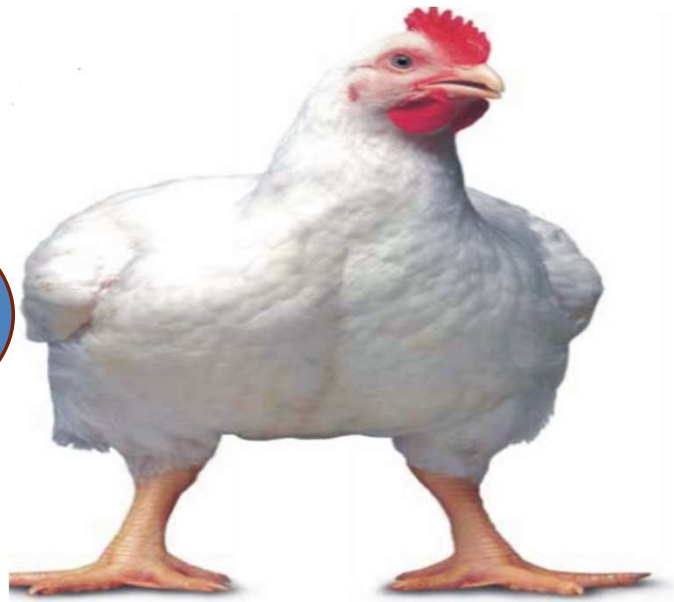
40 gm

32 Days



2 kg

52 wks

18 kg (44 g/d)

310-330 eggs/year

1.3 kg

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Key? **Balanced Diet**

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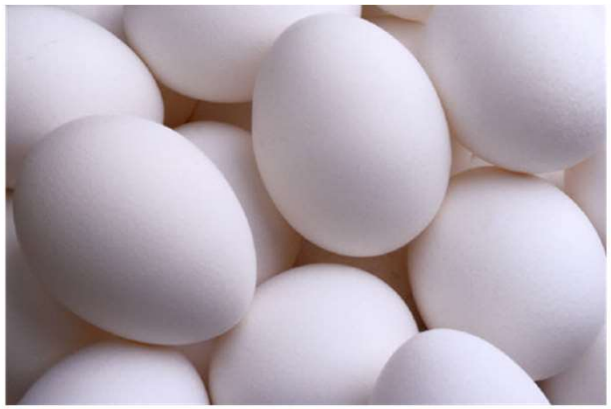
Broiler Chicken Meat (mmt)

4.3 mmt

- Availability – 3.6 kg/year
- Requirement – 10.8 kg/year

Egg Production (Billions)

129 Billions



Availability 92/yr
Requirement 180/Yr (ICMR)

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Great SCOPE

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Soybean meal

Protein–barrel theory

- About **20% of poultry** diet is SBM
- SBM contributes 60% of **high-quality protein**

Functions:

- Structural parts of **soft tissues**
- **Blood proteins** albumin, globulin, fibrinogen, hemoglobin, etc.,
- Enzymes, hormones, antibodies etc.

AA digestibility

	Meth.	Cystine	Lysine	Arginine	Thr.
Maize	91	85	81	89	84
Wheat	87	87	81	88	83
SBM	92	82	91	92	88
Maize gluten meal	91	80	88	96	92
Meat meal	85	58	79	85	79
Feather meal	76	59	66	83	73

NRC (1994)

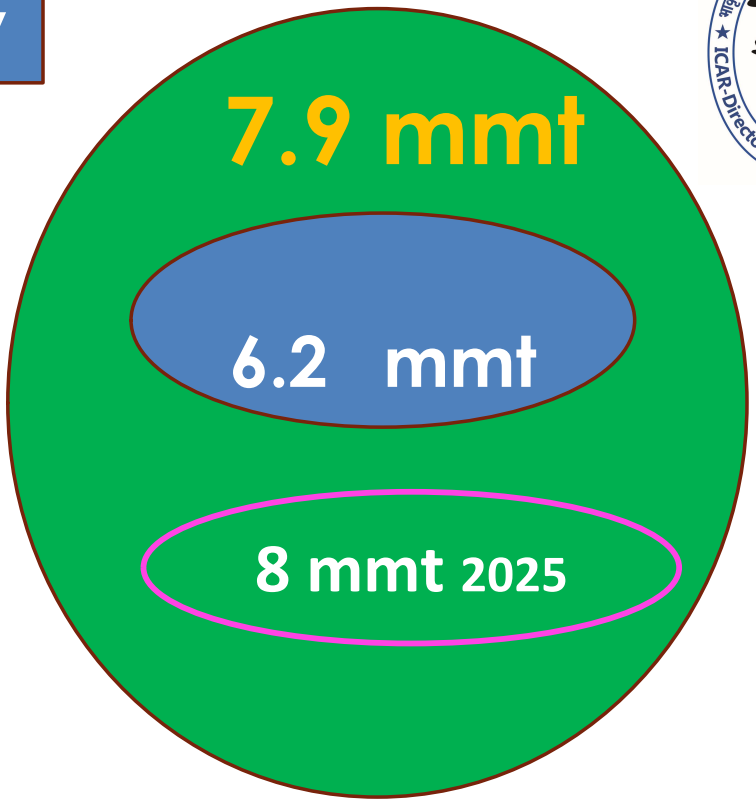
SBM Availability

Layers 320 m: 12.8 mmt per yr

Broiler 4600 m: 18.4 mmt per yr

Poultry feed– 31 Mmt (2021-22)

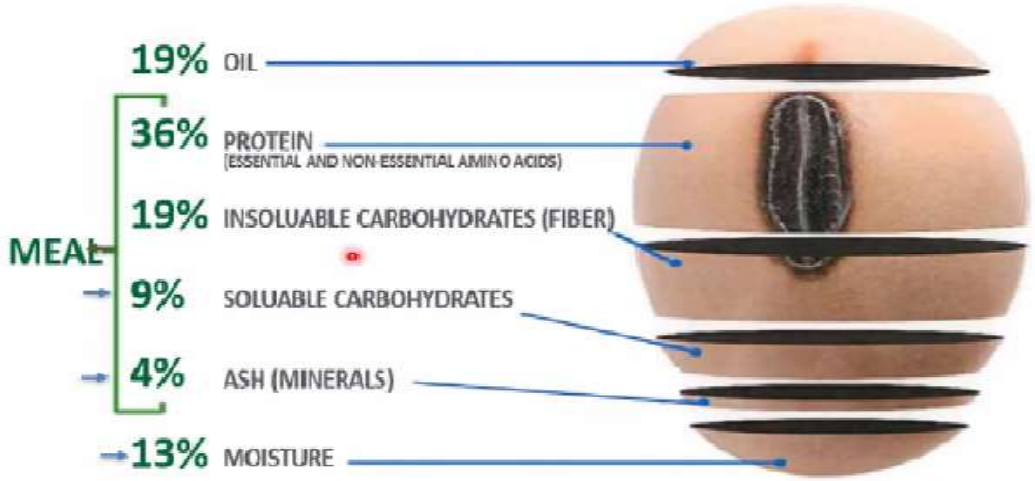
39 Mmt (2025)



https://www.indexmundi.com/agriculture/?country=in&commodity=soybean-meal&graph=production (USDA)

Soybean Composition

- **Soybeans**: Source of proteins and fat



Problem: Naturally, soybeans have anti nutritional factors (ANF) and allergens

Limitations with SBM

- **Adulteration**
  - Guar
  - Sand
  - DORB
  - Saw dust
- **Improper processing**
- **Expensive**
- **Non-Available**

Anti-Nutritional Factors (ANF) on Soybeans

- **Trypsin Inhibitors (Proteases)**:
  - Reduce protein digestibility
  - Reduce growth (make susceptible to diseases)
- Lecithin:
  - Damage to intestine walls– effect on nutrient absorption.
- Glycine:
  - Gastrointestinal problems– allergens.
- Urease:
  - Increase available nitrogen (indicator of level of processing)

Quality control tests for heat-treated SBM

Test	Principle	Duration	Accuracy	Measurement	Recommended Values
Urease Index	Heat DENATURES UREASE and thus anti-nutritional; indicator of under-heating.	20 min.	Average	pH increase due to NH_3 release	0.02 - 0.30
0.2%KOH solubility	Over-heating reduces N solubility in 0.2 % KOH; quantification of over-heating.	20 min.	Average	Protein solubilized	70-85% (70%)
TIA (Trypsin Inhibitor Activity)	Direct measurement of Trypsin Inhibitor; indicator of all anti-nutritional components	>24 hr.	Good	Presence of trypsin inhibitors	< 5 mg/g
Dye-Binding (cresol red)	Measures lysine (free epsilon amino group); reduced by over-heating,	< 10 min.	Low	Dye binding related to protein solubility.	5.0 – 6.5 mg/g

Trypsin inhibitor inactivation with heat treatment

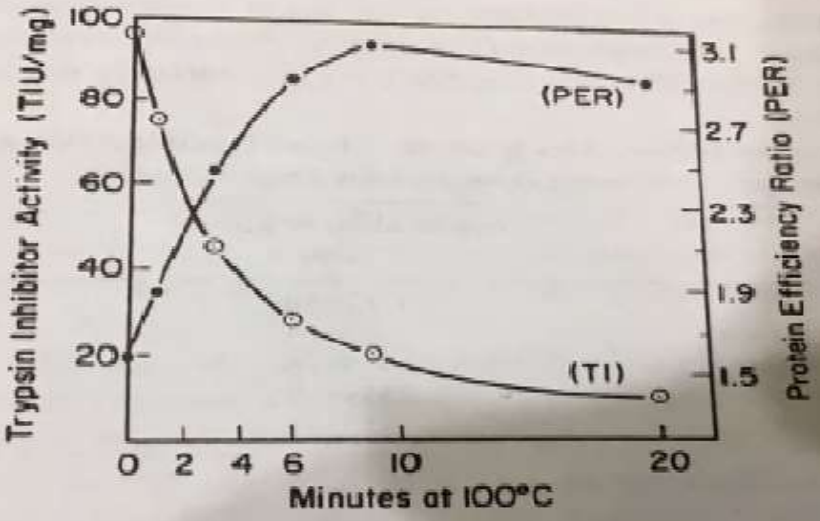


Figure 2.11. Effect of steaming on trypsin inhibitor activity and protein efficiency ratio (PER) of soy meal. From Rackis (1974).

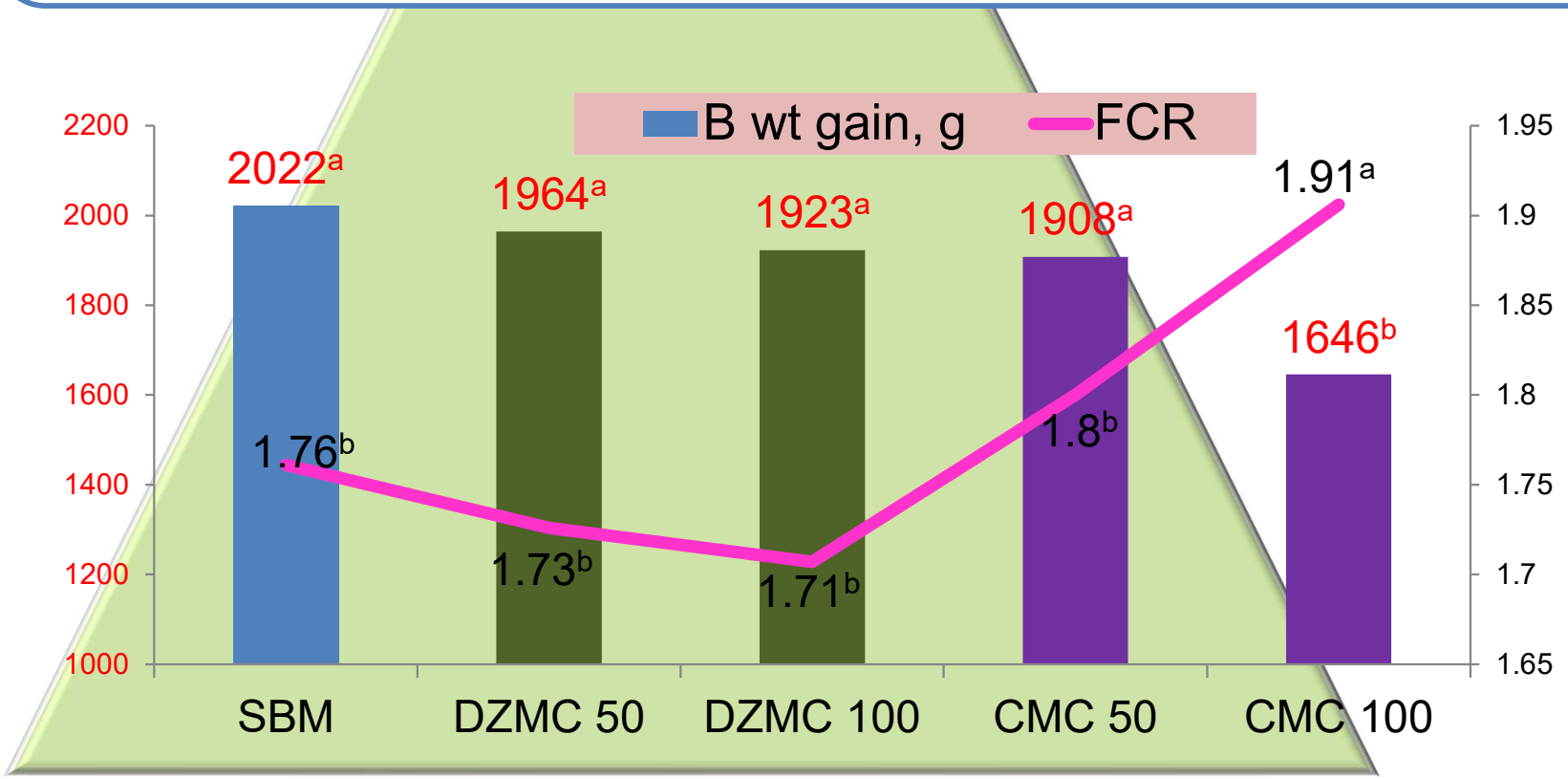
Soybeans
by KeShun Liu

Alternate Protein Sources to cut down the cost of production

Contain intrinsic constituents - **hamper performance** at higher levels

Guar meal: (Residual gum (18–20%) and Trypsin inhibitor)

Xylanase 6500, Glucanase 2400. Cellulase 1780, Mannanase 8000 and Protease 8000 Units/kg diet



Rama Rao et al (2005 & 2014)

SBM

- AA profile is complementary to cereal protein
- Properly processed SBM (No ANF)
- High Protein (40-50%)
- Excellent source of Lys. (2.96%), Try., Thr.
- High AA digestibility (89%)

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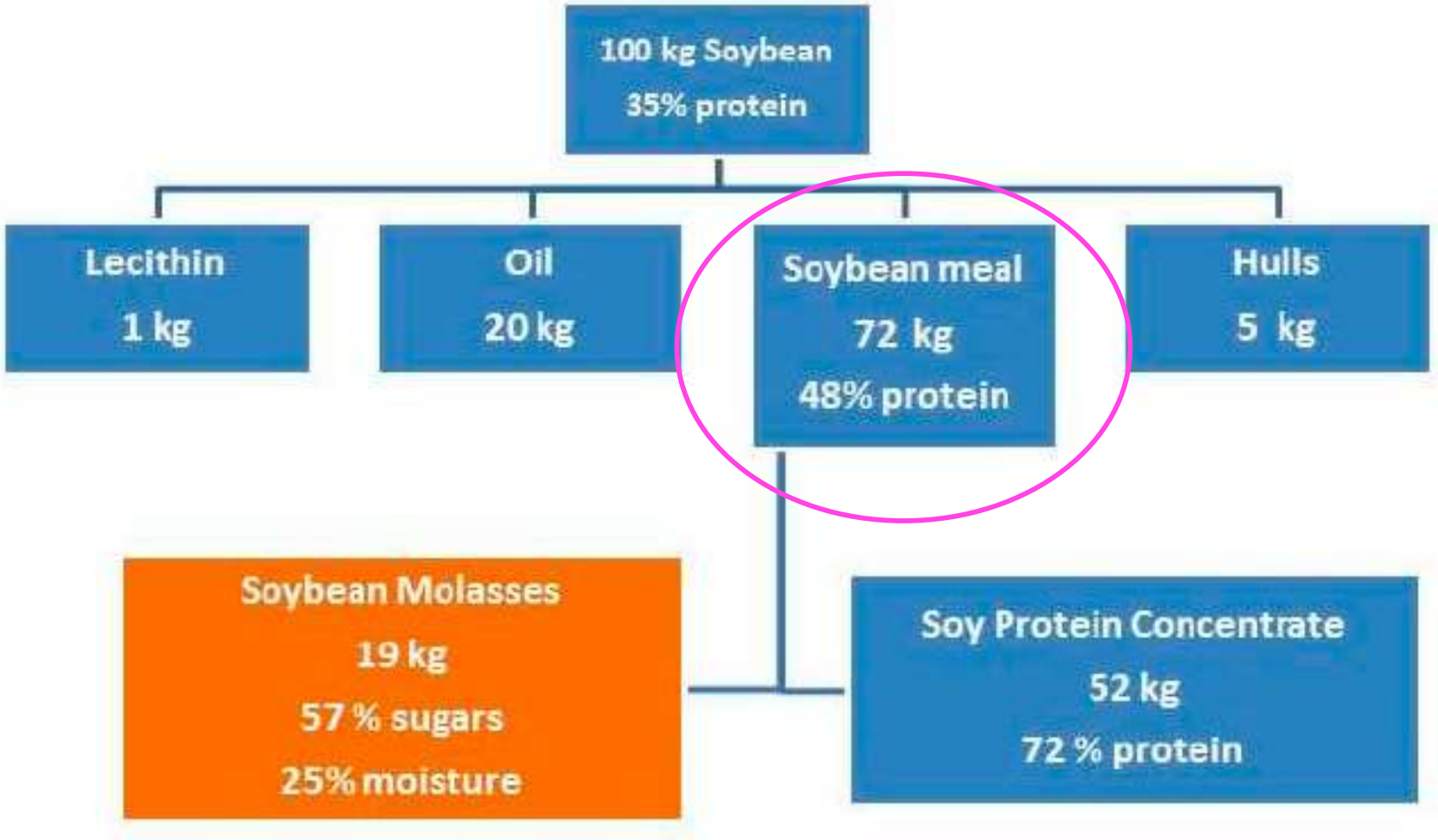
SB: Products of Processing



Karp et al (2016)

SB Products in Broiler Chicken

Table 1. Chemical composition of soybean feeds.

Item	Soybean Meal GM	Soybean Expeller Cake Non-GM	Extruded Full-Fat Soybean Non-GM
Basal nutrients ($g \cdot kg^{-1}$)			
dry matter	894.6	940.4	939.8
crude ash	70.3	60.0	51.6
crude protein	452.0	443.6	349.5
crude fat	20.7	55.7	218.0
crude fibre	66.0	59.0	61.8
N-free extractives	285.6	322.1	258.9
Gross energy ($kcal \cdot kg^{-1}$)	2868	4730	5420
Anti-nutritional factors ($g \cdot kg^{-1}$)			
trypsin inhibitors	1.40	5.90	8.88
tannins	14.9	2.90	5.08

Alina et al (2022): Animals

Table 3. Rearing results of broiler chickens.

Item	Group			SEM	*p*-Value
	SBM	SEC	EFS		
			Bodyweight (g)		
1 day	42.9	43.0	43.0	0.096	0.682
21 day	721 ^{b}	760 ^{a}	715 ^{b}	7.42	<0.05
42 day	2294 ^{b}	2400 ^{a}	2361 ^{a}	13.5	<0.05
			Bodyweight gain (g)		
1–21 days	678 ^{b}	717 ^{a}	678 ^{b}	7.42	<0.05
22–42 days	1573 ^{b}	1639 ^{a}	1646 ^{a}	12.61	<0.05
1–42 days	2251 ^{b}	2357 ^{a}	2318 ^{a}	13.48	<0.05
			Feed conversion ratio (kg)		
1–21 days	1.59 ^{b}	1.52 ^{c}	1.66 ^{a}	0.017	<0.05
22–42 days	1.75 ^{a}	1.67 ^{b}	1.83 ^{a}	0.020	<0.05
1–42 days	1.69 ^{b}	1.68 ^{b}	1.76 ^{a}	0.012	<0.05

SBM—soybean meal, SEC—soybean expeller cake non-GM, EFS—extruded full-fat soybean non-GM, SEM—standard error of mean; ^{a,b,c}—means with different superscripts within a row are significantly different at $p \leq 0.05$.

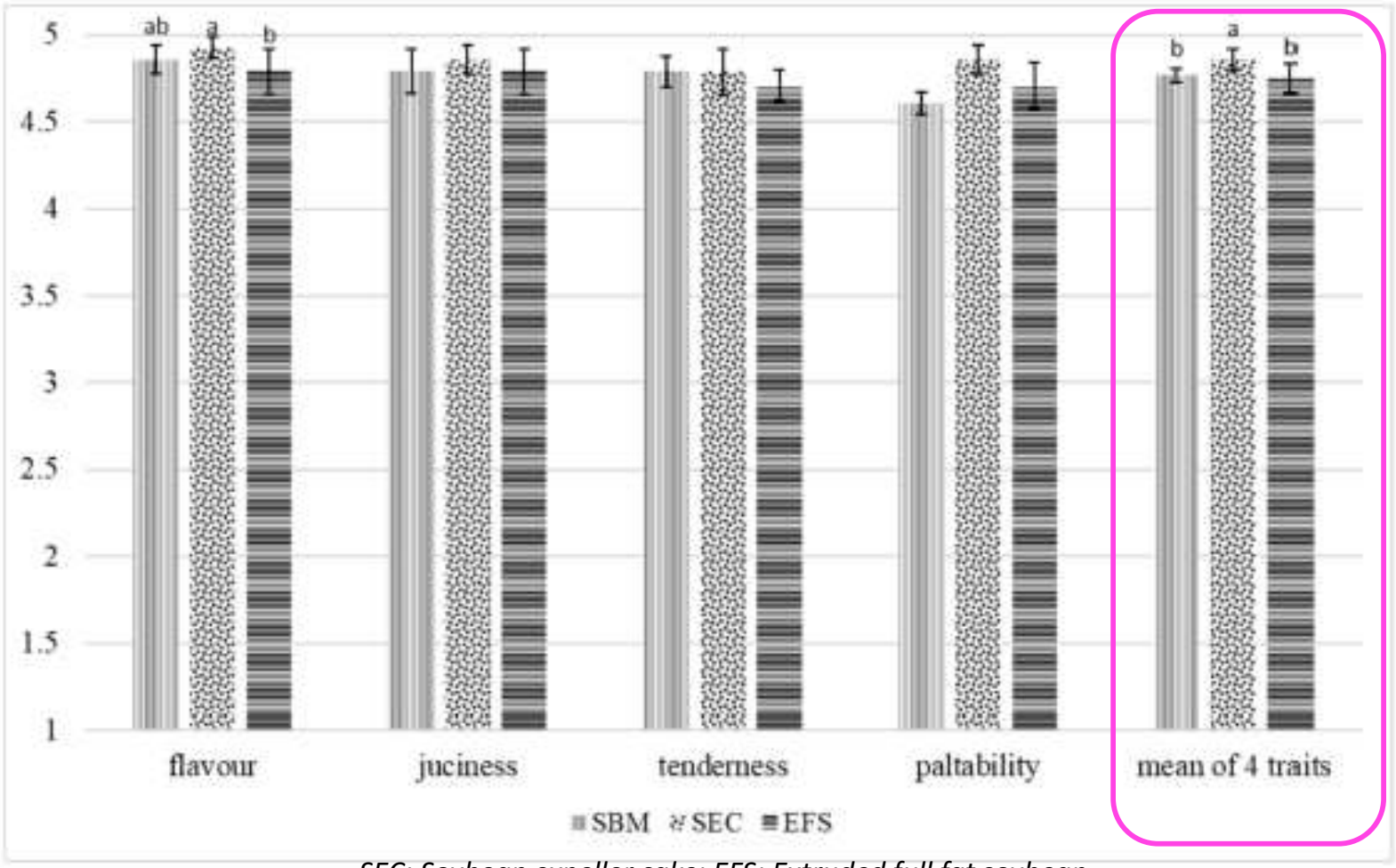
Alina et al (2022): Animals

Fatty acid profile (% of total fatty acids) in thigh muscle

Fatty acids	Groups				
	SBM	Soybean expeller cake	Extruded full fat soybean	SEM	P value
C18:n-6	31.2^{b}	32.6^{b}	43.0^{a}	1.44	<0.05
C18:n-3	1.35^{c}	1.59^{b}	2.24^{a}	0.11	<0.05
SFA	27.99^{a}	26.89^{a}	21.17^{b}	0.82	<0.05
USFA	71.84^{a}	72.87^{a}	78.67^{b}	0.83	<0.05
MUFA	38.9^{a}	38.4^{a}	33.21^{b}	0.75	<0.05
PUFA	32.95^{b}	34.42^{b}	45.4^{a}	1.54	<0.05
n-6:n-3	22.64	20.52	19.20	0.72	0.09
DFA= (UFA+C18)	76.99^{b}	77.91^{b}	82.64^{a}	0.695	<0.05
OFA= (C14+C16)	22.56^{a}	21.97^{a}	16.87^{b}	0.702	<0.05

DFA: neutral and hypocholesteremic fatty acid
OFA: hypercholesterolemic fatty acids

Alina et al (2022): Animals



SEC: Soybean expeller cake; EFS: Extruded full fat soybean

Figure 2. Sensory evaluation of thigh muscles (point). a,b—means with different superscripts within a row are significantly different at $p < 0.05$.

Recommended Soybean expeller cake and Extruded full fat soybean as complete substitute for SBM in broiler chicken

Alina et al (2022): Animals

Key nutrient composition of some soy protein ingredients used in animal feeds.

	Unit	Full-fat Soy-beans (FFSB)	SBM; Mecha-nical Extract.	SBM; Solvent Extract. 44	SBM; Solvent Extract. 48	SBM; Solvent Extract. 50	Soybean Hulls	SBM-Fermen-ted	SPC (Soy Protein Conc.)	SPI (Soy Protein Isolate)
Dry matter	%	89.4	89.8	88.1	87.6	88.2	89.8	90.1	91.8	93.4
Crude protein	%	37.1	43.9	44.0	46.4	48.8	12.0	52.1	68.6	86.9
Crude fiber	%	5.1	5.5	6.3	5.4	3.4	34.1	3.6	1.7	1.3
Ether extract	%	18.4	5.7	1.8	2.1	1.3	2.2	2.7	2.0	0.6
Ash	%	4.9	5.7	6.3	6.0	5.8	4.5	6.6	5.2	3.4
NDF[3]	%	13.0	21.4	13.0	11.8	10.0	56.9	9.0	13.5	-
ADF[3]	%	7.2	10.2	8.8	7.0	5.0	42.1	5.6	5.4	-
ADL[3]	%	4.3	1.2	0.7	0.9	0.4	2.1	0.3	0.4	-
Starch[4]	%	<0.5	<1.0	<1.0	1.1	0.8	0.7	<0.5	0.0	0.0
NSP[5]	%	24.3	32.2	34.2	31.1	30.9	68.5	27.9	15.2	3.0
Gross energy[6]	kcal/kg	5013	4420	4165	4130	4120	3890	4700	4665	5370

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Dry matter	%	89.4	89.8	88.1	87.6	88.2	89.8	90.1	91.8	93.4
Crude protein	%	37.1	43.9	44.0	46.4	48.8	12.0	52.1	68.6	85.9
Lysine	%	2.26	2.65	2.73	2.90	3.00	0.73	3.02	4.42	5.31
Lysine/CP		6.10	6.03	6.20	6.24	6.15	6.10	6.03	6.44	6.18
Methionine	%	0.52	0.60	0.62	0.64	0.67	0.14	0.65	0.96	1.09
Cystine	%	0.53	0.64	0.66	0.70	0.73	0.19	1.03	0.95	1.02
Arginine	%	2.66	3.05	3.23	3.46	3.56	0.62	3.52	5.15	6.42
Isoleucine	%	1.68	1.95	2.01	2.15	2.21	0.44	2.24	3.17	4.12
Valine	%	1.75	2.07	2.11	2.26	2.30	0.52	2.48	3.29	4.21
Glycine	%	1.58	1.81	1.89	2.01	2.11	0.91	2.15	2.80	3.59
Serine	%	1.86	2.08	2.24	2.40	2.50	0.65	2.35	3.45	4.37
Tryptophane	%	0.49	0.58	0.60	0.63	0.65	0.16	0.66	0.84	1.14

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Concentration of energy, DM, and nutrients in soybean meal from five origins.

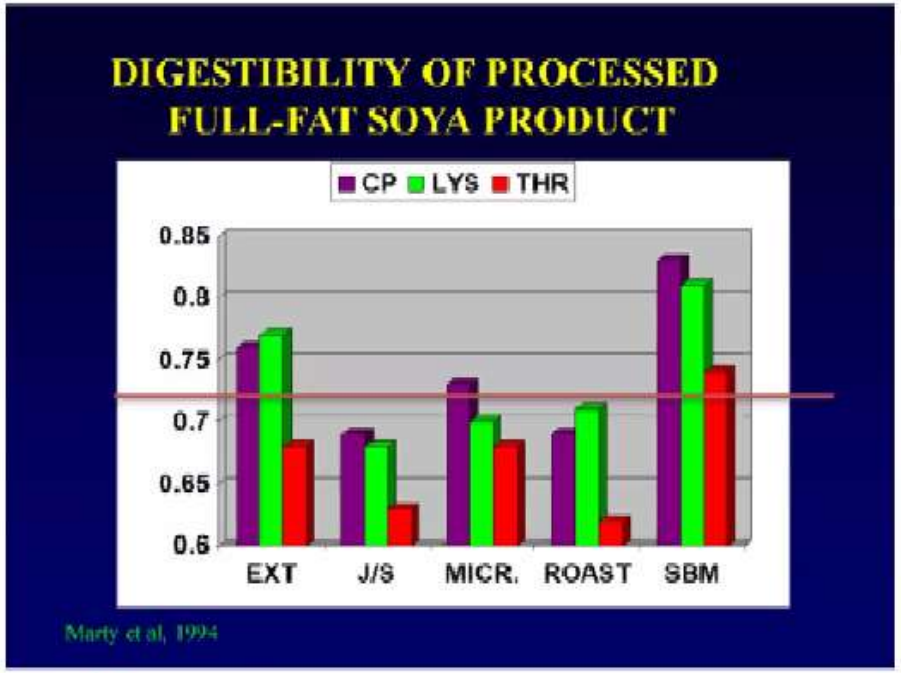
Item		Country U.S.	China	Argentina	Brazil	India	SEM	P-value
DM,	%	88.5^{b}	89.5^{a}	89.1^{ab}	88.4^{b}	88.3^{b}	0.3	0.038
CP,	%	47.3^{b}	45.1^{c}	46.7^{b}	49.3^{a}	49.5^{a}	0.54	<0.001
ADF,	%	3.69b	5.60a	3.69b	4.95ab	6.41a	0.52	0.007
Sucrose,	%	8.59^{ab}	8.91^{a}	7.56^{b}	5.52^{c}	4.69^{c}	0.42	<0.001
Raffinose,	%	1.45^{bc}	1.18^{c}	1.47^{bc}	1.54^{b}	1.98^{a}	0.12	0.003
Stachyose,	%	6.47^{a}	5.55^{b}	5.23^{bc}	4.47^{c}	5.09^{bc}	0.28	0.001
TIU/mg[4]	mg/g	2.69^{bc}	2.92^{bc}	1.99^{c}	3.46^{ab}	4.10^{a}	0.35	0.006

[4]TIU = trypsin inhibitor units.

(Lagos and Stein; 2017)

Amino Acid Digestibility

- Ext = Extrusion
- J/S = Jet Sploding
- MICR = Micronizing
- ROAST = Roasting
- SBM = soybean meal solvent extraction
- CP = Protein
- LYS = Lysine
- THR = Threonine



Fermented SBM on Broiler chicken: Meta analysis

Table 3. Descriptive statistics to compare chemical composition profile between soybean meal and fermented soybean meal of the studies included in the meta-analysis

Compositions	n	SBM		FSBM	
		Mean	SD	Mean	SD
Crude protein (g/kg DM)	21	433.9	40.27	495.9	10.89
Lys (g/kg DM)	13	28.0	1.27	29.5	1.15
Met (g/kg DM)	13	5.3	0.42	5.5	0.34
Trypsin inhibitor (mg/g)	13	238.6	234.28	0.7	0.45
Peptide (mg/g)	6	21.8	6.90	167.4	89.75
Glycinin, (mg/g)	8	85.3	27.90	15.2	4.41
β-Conglycinin (mg/g)	10	55.3	19.98	11.2	4.61

Bacillus subtilis: 57.4%
Aspergillus niger
Saccharomyces cerevisiae

Nutritional improvement associated with better nutrient utilization, BWG and FCR in broiler chicken

Irawan et al (2022) Animal Biosciences

Quantifying the value of SBM in Poultry

SB genotype selection focused on **yield improvement** and decreased **protein** content and **EAAs** over time (Patil et al 2017).

The analysis aimed to

1) Understand the financial value associated with varying Protein, amino acid and energy concentrations in SBM for poultry.
2) Estimating the **ECONOMIC VALUE OF SBM BASED ON NUTRIENTS**.

Pope et al (2023) The Journal of Applied Poultry Research

Table 1. Linear and predictive values of amino acids for SBM crude protein concentrations 44.0% to 48.0%.

Amino Acid	Intercept	Slope	*P*-value	R-squared	44%	45%	46%	47%	48%
MET	0.041	0.013	<0.0001	0.790	0.619	0.632	0.645	0.659	0.672
CYS	−0.106	0.018	<0.0001	0.528	0.665	0.683	0.700	0.718	0.735
MET + CYS	0.005	0.029	<0.0001	0.680	1.264	1.293	1.321	1.350	1.379
LYS	−0.168	0.066	<0.0001	0.881	2.745	2.812	2.878	2.944	3.010
THR	0.030	0.038	<0.0001	0.907	1.718	1.757	1.795	1.833	1.872
TRP	0.008	0.014	<0.0001	0.858	0.612	0.626	0.640	0.653	0.667
ARG	−0.629	0.087	<0.0001	0.938	3.193	3.280	3.367	3.454	3.541
ILE	−0.236	0.051	<0.0001	0.902	1.994	2.045	2.095	2.146	2.197
LEU	−0.132	0.078	<0.0001	0.921	3.316	3.394	3.473	3.551	3.629
VAL	−0.117	0.050	<0.0001	0.960	2.089	2.139	2.189	2.239	2.289
HIS	−0.052	0.028	<0.0001	0.887	1.159	1.186	1.214	1.241	1.269
PHE	−0.044	0.051	<0.0001	0.912	2.213	2.264	2.315	2.367	2.418

Pope et al (2023) The Journal of Applied Poultry Research

SBM Utilization (kg/MT)

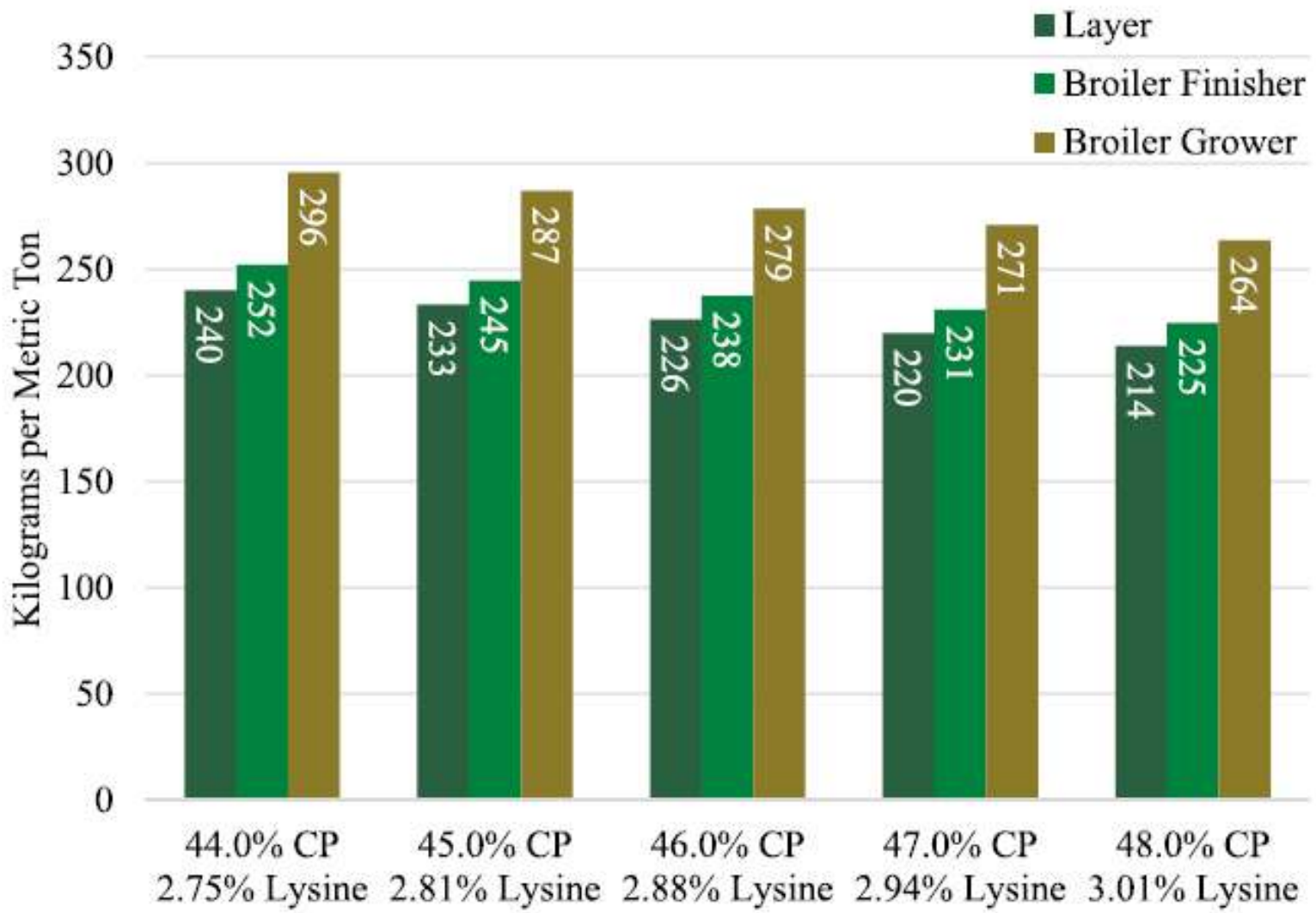


Figure 3. Soybean meal utilization in poultry diets, kilograms per metric ton of feed by crude protein (CP) and total lysine (%).

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Cost of Poultry Diet

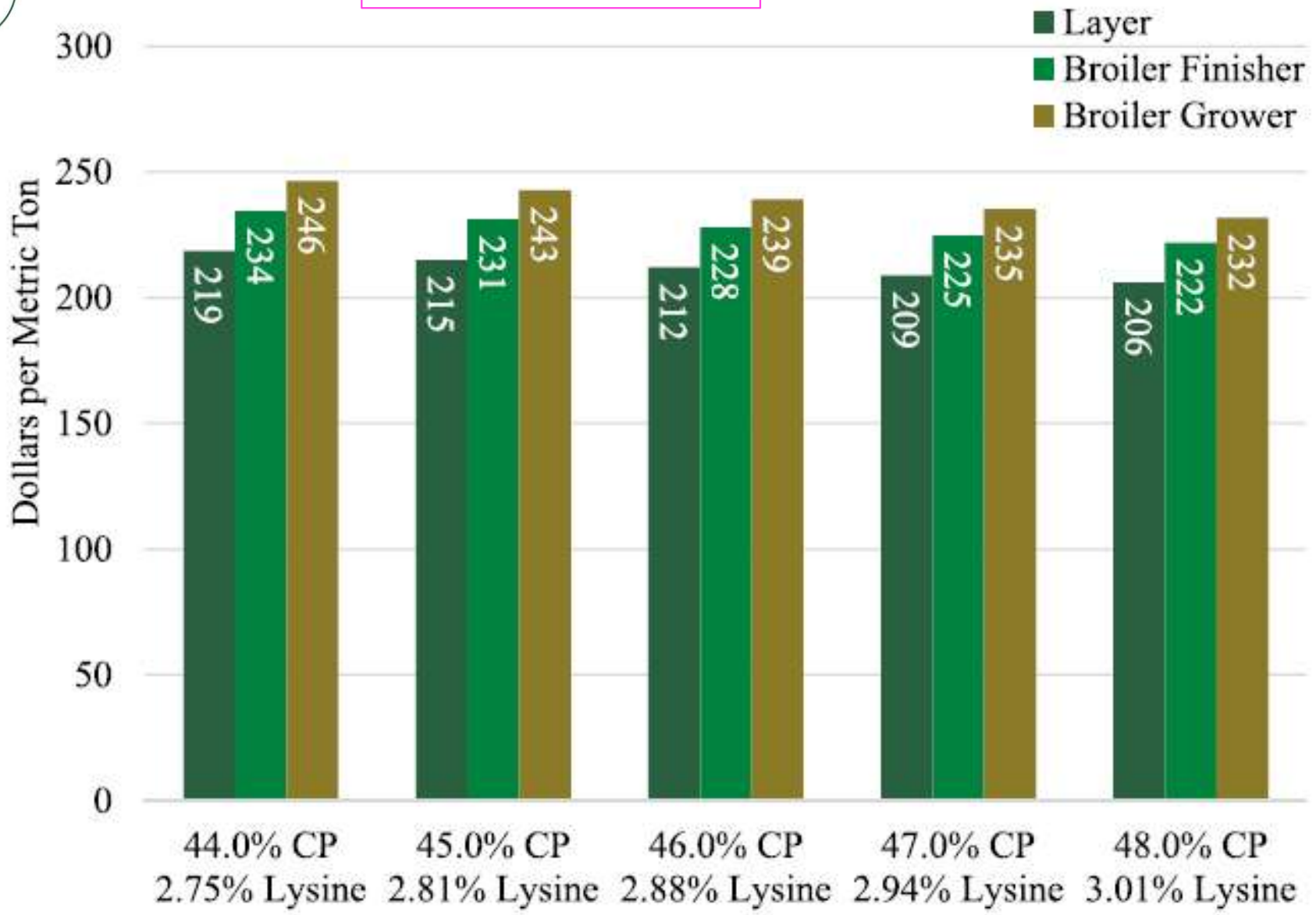

Figure 5. Total diet costs for poultry diets, dollars per metric ton by crude protein (CP) and total lysine (%).

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Relative Value

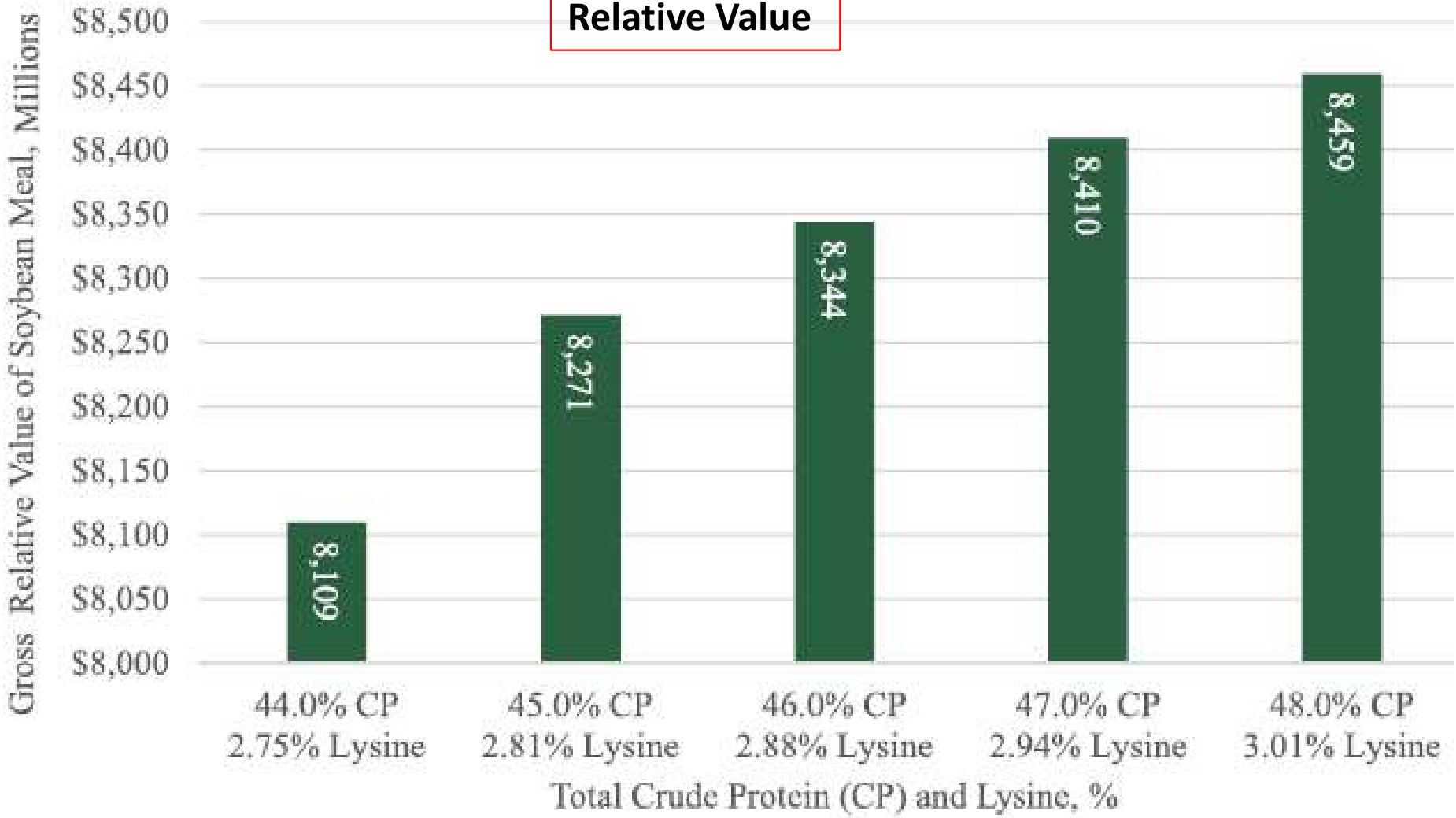

Figure 8. US gross relative value of soybean meal, 2018–2019 marketing year.

Each 1% increase in CP concentration from 44.0 to 48.0% (lysine 0.065%; 2.75 to 3.01%) increases SBM value approximately $12.62 per MT in poultry diets

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Future Challenges

- Increased demand for **vegetable oil for biodiesel production** may in turn reduce overall production of soybean in favour of other oilseed crops that produce more oil per acre.

Per acre (**SB 36 L**, safflower 72 L, sunflower 84 L and canola 108 L/acre)

- **By-products** from **ethanol and biodiesel** production (e.g. DDGS) are now competing with maize and soybean meal for their place in animal diets.

- Pressures to **improve nutritional** value of soybean through breeding to modify the **anti-nutritive factors**, fatty acid profile, and oligosaccharide or protein synthesis for animal feeding.


Soybean meal:
ultimate protein source for
feeding of Poultry


Thank You Sirs