Relationship between Plasma Amino Acid Profile and Ovarian Function around the Time of Ovulation in Beef Cows

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Summary and Implications

Pairing low quality forage with coproducts from the ethanol industry, likely results in excess dietary crude protein (CP) consumption. The effects of these excessive CP diets on beef cow reproduction have been shown to enhance ovarian parameters. However, the effects of excess dietary CP on circulating plasma amino acid (AA) profile are dependent on source and amount being supplemented. In the present study, we observed if relationships between blood plasma AA and ovarian parameters of beef cows consuming excess dietary CP (25 - 50%) around the time of ovulation existed. We observed that total plasma AA and essential AA were positively correlated with length of proestrus. In addition, as a percent of total plasma AA, progesterone concentrations 7 d post estrus were positively correlated with total essential AA. Based on these data, blood plasma AA appear to be correlated with ovarian parameters around the time of ovulation when cows are fed excess dietary CP. However, more research is warranted to elucidate how blood plasma AA directly impact ovarian parameters and influence reproduction in beef cows.

Introduction

As a part of two recent studies in our lab, offering non-lactating, non-pregnant cows ad libitum access to processed corn stalks with excess dietary protein appeared to enhance beef cow reproductive parameters around the time of ovulation. In addition, excess CP consumption has shown to impact circulating plasma AA concentrations, however the interactions of individual AA with ovarian parameters is highly unknown and warrants further investigation. Also, previous research evaluating plasma AA concentrations have shown branched-chain AA (isoleucine, leucine and valine) to interact with preovulatory parameters. More specifically, leucine has been noted to interact with metabolic pathways associated with tissue synthesis, such as the IGF-1 and mTOR pathways, which may increase growth of preovulatory follicles and luteal tissue development.

Therefore, the objective of this study was to determine if there are any relationships that exist between circulating blood plasma amino acids and ovarian parameters around the time of ovulation in beef cows consuming excess dietary CP with ad libitum access to low quality forage.

Materials and Methods

To study the relationship between plasma AA and ovarian parameters, we combined data from 2 studies which assessed the effects of excess (25 – 50%) dietary MP supplementation on ovarian parameters. Variables analyzed are presented in Table 1. Data were compiled across datasets and analyzed for correlations between AA profile and ovarian parameters of ovulatory follicular wave characteristics, corpus luteum development and hormone profiles. Data were analyzed using PROC CORR of SAS.

Results and Discussion

When total blood plasma AA and ovarian parameters were analyzed, a positive relationship ($r \geq 0.44$, $P < 0.05$) between length of proestrus and total AA, essential AA, glycogenic AA, branched-chain AA, urea cycle AA, arginine, isoleucine, lysine, threonine, tryptophan and valine were observed (Table 2). Progesterone concentrations 7 d post estrus were positively correlated ($r = 0.46$, $P \leq 0.02$) with urea cycle AA and arginine. Arginine is known to be a precursor for nitric oxide synthesis, which is a driver of blood flow, and may interact with circulating hormone concentrations by increasing ovarian blood flow. As a percent of total AA (Table 3), essential AA, urea cycle AA, arginine, thryptophan and valine were positively correlated with circulating progesterone 7 d post-estrus ($r \geq 0.40$, $P \leq 0.04$).

Based on these data, relationships do appear to exist between plasma AA and ovarian parameters around time of ovulation. Specifically, several branched-chain AA appear to be positively correlated with ovarian parameters and may be an area to focus on in future research.

Table 1. Ovarian parameters and amino acids analyzed for correlations

Variable	N	Mean	SD	Min	Max
Follicular wavelength, d	26	9	1.79	6	13
Ovulatory follicle diameter, mm	26	14	1.80	11	18
Secondary follicle diameter, mm	26	9	1.92	5	13
Ovulatory follicle size at dominance, mm	26	9	1.34	8	14
Duration of dominance, d	26	6.5	2.3	3	11
Average antral follicle count (AFC)	26	16	3	8	23
Corpus luteum volume 7d post- estrus	26	4.30	2	0.23	9.15
Progesterone 7 d post-estrus, ng/mL	26	4.14	1.74	0.14	6.95
Progesterone: CL volume, $ng \cdot mg^{-1} \cdot cm^{3\ -1}$	26	1.16	0.89	0.39	4.89
Peak Estradiol, pg/mL	26	7	2.1	3.4	11
Proestrus, h	25	48	0.89	12	96
Plasma AA (µmol/L)					
Total AA	26	1580	238	1080	2091
Essential AA	26	735	164	435	1099
Nonessential AA	26	845	127	629	1095
Glycogenic AA	26	968	139	715	1199
Ketogenic AA	26	219	58	101	380
Branched-chain AA	26	676	103	485	964
Urea cycle AA	26	205	51	113	304
Arginine	26	67	25	30	126
Histidine	26	53	9.7	30	71
Isoleucine	26	77	16.9	41	108
Leucine	26	154	51	66	279
Lysine	26	66	27	24	134
Methionine	26	19	4.55	11	27
Phenylalanine	26	55	14	35	96
Threonine	26	44	18	18	83
Tryptophan	26	24	7	10	40
Valine	26	177	41	114	271

Table 2. Relationship between total blood plasma AA and ovarian function

r (*P*-value)	Wavelength	Ovulatory follicle diameter	Secondary follicle diameter	Size at dominance	Duration of dominance	Average AFC	Total CL Volume	Progesterone	Progesterone: CL Volume	Peak Estradiol	Proestrus
Total AA	-0.04 (0.84)	-0.09 (0.67)	0.11 (0.58)	-0.17 (0.40)	0.22 (0.29)	-0.16 (0.44)	-0.27 (0.19)	-0.10 (0.64)	-0.02 (0.94)	-0.16 (0.42)	0.49 **(0.01)**
Essential AA	-0.07 (0.75)	-0.11 (0.59)	0.13 (0.54)	-0.13 (0.53)	0.15 (0.46)	-0.08 (0.69)	-0.26 (0.20)	0.15 (0.46)	0.09 (0.65)	-0.03 (0.89)	0.48 **(0.01)**
Nonessential AA	0.01 (0.97)	-0.02 (0.92)	0.05 (0.80)	-0.15 (0.45)	0.21 (0.30)	-0.19 (0.35)	-0.16 (0.43)	-0.38 (0.06)	-0.15 (0.46)	-0.27 (0.18)	0.30 (0.14)
Glycogenic AA	-0.06 (0.77)	-0.02 (0.90)	0.15 (0.46)	-0.12 (0.57)	0.21 (0.29)	-0.16 (0.45)	-0.16 (0.44)	-0.15 (0.46)	-0.07 (0.75)	-0.21 (0.30)	0.44 **(0.03)**
Ketogenic AA	-0.17 (0.42)	-0.13 (0.51)	-0.03 (0.89)	-0.22 (0.27)	0.04 (0.86)	-0.07 (0.74)	-0.30 (0.14)	-0.06 (0.76)	0.03 (0.87)	-0.08 (0.71)	0.34 (0.10)
Branched-chain AA	-0.07 (0.75)	-0.08 (0.71)	0.04 (0.85)	-0.18 (0.38)	0.15 (0.47)	-0.12 (0.54)	-0.17 (0.41)	-0.12 (0.56)	-0.12 (0.55)	-0.13 (0.52)	0.41 **(0.04)**
Urea AA	-0.18 (0.38)	0.03 (0.88)	0.26 (0.21)	-0.06 (0.77)	0.06 (0.77)	0.19 (0.36)	-0.09 (0.65)	0.46 **(0.02)**	0.19 (0.35)	0.01 (0.98)	0.5 **(0.01)**
Arginine	-0.09 (0.66)	-0.08 (0.68)	0.22 (0.27)	-0.01 (0.95)	0.05 (0.8)	0.06 (0.76)	-0.11 (0.59)	0.51 **(0.01)**	0.31 (0.12)	0.07 (0.74)	0.5 **(0.01)**
Histidine	0.22 (0.27)	-0.11 (0.58)	0.20 (0.34)	-0.21 (0.31)	0.39 **(0.05)**	-0.14 (0.50)	-0.35 (0.08)	-0.03 (0.88)	0.02 (0.94)	-0.19 (0.36)	0.38 (0.06)
Isoleucine	0.08 (0.68)	-0.19 (0.36)	0.12 (0.57)	-0.14 (0.49)	0.21 (0.32)	-0.09 (0.66)	-0.36 (0.07)	0.07 (0.73)	0.13 (0.51)	-0.16 (0.44)	0.49 **(0.01)**
Leucine	-0.20 (0.34)	0.01 (0.96)	-0.07 (0.71)	-0.19 (0.36)	0.03 (0.90)	-0.09 (0.67)	-0.12 (0.55)	-0.17 (0.40)	-0.12 (0.58)	-0.06 (0.76)	0.04 (0.84)
Lysine	0.02 (0.94)	-0.31 (0.13)	0.09 (0.68)	-0.12 (0.55)	0.03 (0.89)	0.02 (0.93)	-0.4 **(0.04)**	0.19 (0.34)	0.29 (0.15)	-0.05 (0.83)	0.64 **(0.001)**
Methionine	-0.08 (0.71)	-0.03 (0.88)	0.09 (0.68)	-0.24 (0.24)	0.13 (0.54)	-0.17 (0.40)	-0.24 (0.24)	-0.02 (0.91)	0.08 (0.68)	-0.03 (0.88)	0.32 (0.11)
Phenylalanine	-0.09 (0.67)	0.1 (0.63)	0.11 (0.58)	-0.16 (0.45)	0.2 (0.32)	-0.14 (0.50)	-0.03 (0.88)	0.008 (0.97)	-0.07 (0.74)	-0.01 (0.95)	-0.02 (0.93)
Threonine	-0.03 (0.87)	-0.12 (0.56)	0.09 (0.64)	-0.04 (0.86)	0.15 (0.47)	-0.12 (0.56)	-0.29 (0.15)	0.18 (0.38)	0.16 (0.44)	0.04 (0.83)	0.54 **(0.01)**
Tryptophan	0.10 (0.62)	-0.08 (0.70)	0.13 (0.52)	-0.01 (0.96)	0.19 (0.35)	-0.12 (0.56)	-0.14 (0.50)	0.28 (0.17)	0.07 (0.72)	0.04 (0.83)	0.46 **(0.02)**
Valine	-0.02 (0.91)	-0.07 (0.75)	0.20 (0.34)	0.01 (0.95)	0.16 (0.42)	-0.07 (0.75)	-0.14 (0.51)	0.24 (0.23)	0.01 (0.96)	0.04 (0.85)	0.52 **(0.01)**

r (*P* - value)	Wavelength	Ovulatory follicle size	Secondary follicle size	Size at dominance	Duration of dominance	Average AFC	Total CL Volume	Progesterone	Progesterone: CL volume	Peak Estradiol	Proestrus
% Essential	-0.09 (0.67)	-0.05 (0.81)	0.13 (0.54)	-0.01 (0.96)	-0.02 (0.93)	0.12 (0.55)	-0.16 (0.42)	0.43 **(0.03)**	0.22 (0.28)	0.14 (0.50)	0.28 (0.18)
% Nonessential	0.09 (0.67)	0.04 (0.81)	-0.13 (0.54)	0.01 (0.96)	0.02 (0.93)	-0.12 (0.55)	0.16 (0.42)	-0.43 **(0.03)**	-0.22 (0.28)	-0.14 (0.50)	-0.28 (0.18)
% Glycogenic	-0.05 (0.81)	0.09 (0.66)	0.02 (0.91)	0.13 (0.54)	-0.02 (0.93)	-0.05 (0.82)	0.28 (0.16)	-0.15 (0.46)	-0.14 (0.50)	-0.07 (0.71)	-0.16 (0.46)
% Ketogenic	-0.17 (0.40)	-0.10 (0.63)	-0.09 (0.67)	-0.22 (0.27)	-0.11 (0.60)	0.08 (0.70)	-0.29 (0.14)	0.01 (0.97)	0.11 (0.59)	0.01 (0.97)	0.08 (0.69)
% Branched-chain AA	-0.02 (0.90)	0.05 (0.83)	-0.19 (0.36)	-0.04 (0.87)	-0.16 (0.44)	0.09 (0.66)	0.30 (0.14)	-0.03 (0.86)	-0.30 (0.13)	0.07 (0.73)	-0.25 (0.23)
% Urea AA	-0.28 (0.17)	0.13 (0.54)	0.28 (0.17)	0.08 (0.69)	-0.16 (0.44)	0.44 **(0.02)**	0.08 (0.71)	0.74 **(< 0.01)**	0.30 (0.13)	0.15 (0.46)	0.33 (0.11)
% Arginine	-0.17 (0.40)	-0.06 (0.79)	0.22 (0.29)	0.10 (0.61)	-0.12 (0.54)	0.21 (0.30)	<-0.01 (0.99)	0.69 **(< 0.01)**	0.41 **(0.04)**	0.16 (0.45)	0.40 **(0.05)**
% Histidine	0.40 **(0.04)**	-0.07 (0.73)	0.18 (0.37)	-0.12 (0.55)	0.34 (0.09)	0.002 (0.99)	-0.27 (0.19)	0.06 (0.79)	0.06 (0.78)	-0.05 (0.80)	-0.03 (0.90)
% Isoleucine	0.14 (0.50)	-0.16 (0.42)	0.07 (0.72)	-0.02 (0.92)	0.06 (0.78)	0.11 (0.58)	-0.28 (0.16)	0.26 (0.21)	0.26 (0.20)	-0.08 (0.68)	0.25 (0.23)
% Leucine	-0.15 (0.46)	0.08 (0.70)	-0.13 (0.53)	0.18 (0.37)	-0.03 (0.88)	-0.01 (0.96)	-0.05 (0.80)	-0.15 (0.45)	-0.11 (0.59)	0.01 (0.95)	-0.24 (0.25)
% Lysine	-0.01 (0.96)	-0.31 (0.12)	0.09 (0.66)	-0.04 (0.86)	-0.12 (0.56)	0.15 (0.46)	-0.39 **(0.05)**	0.29 (0.15)	0.39 **(0.05)**	-0.01 (0.96)	0.58 **(< 0.01)**
% Methionine	-0.08 (0.71)	0.03 (0.87)	0.03 (0.90)	-0.26 (0.20)	-0.01 (0.96)	-0.07 (0.72)	-0.18 (0.38)	0.08 (0.70)	0.20 (0.32)	0.08 (0.70)	0.06 (0.78)
% Phenylalanine	-0.06 (0.77)	0.14 (0.50)	0.02 (0.94)	-0.13 (0.52)	0.12 (0.57)	-0.04 (0.84)	0.12 (0.57)	0.08 (0.69)	-0.06 (0.79)	0.22 (0.10)	-0.33 (0.11)
% Threonine	-0.04 (0.83)	-0.04 (0.84)	0.14 (0.49)	0.09 (0.65)	0.05 (0.81)	<0.01 (1.0)	-0.27 (0.18)	0.30 (0.13)	0.24 (0.24)	0.64 (0.49)	0.44 **(0.03)**
% Tryptophan	0.07 (0.74)	-0.01 (0.96)	0.08 (0.69)	0.15 (0.47)	0.02 (0.93)	0.02 (0.91)	0.06 (0.78)	0.40 **(0.04)**	0.08 (0.70)	0.13 (0.54)	0.26 (0.22)
% Valine	-0.03 (0.88)	0.05 (0.81)	0.19 (0.35)	0.21 (0.30)	<-0.01 (0.99)	0.11 (0.58)	0.10 (0.61)	0.48 **(0.01)**	0.02 (0.92)	0.21 (0.30)	0.26 (0.20)

Table 3. Relationship between percent of total blood plasma AA and ovarian function