



Commercial Amino Acids

November 2017

Jon Evans

Report Code: BIO007L

Table of Contents

Chapter 1: Introduction	1
Study Goals and Objectives.....	1
Reasons for Doing This Study.....	1
Intended Audience.....	1
Scope of Report.....	2
Methodology and Information Sources.....	2
Analyst’s Credentials.....	4
Related BCC Research Reports.....	4
Chapter 2: Summary and Highlights	6
Chapter 3: Market and Technology Background	10
Commercial Interests.....	14
Feed Fortification	16
Food Flavoring Agents.....	16
Specialty Uses	16
Dietary Needs.....	16
Biologic Value of Amino Acid Mixtures.....	17
Recommended Daily Allowance	18
Amino Acid Metabolism.....	19
Properties.....	19
Chemical Structure.....	19
Isolation and Analysis.....	20
Microbiological Assay.....	20
Chromatographic Separation	20
Production Technology	21
Extraction	22
Fermentation.....	22
Microbiological Processes	22
Chemical D Synthesis.....	23
Enzymatic Conversion	24
Regulation	24
Federal Drug Administration.....	24
U.S. Pharmacopoeia	25
Dietary Supplement and Non-Prescription Drug Consumer Protection Act.....	25
Chapter 4: Structure of the Industry and Its Competitive Aspects	27
Important Strategies.....	29
Major Manufacturers.....	30
New Capacity	31
Market Share	32
Market Forces	33
Global Market	34
China.....	35
Western Europe	35
U.S.	35
Asia-Pacific and Other	35
Latin America.....	35

Animal Feed Supplements	37
Phase Feeding.....	37
Animal Feed Regulation	38
International Regulation	38
Typical Animal Feed Product.....	39
Complete Protein Sources.....	39
New Amino Acid-based Feed Products	39
Amino Acid Research and Animal Nutrition.....	40
Summary of U.S. Market for Amino Acids used in Animal Feed	40
Poultry Feeds.....	42
Swine Feeds.....	43
Technical Factors	44
Phytase	44
High Corn Oil	44
Hydrolysates.....	44
Animal By-Products	44
Dairy and Beef Cattle Feeds	44
Sheep Feeds	44
Aquaculture.....	45
Pet Foods.....	45
Chapter 5: Methionine.....	47
Methionine.....	47
Methionine Applications and Consumption Patterns.....	48
Methionine Product Types and Comparative Nutritional Values	49
U.S. Methionine Market.....	50
Methionine Capacity and Manufacturers	50
Price of Methionine.....	53
Chapter 6: Lysine	55
Lysine	55
Consumption Patterns	56
U.S. Lysine Market.....	56
Lysine Capacity and Manufacturers	57
China and Feed	59
Pricing.....	60
Chapter 7: Threonine	63
Threonine.....	63
Threonine Applications and Consumption Patterns	64
U.S. Threonine Market	64
Threonine Capacity and Manufacturers.....	65
Threonine Pricing	66
Chapter 8: Tryptophan.....	68
Tryptophan.....	68
Tryptophan Applications and Consumption Patterns	69
Tryptophan Regulations	69
Tryptophan Health Applications.....	69
Tryptophan as a Fat Fighter	70
U.S. Tryptophan Market.....	70
Tryptophan Capacity	71

Pricing.....	72
Chapter 9: Food Flavoring Agents	74
Food Flavoring Agents.....	74
U.S. Market for Food Flavorings.....	75
Chapter 10: Phenylalanine	78
Phenylalanine Applications and Consumption Patterns.....	78
Aspartame Artificial Sweeteners	78
Competitive Aspects of the Sweetener Market.....	78
Aspartame-Sweetened Products	78
Diet Beverage Aspartame Use	79
Diet Candy Market	79
Aspartame and Coffee.....	80
Problems with Aspartame	80
Pharmaceutical Uses of Phenylalanine	80
Aspartame in Europe.....	80
U.S. Phenylalanine Market	81
Phenylalanine Capacity and Manufacturers	81
Phenylalanine Pricing	82
Chapter 11: Glutamic Acid	84
Glutamic Acid Production Technology.....	84
Glutamic Acid Applications and Consumption Patterns	85
MSG Regulation	85
Chinese Restaurant Syndrome.....	85
FASEB Report on MSG.....	86
FDA Proposals for MSG	87
Dangers of MSG.....	87
Truth in Labeling Campaign.....	87
U.S. Glutamic Acid Market	88
Glutamic Acid Capacity and Manufacturers.....	88
Pricing.....	89
Chapter 12: Cysteine/Cystine.....	91
Cysteine/Cystine Applications and Consumption Patterns	91
Cysteine and Nutraceuticals	91
Cysteine/Cystine Production Technology	92
U.S. Cysteine/Cystine Market.....	92
Cysteine/Cystine Capacity and Manufacturers	93
Cysteine Pricing	94
Chapter 13: Aspartic Acid.....	96
Aspartic Acid Applications and Consumption Patterns	96
Aspartic Acid Copolymers	96
Aspartic Acid Production Technology	96
U.S. Aspartic Acid Market.....	96
Aspartic Acid Capacity and Manufacturers	97
Aspartic Acid Pricing.....	98
Chapter 14: Specialty Uses.....	100
Pharmaceutical Products	103

Chemical Intermediates	104
Cosmetics and Amino Acids	104
Photography and Amino Acids.....	104
Detergent and Amino Acids	105
Chapter 15: Glycine.....	108
Glycine.....	108
Glycine Applications	108
U.S. Glycine Market.....	109
Glycine Capacity and Manufacturers	109
Glycine Pricing	110
Chapter 16: Alanine	112
Alanine	112
Alanine Production Technology	112
Alanine Applications and Consumption Patterns.....	113
U.S. Alanine Market.....	113
Alanine Capacity and Manufacturers	113
Alanine Pricing.....	114
Chapter 17: Arginine	116
Arginine	116
Applications.....	116
U.S. Arginine Market	117
Arginine Capacity and Manufacturers.....	117
Arginine Pricing	118
Chapter 18: Proline	120
Proline	120
Proline Technology.....	120
U.S. Proline Market	120
Proline Capacity and Manufacturers.....	121
Proline Pricing.....	121
Chapter 19: Leucine	123
Leucine.....	123
Leucine Applications and Consumption Patterns	123
Leucine Production Technology	123
U.S. Leucine Market	124
Leucine Capacity and Manufacturers.....	124
Leucine Pricing.....	125
Chapter 20: Valine	127
Valine	127
Valine Applications and Consumption Patterns.....	127
Valine Production Technology	127
U.S. Valine Market.....	127
Valine Capacity and Manufacturers	128
Valine Pricing.....	129
Chapter 21: Tyrosine.....	131
Tyrosine.....	131
Tyrosine Applications and Consumption Patterns	131

Tyrosine Production Technology.....	132
U.S. Tyrosine Market.....	132
Tyrosine Capacity and Manufacturers	132
Tyrosine Pricing.....	133
Chapter 22: Isoleucine	135
Isoleucine	135
Isoleucine Applications and Consumption Patterns	135
Isoleucine Production Technology	136
U.S. Isoleucine Market	136
Isoleucine Capacity and Manufacturers.....	137
Isoleucine Pricing.....	138
Chapter 23: Serine	140
Serine	140
Serine Applications and Consumption Patterns.....	140
Serine Production Technology	140
U.S. Serine Market.....	141
Serine Capacity and Manufacturers.....	141
Serine Pricing.....	142
Chapter 24: Asparagine.....	144
Asparagine Applications and Consumption Patterns	144
Asparagine Production Technology	144
U.S. Asparagine Market.....	145
Asparagine Capacity and Manufacturers	145
Asparagine Pricing.....	146
Chapter 25: Glutamine.....	148
Glutamine Applications and Consumption Patterns.....	148
Glutamine Production Technology	148
U.S. Glutamine Market.....	148
Glutamine Capacity and Manufacturers	149
Glutamine Pricing and Consumption	150
Chapter 26: Histidine	152
Histidine Applications	152
Histidine Production Technology.....	152
U.S. Histidine Market	153
Histidine Capacity and Manufacturers.....	153
Histidine Pricing.....	154
Chapter 27: Company Profiles	156
About BCC Research.....	169
About BCC Research.....	170
BCC Membership	170
BCC Custom Research.....	170

List of Tables

Summary Table U.S. Amino Acid Market, by Application, Through 2022 (\$ Millions)	7
Table 1 Commercial Amino Acids by Use.....	10
Table 2 U.S. Amino Acid Market, by Application, Through 2022 (\$ Millions).....	11
Table 3 Global Amino Acid Market Shares, by Segment and Application, 2017 (%)	12
Table 4 Protein Amino Acids	13
Table 5 Major Commercial Applications	14
Table 6 U.S. Market for Amino Acids, by Application and Specialty, Through 2022 (\$ Millions)	15
Table 7 Essential Amino Acids.....	17
Table 8 Protein Values of Selected Foods.....	18
Table 9 Chemical Structures of Amino Acids	20
Table 10 Amino Acids, by Production Method	21
Table 11 Amino Acid Production by Fermentation (Grams/Liter)	23
Table 12 USP Verified Amino Acid Products	25
Table 13 Major Amino Acid Producers, 2017	28
Table 14 Leading Producers of Amino Acid, by Type, 2017	30
Table 15 Global Demand for Amino Acids, by Region, 2017 (\$ Millions)	34
Table 16 Global Demand for Amino Acids, by Region, 2022 (\$ Millions)	36
Table 17 U.S. Market for Amino Acids Used in Animal Feed, 2016–2022 (\$ Millions/%).....	41
Table 18 Poultry Feed Compositions (%)	42
Table 19 Amino Acid Feed Compositions (Pound/Ton)	43
Table 20 U.S. Consumption of Methionine, Through 2022 (Million Pounds, 99% DL-Methionine Basis)..	49
Table 21 U.S. Methionine Market, Through 2022 (\$ Millions)	50
Table 22 Global Methionine Market, by Region, 2017 and 2022 (\$ Millions)	50
Table 23 Methionine Manufacturers.....	51
Table 24 Global Methionine Production Capacity, by Manufacturer, 2017 (Kiloton/%).....	52
Table 25 U.S. Consumption of Lysine in Animal Feeds, Through 2022 (\$ Millions).....	56
Table 26 U.S. Lysine Market, Through 2022 (\$ Millions)	57
Table 27 Global Lysine Market, by Region, 2017 and 2022 (\$ Millions).....	58
Table 28 Global Lysine Production Capacity, by Manufacturer, 2017 (Kilotons/%)	58
Table 29 U.S. Threonine Market, Through 2022 (\$ Millions).....	64
Table 30 Threonine Producers, 2017.....	65
Table 31 Global Threonine Market, by Region, 2017 and 2022 (\$ Millions)	65
Table 32 Threonine Production Capacity, by Manufacturer, 2017 (Kilotons/%).....	66
Table 33 U.S. Tryptophan Market, Through 2022 (\$ Millions)	71
Table 34 Global Tryptophan Market, by Region, 2017 and 2022 (\$ Millions)	71
Table 35 Tryptophan Producers, 2017.....	72
Table 36 U.S. Amino Acid Flavoring Agents Market, Through 2022 (\$ Millions)	76
Table 37 Global Amino Acid Flavoring Agents Market, by Region, 2017 and 2022 (\$ Millions).....	76
Table 38 U.S. Phenylalanine Market, Through 2022 (\$ Millions)	81
Table 39 Global Phenylalanine Market, by Region, 2017 and 2022 (\$ Millions)	81
Table 40 Phenylalanine Producers, 2017.....	82
Table 41 U.S. Glutamic Acid Market, Through 2022 (\$ Millions).....	88
Table 42 Global Glutamic Acid Market, by Region, 2017 and 2022 (\$ Millions)	89
Table 43 Glutamic Acid Manufacturers, 2017	89
Table 44 U.S. Cysteine Market, Through 2022 (\$ Millions)	93
Table 45 Global Cysteine Market, by Region, 2017 and 2022 (\$ Millions)	93
Table 46 Cysteine Producers, 2017.....	94

Table 47 U.S. Aspartic Acid Market, Through 2022 (\$ Millions)	97
Table 48 Global Aspartic Acid Market, by Region, 2017 and 2022 (\$ Millions).....	97
Table 49 Aspartic Acid Manufacturers, 2017.....	98
Table 50 Amino Acids for Specialty Uses, 2017	100
Table 51 Market Shares of Specialty Amino Acids, 2017 (%).....	101
Table 52 U.S. Market for Specialty Amino Acids, Through 2022 (\$ Millions)	102
Table 53 Global Specialty Amino Acids Market, by Region, 2017 and 2022 (\$ Millions)	102
Table 54 U.S. Glycine Market, Through 2022 (\$ Millions)	109
Table 55 Global Glycine Market, by Region, 2017 and 2022 (\$ Millions).....	109
Table 56 Glycine Manufacturers, 2017	110
Table 57 U.S. Alanine Market, Through 2022 (\$ Millions)	113
Table 58 Global Alanine Revenues, by Region, 2017 and 2022 (\$ Millions).....	114
Table 59 Alanine Manufacturers, 2017.....	114
Table 60 U.S. Arginine Market, Through 2022 (\$ Millions).....	117
Table 61 Global Arginine Revenues, by Region, 2017 and 2022 (\$ Millions)	117
Table 62 Arginine Manufacturers, 2017	118
Table 63 U.S. Proline Market, Through 2022 (\$ Millions).....	121
Table 64 Global Proline Revenues, by Region, 2017 and 2022 (\$ Millions).....	121
Table 65 Proline Manufacturers, 2017	121
Table 66 U.S. Leucine Market, Through 2022 (\$ Millions).....	124
Table 67 Global Leucine Market Market, by Region, 2017 and 2022 (\$ Millions).....	124
Table 68 Leucine Manufacturers, 2017	124
Table 69 U.S. Leucine Prices, 2017 (1 kilogram/\$).....	125
Table 70 U.S. Valine Market, Through 2022 (\$ Millions)	128
Table 71 Global Valine Market, by Region, 2017 and 2022 (\$ Millions).....	128
Table 72 Valine Producers, 2017	128
Table 73 U.S. Tyrosine Market, Through 2022 (\$ Millions)	132
Table 74 Global Tyrosine Market by Region, 2017 and 2022 (\$ Millions)	133
Table 75 Tyrosine Manufacturers, 2017	133
Table 76 U.S. Isoleucine Market, Through 2022 (\$ Millions).....	137
Table 77 Global Isoleucine Market by Region, 2017 and 2022 (\$ Millions)	137
Table 78 Isoleucine Manufacturers, 2017	137
Table 79 U.S. Serine Market, Through 2022 (\$ Millions).....	141
Table 80 Global Serine Market, by Region, 2017 and 2022 (\$ Millions).....	142
Table 81 Serine Manufacturers, 2017.....	142
Table 82 U.S. Asparagine Market, Through 2022 (\$ Millions)	145
Table 83 Global Asparagine Market by Region, 2017 and 2022 (\$ Millions).....	145
Table 84 Asparagine Manufacturers, 2017.....	146
Table 85 U.S. Glutamine Market, Through 2022 (\$ Millions)	149
Table 86 Global Glutamine Market, by Region, 2017 and 2022 (\$ Millions)	149
Table 87 Glutamine Manufacturers, 2017.....	149
Table 88 U.S. Histidine Market, Through 2022 (\$ Millions)	153
Table 89 Global Histidine Market, by Region, 2017 and 2022 (\$ Millions).....	153
Table 90 Histidine Manufacturers, 2017	154

List of Figures

Summary Figure U.S. Amino Acids Market, by Application, 2016–2022 (\$ Millions).....	8
Figure 1 U.S. Amino Acid Market, by Application, 2016–2022 (\$ Millions).....	11
Figure 2 Regional Production of Amino Acids, 2017 (%)	29
Figure 3 Manufacturer Market Shares of All Amino Acids, 2017 (%)	32
Figure 4 U.S. Market for Amino Acids Used in Animal Feed, 2016–2022 (\$ Millions).....	41
Figure 5 Market Shares of Methionine Consumption, 2017 (%)	48
Figure 6 Market Shares of Lysine Consumption, by Feed Type, 2017 (%).....	57
Figure 7 Global Market Shares of Leading Lysine Producers, 2017 (%).....	60
Figure 8 U.S. Market Shares of Amino Acid Flavorants, 2017 (%)	75



About BCC Research

About BCC Research

With our unparalleled 45-year history, BCC Research provides comprehensive analysis of global market sizing, forecasting and industry intelligence, covering markets where advances in science and technology are improving the quality, standard and sustainability of businesses, economies and lives.

BCC Membership

From market sizing and forecasts, to opportunity assessments and competitive analyses, our ever-expanding library gives you the data, insights and intelligence required to ensure your project is a success. Members benefit from ongoing, unlimited access to the category or collections of their choice, and most membership packages pay for themselves within two to three reports being accessed.

Did you buy this report? You may qualify to apply your purchase price towards a full membership. Call 866/285-7215 or email info@bccresearch.com to request a demo.

BCC Custom Research

Our experts provide custom research projects to those working to identify new markets, introduce new products, validate existing market share, analyze competition and assess the potential for products to impact existing markets. With impressive academic credentials and broad and deep knowledge of global industrial markets, our independent analysts and consultants develop the facts, figures, analysis and assessments to inform the decisions that will move your company ahead. Confidential inquiries to: custom@bccresearch.com or 781/205-2429.

DISCLAIMER

The information developed in this report is intended to be as reliable as possible at the time of publication and is of a professional nature. This information does not constitute managerial, legal or accounting advice, nor should it be considered as a corporate policy guide, laboratory manual or an endorsement of any product, as much of the information is speculative in nature. BCC Research and the author assume no responsibility for any loss or damage that might result from reliance on the reported information or from its use.

ISBN: 978-1-62296-578-6
November 2017